

Nurse Staffing and Quality of Patient Care

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Preface

The Agency for Healthcare Research and Quality (AHRQ), through its Evidence-Based Practice Centers (EPCs), sponsors the development of evidence reports and technology assessments to assist public- and private-sector organizations in their efforts to improve the quality of health care in the United States. The reports and assessments provide organizations with comprehensive, science-based information on common, costly medical conditions, and new health care technologies. The EPCs systematically review the relevant scientific literature on topics assigned to them by AHRQ and conduct additional analyses when appropriate prior to developing their reports and assessments.

To bring the broadest range of experts into the development of evidence reports and health technology assessments, AHRQ encourages the EPCs to form partnerships and enter into collaborations with other medical and research organizations. The EPCs work with these partner organizations to ensure that the evidence reports and technology assessments they produce will become building blocks for health care quality improvement projects throughout the Nation. The reports undergo peer review prior to their release.

AHRQ expects that the EPC evidence reports and technology assessments will inform individual health plans, providers, and purchasers as well as the health care system as a whole by providing important information to help improve health care quality.

We welcome written comments on this evidence report. They may be sent to the Task Order Officer named below at: Agency for Healthcare Research and Quality, 540 Gaither Road, Rockville, MD 20850, or by email to epc@ahrq.gov.

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Structured Abstract

Objectives: To assess how nurse to patient ratios and nurse work hours were associated with patient outcomes in acute care hospitals, factors that influence nurse staffing policies, and nurse staffing strategies that improved patient outcomes.

Data Sources: MEDLINE[®] (PubMed[®]), CINAHL, Cochrane Databases, EBSCO research database, BioMed Central, Federal reports, National Database of Nursing Quality Indicators, National Center for Workforce Analysis, American Nurses Association, American Academy of Nurse Practitioners, and Digital Dissertations.

Review Methods: In the absence of randomized controlled trials, observational studies were reviewed to examine the relationship between nurse staffing and outcomes. Meta-analysis tested the consistency of the association between nurse staffing and patient outcomes; classes of patient and hospital characteristics were analyzed separately.

Results: Higher registered nurse staffing was associated with less hospital-related mortality, failure to rescue, cardiac arrest, hospital acquired pneumonia, and other adverse events. The effect of increased registered nurse staffing on patients safety was strong and consistent in intensive care units and in surgical patients. Greater registered nurse hours spent on direct patient care were associated with decreased risk of hospital-related death and shorter lengths of stay. Limited evidence suggests that the higher proportion of registered nurses with BSN degrees was associated with lower mortality and failure to rescue. More overtime hours were associated with an increase in hospital related mortality, nosocomial infections, shock, and bloodstream infections. No studies directly examined the factors that influence nurse staffing policy. Few studies addressed the role of agency staff. No studies evaluated the role of internationally educated nurse staffing policies.

Conclusions: Increased nursing staffing in hospitals was associated with lower hospital-related mortality, failure to rescue, and other patient outcomes, but the association is not necessarily causal. The effect size varied with the nurse staffing measure, the reduction in relative risk was greater and more consistent across the studies, corresponding to an increased registered nurse to patient ratio but not hours and skill mix. Estimates of the size of the nursing effect must be tempered by provider characteristics including hospital commitment to high quality care not considered in most of the studies. Greater nurse staffing was associated with better outcomes in intensive care units and in surgical patients.

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Executive Summary

Introduction

A shortage of registered nurses, in combination with increased workload, has the potential to threaten quality of care.¹⁻³ Increasing the nurse to patient ratios has been recommended as a means to improve patient safety.^{4,5} However, the cost effectiveness of increasing registered nurse (RN) staffing is controversial.^{6,7}

This systematic review analyzes associations between hospital nurse staffing and patient outcomes with consideration of variables that could influence the primary association. The basic research questions were:

1. How is a specific nurse to patient ratio associated with patient outcomes (i.e., mortality; adverse drug events, nurse quality outcomes, length of stay; patient satisfaction with nurse care)? How does this association vary by patient characteristics, nurse characteristics, organizational characteristics, and nursing outcomes?
2. How is a measure of nurse work hours (hours per patient or patient day) associated with the same patient outcomes?
3. What factors influence nurse staffing policies?
4. What nurse staffing strategies are effective for improving the patient outcomes listed in question 1?
5. What gaps in research on nurse staffing and patient outcomes can be identified to address in future studies?

Questions 1, 2, and 4 are addressed in the systematic review using meta-analytic approaches. The literature associated with question 3 does not lend itself to meta-analysis.

Questions 1 and 2 address the same basic association but employ two different measures of nurse staffing. The nurse to patient ratio relies on a general ratio, which may include all nurses assigned to a unit, including non-clinical time, whereas nurse work hours look specifically at nurses involved in patient care. Even beyond this distinction, the varied ways staffing rates are calculated complicates pooling data.

Methods

Observational studies from from 1990 to 2006 from the United States and Canada were reviewed for questions 1, 2, and 4. Studies for question 3 addressed implications for nurse staffing policies. No studies primarily empirically examined a specific nurse staffing policy. Sources included journal articles, administrative reports, and dissertations.

For questions 1, 2, and 4, we present the relative risks of nurse staffing levels on various patient outcomes adjusted for measured confounding factors. Meta-analysis was used to test the consistency of the association between nurse staffing and both patient outcomes and economic outcomes (e.g., length of stay); the analyses were conducted separately for classes of patients and hospital characteristics.

Results

Of the 94 eligible studies from 96 reports, 7 percent were case-control studies; 3 percent were case-series; 44 percent were cross-sectional studies; 46 percent assessed temporality in the association between nurse staffing and patient outcomes. The overall quality of the studies averaged 38 (of a possible 50).

Patient Outcomes and Nurse Staffing Ratios

Consistent evidence from observational studies suggests that an increase in Registered Nurse (RN) to patient ratios was associated with a reduction in hospital-related mortality, failure to rescue,¹ and other nurse sensitive outcomes, as well as reduced length of stay (LOS), after adjustment for patient and provider characteristics but does not establish a causal relationship. The effect size is greater in surgical patients; ratios less than 2.5 patients per RN per shift in intensive care units (ICUs) and less than 3.5 patients per RN in surgical units were associated with the largest risk reduction based on quartiles of nurse staffing ratios.

Pooled results showed that every additional RN full time equivalent (FTE) per patient day was associated with a relative risk reduction in hospital-related mortality by 9 percent in intensive care units and 16 percent in surgical patients.⁸⁻²¹ If the relationship were indeed causal, we estimate that an increase by one RN FTE per patient day would save five lives per 1,000 medical patients, and six per 1,000 surgical patients. Reducing the workload from more than six to two or less patients per RN per shift would save 25 lives per 1,000 hospitalized patients and 15 lives per 1,000 surgical patients. A further reduction from two to four patients to less than 1.5 patients per RN would save four lives per 1,000 hospitalized patients and nine lives per 1,000 surgical patients. However, staffing rates of this magnitude may not be realistic.

Every additional patient per RN per shift was associated with a 7 percent increase in relative risk of hospital acquired pneumonia,^{13,14,22} a 53 percent increase in pulmonary failure,^{13,14,23,24} a 45 percent increase in unplanned extubation,^{13,14,23-25} and a 17 percent increase in medical complications.^{13,23,24} The increase in relative risk of unplanned extubation and pulmonary failure was higher and in hospital acquired pneumonia was lower, corresponding to an increase in patients per nurse ratios. We estimated that if the relationship were causal, one additional patient per RN per shift would result in 12 additional cases of failure to rescue, six cases of pulmonary failure, and five accidental extubations per 1,000 hospitalized patients.

The associations vary by clinical settings and patient population. In ICUs, an increase by one RN FTE per patient day was associated with a consistent decrease across studies in relative risk of these patient outcomes: a 28 percent decrease of cardiopulmonary resuscitation,^{13,23,24} a 51 percent decrease of unplanned extubation,^{13,14,23-25} a 60 percent decrease of pulmonary failure,^{13,14,23,24} and a 30 percent decrease of hospital acquired pneumonia.^{13,14,22} In surgical patients, an increase of one RN FTE per patient day was associated with a consistent reduction in the relative risk of failure to rescue by 16 percent,^{12,15,16,20,21} and in nosocomial bloodstream infections of 31 percent.

¹ The number of deaths in patients who developed an adverse occurrence among the number of patients who developed an adverse occurrence.

The data on other nursing personnel is limited and not replicable in the studies. LOS was shorter by 24 percent in ICUs and by 31 percent in surgical patients, corresponding to an additional RN FTE per patient day.^{8,9,13,14}

Patient Outcomes and Nurse Staffing Hours

An increase in total nurse hours per patient day was associated with reduced hospital mortality, failure to rescue, and other adverse events. The death rate decreased by 1.98 percent for every additional total nurse hours per patient day (95 percent confidence interval [CI] 0.96-3 percent).²⁶⁻²⁹ The association with RN hours per patient day did not show significant changes in mortality rates.²⁶⁻²⁹ The relative risk of death was lower by 1 percent per 1 additional RN hour per patient day in ICUs^{8,9,13,14,16} and in medical^{8,10,11,17-19,26,27,30-32} and surgical patients.^{9,12-16,20,26,27} The association between LPN/LVN hours per patient day and death rate was not consistent across studies.^{17,20,26,27,33,34}

The association between patient outcomes and RN and LPN/LVN hours was inconsistent across the studies. Pooled analysis showed that 1 additional RN hour per patient day was associated with a reduction in relative risk of hospital acquired pneumonia by four percent,^{13,14,22} pulmonary failure by 11 percent,^{13,14,23,24} unplanned extubation by 9 percent in ICUs,^{13,14,23-25} failure to rescue by 1 percent in surgical^{12,15,16,20,26,27,30} and medical patients,^{26,27,35} and deep venous thrombosis by 2 percent in medical patients.^{27,35}

The LOS in hospitals was lower for additional total nursing, but not for licensed LPN/LVN and unlicensed assistive personnel (UAP) hours. The association between RN hours and LOS was not consistent across studies.

Other Attributes of Nursing

There was a significant negative correlation between the percentage of nurses with Bachelor of Science in Nursing (BSN) degrees and the incidence of deaths related to health care ($r = -0.46$, $p = 0.02$). Nurse job satisfaction and autonomy was associated with a significant reduction in the risk of death. An increase in nurse turnover increased the rate of patient falls by 0.2 percent.³⁶

Staffing policies examined for this review related to the shift length, scheduling nurses to rotate to different shifts, mandatory overtime, weekend staffing, use of agency or temporary nurses, assigning nurses to nursing units other than those they are regularly assigned to work (floating), use of full-time, part-time, and internationally educated nurses (IENs), the nurse-to-patient ratio or nursing hours per patient day for nursing units, and the skill mix (licensed vs. unlicensed staff) of nursing units. Overall, few studies for any of these staffing policy variables limited drawing any conclusions. Trends in the literature suggested that rotating shifts may have negative effects on nurses' stress levels and job performance perceptions. Further, several studies indicated that nurses working longer hours may have a negative impact on patient outcomes and safety. No research provides guidance on the impact or effective use of agency/temporary staff. Research on the use and effectiveness of IENs in U.S. hospitals³⁷ includes qualitative exploratory studies^{38,39} and descriptive studies⁴⁰⁻⁴² that examined IEN use in healthcare. No studies empirically evaluated the interaction of IEN staffing policies with organizational, nurse, or patient care unit factors.

Within the limits of scant literature, RN overtime is not associated with the location of the hospital, teaching status of the hospital, average hours in a nurses' work week, acute bed occupancy, acute average daily census, or financial margin of the hospital.^{37,42-44} More overtime hours were associated with an increase in hospital-related mortality, nosocomial infections, shock, and bloodstream infections. The proportion of float nurses was positively associated with the risk of nosocomial bloodstream infections.⁴⁵⁻⁴⁷ More contract hours was associated with an increase in LOS.^{28,45,48,50}

Discussion

This review confirms previous contentions that increased nurse staffing in hospitals is associated with better care outcomes,⁵¹ but this association has not been shown to reflect a causal relationship. Hospitals that invest in more nurses may also invest in other actions that improve quality. Magnet hospitals that are said to provide high quality care have better nurse staffing strategies.^{10,52} Overall hospital commitment to a high quality of care in combination with effective nurse retention strategies leads to better patient outcomes, patient satisfaction with overall and nursing care, and nurse satisfaction with job and provided care.^{10,52-59}

Two general measures of nurse staffing were studied.⁶⁰ One addressed hours of care provided by nursing staff averaging FTEs of different nurse categories at the hospital level,^{11,18,19} sometimes including only productive hours worked in direct care.^{28,61,62} The other relies on less precise data of total nurse staffing to patient volume derived from administrative databases^{61,63-65} averaging annual nurse to patient ratios²⁰ at the hospital or unit level.²⁰ The ratio of patients per RN per shift ratio was more frequently used and provided greater evidence of the effect, but both showed generally the same trends.

The effect size varied with the nurse staffing measure. The reduction in relative risk of hospital related mortality was 16 percent for one RN FTE per patient day, and 1 percent for an additional RN hour per patient day in surgical patients. Assuming that every additional RN FTE per patient day would provide approximately 8 additional RN hours per patient day, the expected reduction should be more than observed in the studies that examined the risk of mortality in relation to nurse hours. The comparison of the effect size on patient outcomes among quartiles of patients per RN per shift ratio and nurse hours per patient day detected the same pattern; the maximum reduction in relative risk of hospital-related mortality and adverse events occurred when no more than two patients were assigned to an RN and more than 11 nurse hours were spent per 1 patient day. We did not find consistent evidence that a further increase in RN FTE per patient day ratio can provide better patient safety. The evidence of the effects of LPN/LVNs and UAP were limited and inconsistent.

It is difficult to transition between nurse hours and nurse-to-patient ratios. Nurse hours per patient day reflect average staffing across a 24-hour period and do not reflect fluctuations in patient census, scheduling patterns during different shifts (even the length of shifts varies),^{9,13} and periods of the year.^{66,67} They do not account for the time nurses spend in meetings, educational activities, and administrative work.

Nurse staffing could have a different effect in different hospital settings. The addition of one unit of nursing care may depend on the baseline rate. The effect of an additional nurse hour might be quite dissimilar in ICUs and typical hospital units. As shown in previous studies,^{26,27} the present meta-analysis found consistent evidence that surgical patients are sensitive to nurse staffing.

The size of the nursing effect must be tempered by all the other factors not considered in most of these studies. No direct measure of other influences on outcomes is typically made. The traditional concerns about factors that affect quality of care, such as the nature of the primary medical and surgical treatment and the skill of the physician staff, are not addressed and are assumed to be evenly distributed to yield noise, but not bias. Many of the studies are performed on data collected at the hospital level over a long period of time. Adjustments for comorbidity depend on simple averages.

Skill, organization, and leadership undoubtedly play a role but are much more difficult to assess. Skill mix did not demonstrate consistent associations with tested patient outcomes in the present review. Nurse competence requirements include education, expertise, and experience^{68,69} Nurse education was associated with lower mortality. The importance of nurses' professional competence and performance have been discussed with regard to developing standards of nurse performance to encourage high quality of care.⁷⁰⁻⁷³

Conclusions

Increased nurse staffing in hospitals is associated with better care outcomes, but this association is not necessarily causal. The effect size varied with the nurse staffing measure and sites of patient care (i.e., ICU, medical vs. surgical units). The size of the nursing effect must be tempered by all the other factors not considered in most of these studies.

Future Research

Future observational studies will need to take cognizance of the many other factors that can affect the outcomes of interest, especially medical care, patient characteristics, and organization of nursing units and staffs. Larger multi-center studies will be needed. More studies should be conducted at the patient level to allow for better control of issues like comorbidity. Hierarchical models that control for both institutional and nursing effects could be employed. Nonetheless, it is unlikely that all the salient variables can be addressed in any one study. Future work will need to target specific questions and collect and analyze enough information to isolate the effects of nurse staffing levels.

Evidence Report

Chapter 1. Introduction

Overview

Reports from the Institute of Medicine addressing quality of health care provided in the United States call for significant improvements at a system level to guarantee effective, efficient, evidence-based, patient-oriented, and equitable care.^{74,84,85} Patient safety from injuries caused by the health care system is critical to improving quality of care and reducing health care costs.⁸⁴ Estimates suggest that 1 percent of health expenditures, or \$8.8 billion, is attributable to preventable adverse events.⁸⁴ Patient safety is included in certification process of health care organizations by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO)⁴ and monitored by the voluntary National Quality Forum (NQF).^{5,87} The health care workforce is crucial to providing patients with high-quality care.⁷⁴ Nurses constitute 54 percent of all health care workers in the United States.⁷⁴ Because of the key role nurses play in patient safety and quality of care, the U.S. Department of Health and Human Services (DHHS) and the Agency for Healthcare Research and Quality (AHRQ) conducted several studies^{51,65,89,90} to examine the association between nurse staffing and patient outcomes which showed that the work environment was a major threat to safe nursing practice in hospitals.²⁷ Hospital restructuring in the last two decades, in response to the advent of managed care, resulted in shorter hospitalizations of acutely ill patients to increase hospitals' efficiency and financial performance.¹⁹ Increased patient turnover placed new stresses on nurses to provide safe patient care.^{3,74} The increased workload, when 23 percent of hospitals reported 7-12 patients per nurse in most medical-surgical units, reduced nurses' trust in hospital and nursing administration as well as reducing nurse autonomy.⁷⁴ At least part of the growing nurse shortage from 6 percent in 2000 to a projected 20 percent in 2020 can be traced to nurse job dissatisfaction.^{1,91}

A nurse shortage, in combination with increased workload, has the potential to threaten quality of care.^{74,51} Hospitals with inadequate nurse staffing have higher rates of adverse events such as hospital acquired infection, shock, and failure to rescue.^{26,27,51} Systematic reviews of the published literature show that better nurse staffing is associated with less hospital mortality and failure to rescue, and shorter lengths of stay.^{51,92,93} A simulation model based on extensive research on nurse staffing estimates the need for additional nurses to achieve the quality goals set for hospital care.^{6,26,27}

The design of nurse staffing studies varies. Some look specifically at individual units or nurses, while others use administrative data bases that address data at the hospital level and do not permit statistical adjustment for many potentially relevant factors. The latter designs allow for only crude associations.

Quality indicators directly related to nurse staffing have been developed.^{89,95} AHRQ, the American Nurses Association (ANA), and the NQF considered failure to rescue and pressure ulcers as patient outcomes that are sensitive to nursing care, but there is less consensus on other quality measures such as hospital acquired pneumonia (AHRQ, NQF), urinary tract infection (NQF, ANA), patient falls (NQF, ANA), patient satisfaction with nursing care (ANA), ventilator associated pneumonia, and catheter associated bloodstream infections (NQF).^{5,89,95}

Few studies have evaluated optimal nurse staffing ratios and hours in different clinical settings; instead, they reported the overall correlation with selected patient outcomes.^{35,92,94,96-99} The effect size varied widely using different definitions of RN to patient ratio. An additional

patient per RN per shift was associated with increased relative risk of mortality by 6-7 percent in surgical patients.^{15,16} An increased patient/RN ratio in the evening was associated with a 90 percent increase in relative risk of death in ICUs.⁹ An increase from 1.06 to 2.66 RN FTE per patient day was associated with a relative reduction in hospital-related mortality by 9 percent.¹⁷ Failure to rescue was reduced by 4-6 percent in surgical patients²⁶ when the proportion of RNs increased by 13 percent.²⁷ Each additional patient per RN was associated with a 5 percent increase in failure to rescue.¹⁶ Few studies examined the effect on patient outcomes of nurse staffing strategies, such as overtime hours¹⁰⁰ and contract or agency nurses.^{28,30,64,101}

Increasing the nurse-to-patient ratios and hours has been recommended as a means to improve patient safety.⁷⁴ Mandatory nurse-to-patient ratios and staffing plans have been established in several states¹⁰² and proposed for all Medicare participating hospitals.¹⁰³ However, most legislative efforts related to mandatory staffing regulations cannot be supported by research that has yielded evidence-based optimal nurse-to-patient ratios or hours.¹⁰⁴ Moreover, the cost effectiveness of increasing the number of RN hours or RN patient ratios is controversial.¹⁰⁵⁻¹⁰⁷ A national estimation of the cost of increasing RN staffing and the concomitant benefits from avoided deaths, reduced length of stay, and patient adverse events (urinary tract infections, hospital acquired pneumonia, shock, upper gastrointestinal bleeding, and failure to rescue) concluded that increased RN hours per patient day without increased total nursing hours could yield a net reduction in cost of care.⁶ Comparing the results of different studies is complicated by the way both staffing and outcomes are measured.

The aim of this systematic review is to analyze associations between hospital nurse staffing and patient outcomes with consideration of variables that could influence the primary association. The idea for this systematic review was supported by the American Organization of Nurse Executives (AONE). AONE had representation on the Technical Expert Panel. A series of research questions was developed by AONE in conjunction with AHRQ staff as follows:

1. How is a specific nurse-to-patient ratio associated with patient outcomes?
 - a. Patient outcomes: mortality; adverse drug events, nurse quality outcomes, length of stay; patient satisfaction with nurse care
 - b. How does this association vary by:
 - i. patient characteristics such as acuity/severity of illness, stage of treatment process; functional capacity
 - ii. nurse characteristics such as nurse level of education, nursing years in practice, contract nurses, foreign-trained nurses
 - iii. organizational characteristics such as type of clinical unit, duration of shift, shift rotation
 - iv. nursing outcomes such as nurse satisfaction, nurse vacancy rate, nurse turnover rate, nurse retention rate
2. How is a measure of nurse work hours (hours per patient or patient day) associated with patient outcomes?
 - a. Patient outcomes: mortality; adverse drug events, nurse quality outcomes, length of stay; patient satisfaction with nurse care
 - b. How does this association vary by:
 - i. patient characteristics such as acuity/severity of illness, stage of treatment process; functional capacity
 - ii. nurse characteristics such as nurse level of education, nursing years in practice, contract nurses, foreign-trained nurses

- iii. organizational characteristics such as type of clinical unit, duration of shift; shift rotation
 - iv. nursing outcomes such as nurse satisfaction, nurse vacancy rate, nurse turnover rate, nurse retention rate
3. What factors influence nurse staffing policies (staffing ratios, hours per patient day, skill mix, shift rotations, shift durations, overtime (mandatory and voluntary), weekend staffing, temporary nurses, full-time/part-time mix, floating to nursing units, foreign graduate nurses)?
 4. What nurse staffing strategies (use of temporary nursing agencies, part-time nurses, proportion of RNs, experience mix of nursing staff, continuing nurse education, use of ancillary personnel) are effective for improving the patient outcomes listed in question 1?
 5. What gaps in the body of research of nurse staffing and patient outcomes can be identified to address in future studies?

Questions 1, 2, and 4 are addressed in the systematic review using meta-analytic approaches. The literature associated with question 3 does not lend itself to meta-analysis. Rather, the third question is approached by a review of the literature. The fifth question is addressed from the results of the overall review and analysis of the studies on nurse staffing and quality.

Questions about nurse ratios and hours are basically similar and examine the same conceptual association between nurse staffing and patient outcomes but employ two different measures of nurse staffing.¹⁰⁸ The nurse to patient ratio relies on a general ratio, which may include all nurses assigned to a unit, including nonclinical time, whereas nurse work hours look specifically at nurses involved in patient care. Ideally, worked hours should not include other time (e.g., vacation, sick leave, conferences) that is included in the ratio. It is important to distinguish wherever possible paid hours from those actually worked.

Even within this distinction, a number of important differences exist in the way staffing ratios are calculated. Various authors used different operational definitions for the nurse to patient ratio, including:

- Number of patients cared for by one nurse per shift.
- FTE per 1,000 patient days.
- Nurse per patient day or FTE per occupied bed.

These differences provide challenges to pool data across studies.

Hours per patient day (HPD) cannot readily be used to accurately determine nurse-to-patient ratios. HPD reflect average staffing across a 24-hour period and do not reflect fluctuations in census, scheduling patterns, or absenteeism. Not all productive nursing hours are spent at the bedside. Nurses may be engaged in activities such as education, administration, and quality assurance. Thus, HPD are likely to overestimate the actual amount of bedside care, and the magnitude of the discrepancy may vary from hospital to hospital.^{60,109}

Other challenges are associated with the type of nursing staff included in the nursing hours or nurse ratios. Some studies include only RNs and other studies include both RNs and LPNs/LVNs.

Outcomes research attempts to isolate the relationship between any type of treatment and outcomes by adjusting for the effects of other salient variables, such as the nature of the disease and patient characteristics. In the case of nurse staffing, the situation is somewhat different. Nurse staffing is only one component of treatment. The ideal study design would simultaneously adjust for the effects of other treatment elements, such as the specific medications and procedures given and the skills of the medical staff. Instead, most nursing studies emphasize the

effect of nursing resources, assuming that all other variables are constant and use average comorbidity scores across hospitals instead of more patient-specific measures. Indeed, individual level patient characteristics are not usually directly addressed, at least not in any detail. Some studies may be conducted on specific units that treat certain types of patients, but the disease mix and severity are generally not addressed specifically.⁸⁶ Whereas a typical medical outcomes study would include variables on patients' disease severity and comorbidities, these can best be addressed in the nurse staffing analyses conducted at patient levels, but most studies were conducted at the unit and hospital level where average values may result from various mixes of patient types.^{110,111}

Given this reality, the conceptual model for the relationship between nurse staffing and outcomes (questions 1 and 2) (shown in Figure 1) focuses on those aspects of care that are generally addressed in such studies.¹¹²⁻¹¹⁵ Two types of outcomes are proposed to be related to nurse staffing: nurse outcomes and patient outcomes. While patient outcomes are the ultimate concern, nurse outcomes can interact with nurse staffing to affect patient outcomes. Nurse characteristics can influence nurse staffing. The model includes patient factors and hospital organizational factors that may influence the effect of nurse staffing on patient outcomes. Patient outcomes will, in turn, affect LOS; greater complication rates will increase LOS. Table 1 provides definitions for the variables included in Figure 1.

The conceptual model for question 3 (Figure 2) focuses on nurse staffing policies and illustrates factors that might affect such policies, including patient care unit factors. The composition of the nursing staff, such as the extent of experience or extent of contract nursing staff, may also play a role in determining nurse staffing policies and vice versa. Hospital factors will influence nurse staffing policies; however, it is proposed that nursing organizational factors are an intervening factor. The definitions for the variables are provided in Table 1.

The conceptual model for question 4 (Figure 3) emphasizes the relationship between nurse staffing strategies and patient outcomes. Although these strategies may be influenced by nurse staffing models, this variable is not overtly considered in this analysis, and hence is shown in a dotted box. Hospital factors and patient factors can directly affect patient outcomes, as can medical care and nurse staffing levels (not shown in the model).

Figure 1. Conceptual framework of nurse staffing and patient outcomes

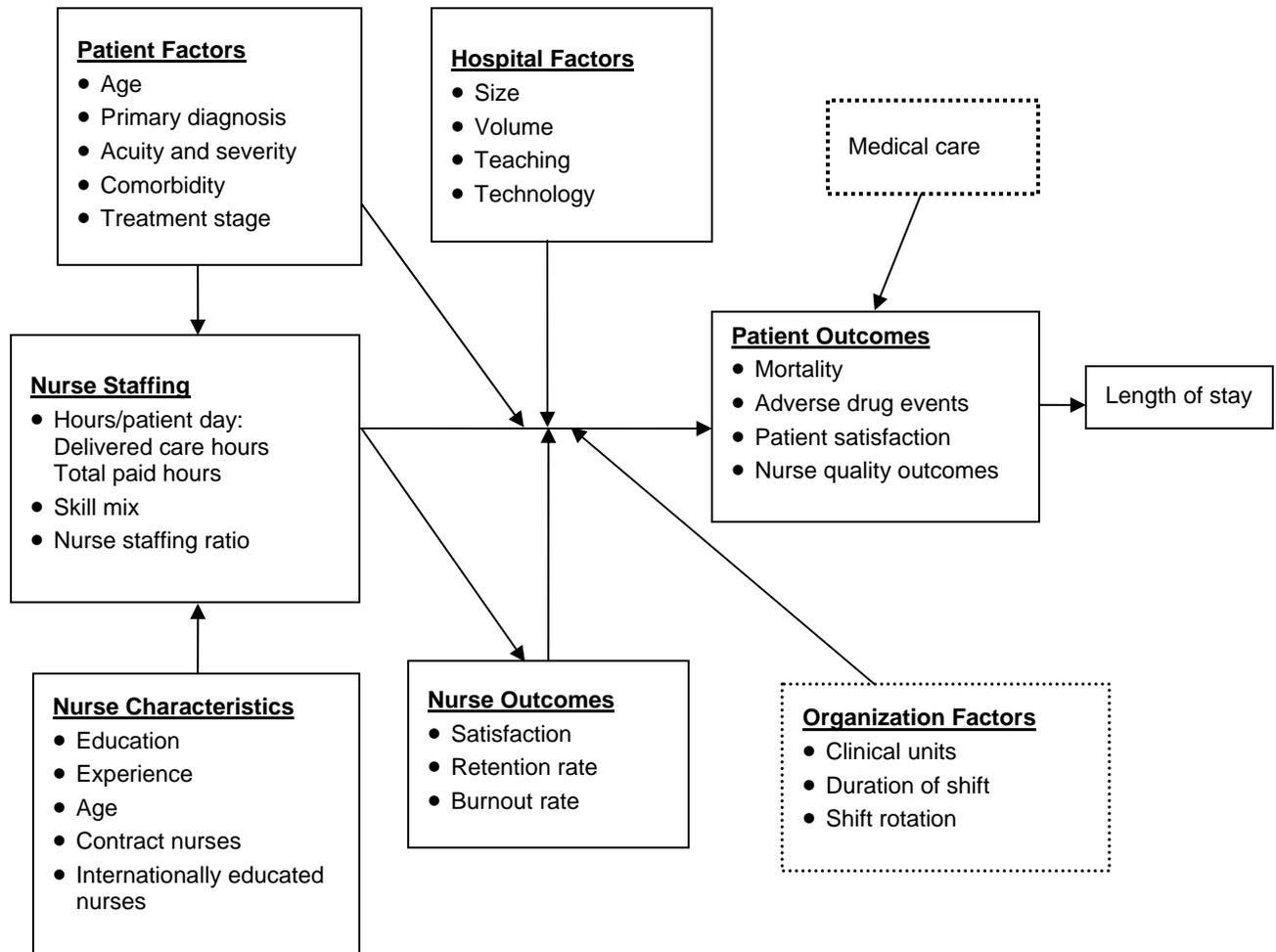


Table 1. Operational definitions

Questions 1 and 2: How is a specific nurse to patient ratio or a measure of nurse work hours associated with patient outcomes and how does this association vary by patient, nurse, and organizational characteristics?

Variable	Definition
Nurse Workforce ¹¹⁶	
Registered Nurse (RN)	An individual who holds a current license to practice within the scope of professional nursing in at least one jurisdiction of the United States.
Licensed Practical/Vocational Nurse (LPN/LVN)	An individual who holds a current license to practice as a practical or vocational nurse in at least one jurisdiction of the United States.
UAP Assistive Nursing Personnel	Unlicensed individuals who assist nursing staff in the provision of basic care to clients and who work under the supervision of licensed nursing personnel. Included in, but not limited to, this category are nurses aides, nursing assistants, orderlies, attendants, personal care aides, medication technicians, and home health aides.
Nursing personnel	This term refers to the full range of nursing personnel including RNs, LPNs/LVNs and UAPs.
Nurse Staffing Measures	
Patient to nurse ratios	Number of patients cared for by one nurse, specified by job category
RN to patient ratio	Number of patients cared for by one RN
LPN to patient ratio	Number of patients cared for by one LPN
UAP to patient ratio	Number of patients cared for by one UAP
Nurse hours per patient day	Total number of productive hours worked by all nursing staff with direct care responsibilities per patient day (a patient day is the number of days any one patient stays in the hospital)
RN hours per patient day	Number of productive hours worked by RN with direct care responsibilities per patient day (a patient day is the number of days any one patient stays in the hospital)
LPN/LVN hours per patient day	Number of productive hours worked by LPN/LVN with direct care responsibilities per patient day (a patient day is the number of days any one patient stays in the hospital)
UAP hours per patient day	Number of productive hours worked by UAP with direct care responsibilities per patient day (a patient day is the number of days any one patient stays in the hospital)
RN/LPN/UAP FTEs per patient day	Number of RN/LPN/UAP FTEs per patient day (FTEs can be composed of multiple part-time or one full-time individual) This ratio has been calculated in several different ways: number of patients cared for by one nurse per shift; FTE/1,000 patient-days; nurse/patient day or FTE/occupied bed. For analytic purposes we operationalized the nurse to patient ratio as the number of patients cared by one nurse per shift and FTE/patient day (see Appendix F for calculations)
FTE	A full-time employee, or a combination of part-time employees whose combined hours are the equivalent of a full-time position, as defined by the employer
Skill mix	Proportion of productive (i.e., direct patient care related) hours worked by each skill mix category (RN, LP/VN, UAP)
Licensed nurse	RN and LP/VN
Patient Outcomes	
Mortality	
Mortality	Death from all causes (intra hospital, 30 days after discharge)
Death in low mortality Diagnosis Related Groups (DRGs)	In-hospital deaths in DRGs with less than 0.5% mortality
Adverse Drug Event	
Adverse Drug Events	An injury related to drugs caused by medical management rather than by the underlying disease or condition of the patient
Length of Stay	
Length of stay	Average length of stay: the number of patient days divided by the number of discharges for a time period
Patient Satisfaction	
Patient satisfaction with nursing care	Measure of patient perception of the hospital experience related to satisfaction with nursing care

Table 1. Operational definitions (continued)

Variable	Definition
Patient satisfaction with pain management	Patient opinion of how well nursing staff managed their pain as determined by scaled responses to a uniform series of questions designed to elicit patient views regarding specific aspects of pain management
Patient satisfaction with educational information	Patient opinion of nursing staff efforts to educate them regarding their conditions and care requirements as determined by scaled responses to a uniform series of questions designed to elicit patient views regarding specific aspects of patient education activities
Patient satisfaction with overall care	Patient opinion of care received during the hospital stay as determined by scaled responses to a uniform series of questions designed to elicit patient views regarding global aspects of care
Nurse Quality Outcomes	
Patient falls, injuries	Unplanned descent to the floor during the course of a hospital stay
Maintenance of skin integrity/pressure ulcers	Stage I-IV ulcers
Nosocomial infection rate	An infection occurring in a patient in a hospital or other healthcare facility in whom it was not present or incubating at the time of admission
Failure to rescue	The number of deaths in patients who developed an adverse occurrence; the number of patients who developed an adverse occurrence ¹¹⁷
Urinary tract infection rate	Disorder involving repeated or prolonged bacterial infection of the bladder or lower urinary tract (urethra)
Surgical bleeding	Post-surgical hematoma or hemorrhage
Upper gastrointestinal bleeding	Gastrointestinal hemorrhage
Post surgical thrombosis	Deep vein thrombosis or pulmonary embolism among surgical patients
Atelectasis and pulmonary failure	Iatrogenic atelectasis and acute respiratory failure in hospitalized patients
Accidental extubation	Iatrogenic accidental extubation
Hospital-acquired pneumonia	An infection of the lungs contracted during a hospital stay
Postoperative infection	Any infection of post-surgical wounds
Cardiac arrest/shock	Cessation of cardiac mechanical activity as confirmed by the absence of signs of circulation
*Restraint prevalence (vest and limb only)	Restricting free movement of another person
Urinary catheter associated infections	Iatrogenic infection of urinary tract associated with a catheterization
Nurse Outcomes	
Staff vacancy rate	Open positions divided by total positions
Nurse satisfaction	Opinion of nurses about their job in terms of pay, reward, administration style, professional status, and interaction with colleagues
Staff turnover rate	Departures from the staff (or hires) divided by total positions
Retention rate	Proportion of nurses employed at the beginning of the year who are still employed there at the end in each participating unit
Burnout rate	Proportion of nurses who reported an excessive stress reaction to professional environment manifested by feelings of emotional and physical exhaustion coupled with a sense of frustration and failure
Patient Characteristics	
Age	Mean age in years
Primary diagnosis	Diagnosis which was a cause for hospitalization (ICD-9 codes)
Comorbidity	Coexistence of two or more disease-processes measured with weighted scales. This data can be collected on the individual patient level or an average figure can be calculated for an entire hospital.
Severity	Severity of illness classified as none or minor, moderate, or major, based on expected impact on length of stay. For surgical patients, a fourth class is added for patients having catastrophic comorbidities or complications; including chronically, critically, or terminally ill.
Stage of treatment	This applies largely to surgical patients and would be pre-op/post-op; could apply to persons undergoing some other defined intervention; could also be used to distinguish rehabilitative phase from acute treatment.
Functional capacity	Individual's maximum capacity to perform daily activities in the physical, psychological, social, and spiritual domains of life

Table 1. Operational definitions (continued)

Variable	Definition
Nurse Characteristics	
Demographics	Age and gender
Level of education	Proportion of nurses with nursing degree: Associate degree; Diploma; BSN; Master of Science (MS); Doctor of Philosophy (PhD)
Nursing experience	Experience in nursing practice in years
UAP	Unlicensed assistive personnel (not RNs or LPNs)
International Educated Nurse (IEN)	Nurses who graduated from schools of nursing in foreign countries
Contract/temporary/agency nurses	Any licensed nurse who is providing service at the facility as an employee of another entity
Organizational Characteristics	
Type of clinical units	Types of patients and services provided on a nursing unit (e.g., telemetry, medical, surgical, critical care)
Duration of shift	Length of working shift (8, 10, or 12 hour shift)
Nursing unions	Organizations that represent nurses for the purposes of collective bargaining
Hospital Factors	
Teaching status	Affiliation with a medical school
Size	Number of beds
Volume	Annual number of procedures performed in a hospital
Technology index	Weighted sum of the number of technologies for direct patient care and services available in a hospital. Availability and saturation in use of computerized physician orders entry systems, computerized nursing, and patient medical records

* Nurse process measures

Question 3: What factors influence nurse staffing policies?

Variable	Definition
Nurse Staffing Policies	
Staffing ratios	Policies regarding the number of patients cared for by one nurse specified by job category (RN, LPN/LVN, UAP)
Staffing hours per patient day	Policies regarding the total number of productive hours worked by nursing staff with direct care responsibilities on acute care units per patient day (total nursing hours, RN hours, LPN/LVN hours, UAP hours)
Staff mix	Policies regarding the proportion of productive hours worked by each skill mix category (RN, LPN/LVN, UAP)
Shift rotations	Policies regarding scheduling nursing staff to work different work shifts (days, evenings, nights) during a defined period of time (e.g., pay period; schedule period)
Shift durations	Policies regarding the length of shifts (e.g., 8 hours; 10 hours; 12 hours)
Overtime (mandatory and voluntary)	Policies requiring or permitting additional worked hours over 40 hours/week or more than 8 hours in a day or more than 80 hours in a pay period
Weekend staffing	Policies regarding the frequency of weekends worked
Temporary nurses	Policies regarding the use of temporary/agency nurses
Full-time/part-time mix	Policies regarding the number and type of nursing staff that are full time and part time
Floating to nursing units	Policies regarding when nurses can be assigned to work on nursing units other than their regularly assigned nursing unit
International Educated Nurses (IEN)	Policies regarding the hiring and use of nurses that have graduated from schools of nursing in foreign countries
Patient Care Unit Factors	
Patient classification system	Systems that classify patients according to the intensity of nursing care required
Patient flow/census fluctuations	Frequency of admissions, discharges, transfers of patients in a nursing unit or a hospital

Table 1. Operational definitions (continued)

Type of nursing unit	Types of patients and services provided in a nursing unit (e.g., telemetry, medical, surgical, pediatric, critical care)
Nursing Organization Factors	
Governance	Organizational models through which nurses control their practice as well as influence administrative areas
Management/leadership style	Degree to which nurses in management and leadership positions make themselves visible and accessible to nursing staff, seek, value, and incorporate feedback from nursing staff, and communicate with nursing staff
Hospital Factors	
Type	Teaching, non teaching, rural, urban
Ownership	Proprietary, government/public, and not-for-profit
Technology use	Electronic medical record
Risk management	Degree to which the organization addresses the prevention of adverse events
Unionization	Percent or proportion of nurses who are members of a collective bargaining unit
Nurse Factors	
Experience in nursing	Years working as a licensed nurse or UAP
Age	Age in years
Education	Proportion of nurses by highest level of education in nursing: practical nursing, associate degree, diploma, baccalaureate, masters, doctorate

Question 4: What nurse staffing strategies are effective for improving outcomes?

Variable	Definition
Nurse Staffing Models	
Patient focused care	RNs serve as care managers managing unlicensed assistive personnel in expanded roles (drawing blood, performing EKGs, and performing certain assessment activities)
Primary nursing	RN accountable for care of patient from admission to discharge; coordinates all care; provides direct care for patient
Total patient care	RN assumes total responsibility for care of the patient during the time the nurse is on duty
Team nursing	RN is a team leader and LPNs and UAPs provide patient care as directed by the RN team leader
Functional nursing	Nursing staff are assigned specific tasks (e.g., treatments, medications, patient hygiene care) according to their skill and education
Staffing Strategies	
Use of temporary nursing agencies	Use of nursing personnel that are employed by an organization that supplies nursing staff
Use of part-time nurses	Proportion of nurses (RN and LPN) working part time (less than 8 hours per shift or less than 40 hours per week)
Proportion of RNs	Proportion of RNs among total hospital and total nursing personnel
Experience mix of nursing staff	Proportion of nursing staff (by type) according to their years of experience
Continuing nurse education	Professional development process after the completion of the pre-registration nurse education program. It consists of planned learning experiences which are designed to augment the knowledge, skills, and attitudes of registered nurses to improve quality of care and patient outcomes.
Use of ancillary personnel	Aides, clerical staff, phlebotomists

Patient outcome measures used for questions 1 and 2 will be used for question 4 as well.

Figure 2. Factors affecting nurse staffing policies

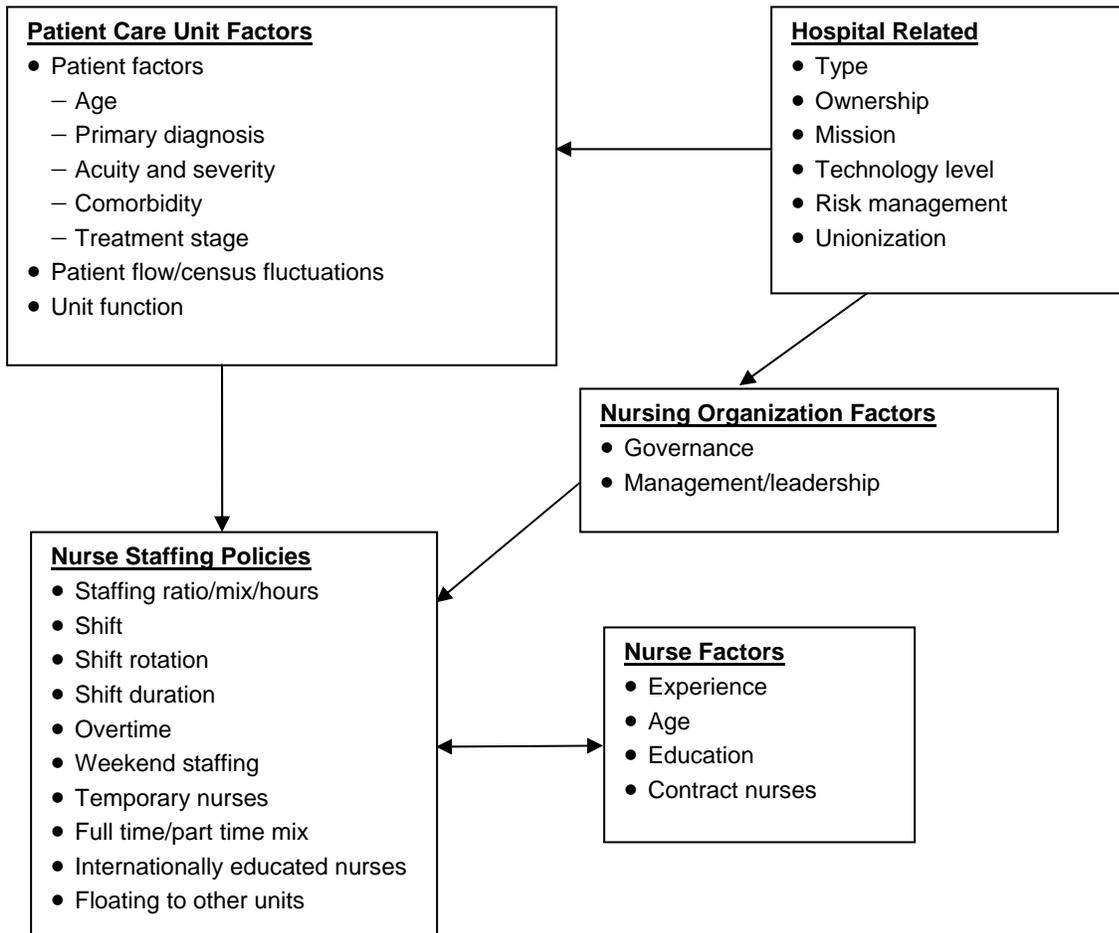
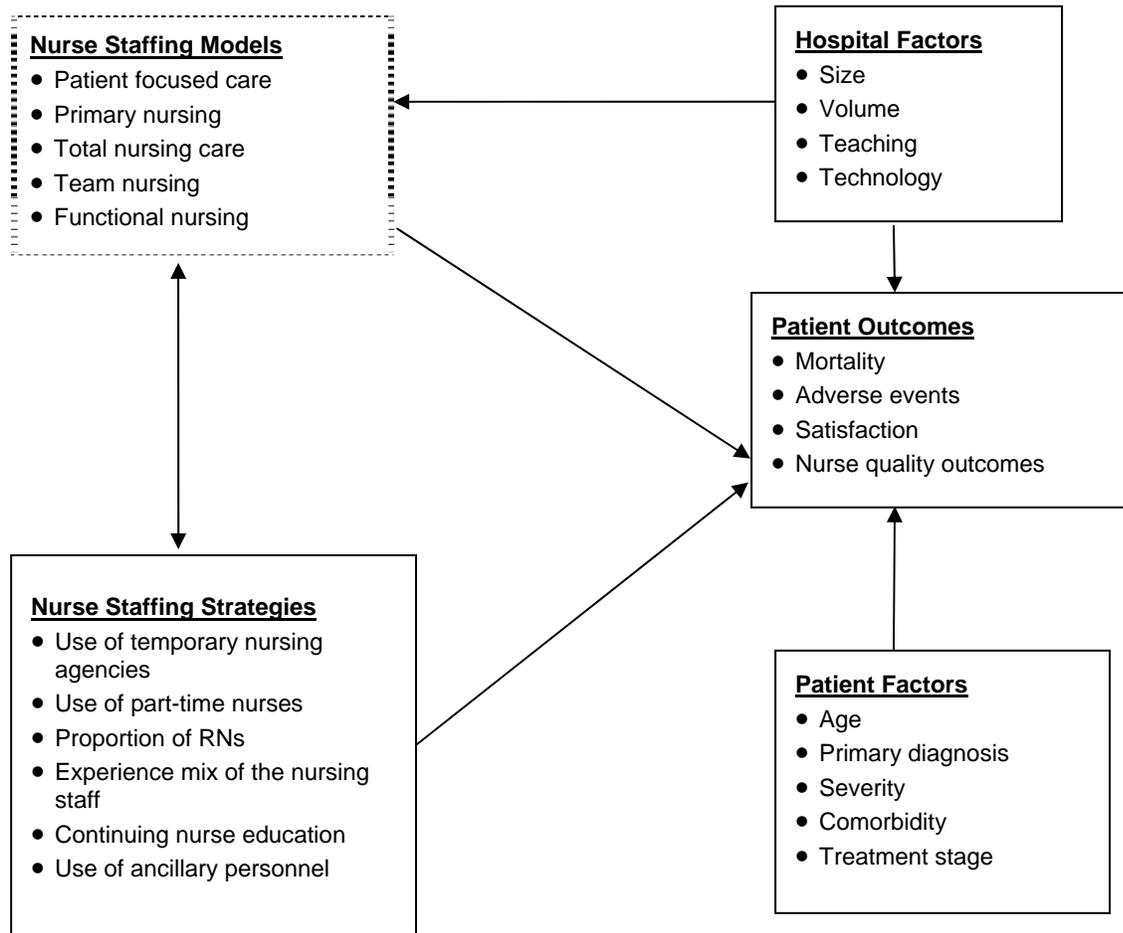


Figure 3. Nurse staffing strategies and patient outcomes



Chapter 2. Methods

Literature Search Strategy and Eligibility Criteria

Search Strategy

Studies were sought from a wide variety of sources, including MEDLINE[®], PubMed[®], CINAHL, Cochrane databases, EBSCO research database, BioMed Central, federal reports, National Database of Nursing Quality Indicators, National Center for Health Workforce Analysis, American Nurses Association, American Academy of Nurse Practitioners, and Digital Dissertations. The search strategies for the four research questions are described in Appendix A*. The same eligibility criteria, selection of studies, and analysis of studies were used to examine the association between nurse staffing and strategies and patient outcomes. The approach was different to identify studies that examined factors that influence nurse staffing policies. As noted earlier, the question about policies was not appropriate for meta-analysis. Excluded references are shown in Appendix B. All work was conducted under the guidance of a Technical Expert Panel (TEP). Members are identified in Appendix C. The data abstraction forms are shown in Appendix D.

Eligibility

Two investigators independently decided on the eligibility of the studies.¹¹⁸ We reviewed abstracts to exclude studies with ineligible target populations conducted in countries other than the United States and Canada and in long-term nursing facilities. Then we confirmed the eligibility status of the study designs, excluding secondary data analysis, reviews, letters, comments, legal cases, and editorials. The full texts of the original epidemiologic studies were examined to define eligible independent variables (nurse staffing and strategies) and eligible outcomes. Then we excluded studies that did not test the associative hypotheses and did not provide adequate information on tested hypotheses (e.g., least square means, relative risk).

Inclusion criteria were applied to select articles for full review. Studies needed to meet one of the following criteria for questions 1, 2, and 4:

- Retrospective observational cohort studies and retrospective cross sectional comparisons
- Administrative cross-sectional survey and analyses;
- Randomized controlled trials with random allocation of subjects to intervention and control groups
- Controlled not randomized clinical trials²
- The studies must evaluate the associations between nurse staffing and patient outcomes/nurse quality measures among eligible target populations (patients hospitalized in acute care hospitals in the United States and Canada) and published after 1990 except conducted in 1982-1989 but frequently cited in recent publications
- Ecologic studies on correlations between nurse staffing and patients outcomes
- Cost-effectiveness analysis of nurse staffing

¹ The literature in this area contained no randomized controlled trials or even non-randomized trials.

* Appendixes and Evidence Tables for this report are provided electronically at <http://www.ahrq.gov/clinic/tp/nursesttp.htm>

Studies were selected for question 3 if the study provided implications for nurse staffing policies. No studies had as a primary purpose to empirically examine a specific nurse staffing policy.

The exclusion criteria included the following:

- Studies published before 1990
- Studies conducted in countries other than United States and Canada and not published in the English language
- Studies with target population as outpatients and patients in long-term care facilities
- Studies with no information relevant to nurse staffing policies and strategies
- Studies that examined the contributions of advance practice nurses (nurse practitioners, nurse clinicians, certified nurse midwives, nurse anesthetists)
- Studies that evaluated the association between nurse staffing and ineligible outcomes (questions 1, 2, and 4)
- Administrative reports and single hospital studies with no control comparisons that do not test an associative hypothesis (questions 1, 2, and 4)

The assessment of the studies' quality was based on "Systems to Rate the Strength of Scientific Evidence."¹¹⁹ For questions 1, 2, and 4 we grouped all criteria into ten dimensions with scores for each aspect assigned a value from 0 to 5 (highest) for a total possible score of 50 for the statistical analysis of the studies' quality (Appendix E).

Given the absence of RCTs, the level of evidence for all studies was estimated using a subset of the U.S. Preventive Services Task Force¹²⁰ criteria noted below:

II-2A: Well-designed cohort (prospective) study with concurrent controls

II-2B: Well-designed cohort (prospective) study with historical controls

II-2C: Well-designed cohort (retrospective) study with concurrent controls

II-3: Well-designed case controlled (retrospective) study

III: Large differences from comparisons between times and/or places with or without interventions (cross-sectional comparisons).

For question 3, an evidence table was developed for each of the nurse staffing variables identifying the purpose of the study, sample, design, independent and dependent variables, and findings.

For questions 1, 2, and 4, descriptive statistics, correlation and regression coefficients, and F and T tests for treatment differences were used to assess reported outliers, variances, and skewness in the data.^{121,122} Baseline data were compared in different studies to test the differences in the target population and unusual patterns in the data.^{123,124} Standard errors, regression coefficients, and 95 percent CI were calculated from reported means, standard deviations, and sample size.^{121,122} The protocol for the meta-analyses was created according to the recommendations for Meta-analysis Of Observational Studies in Epidemiology (MOOSE).¹²⁵

We used [the Trim and Fill method](#)¹²⁶ to detect publication bias defined as the tendency to publish positive results and to predict the association when all conducted (published and unpublished) studies are analyzed. Time trends in positive results were assessed with interaction models with time of the events as continuous variables.

The evaluations of the studies and the data extraction were performed manually and independently by two researchers. The principal investigators of some studies were contacted to assess the additional and missing information when necessary. Errors in the data extractions were assessed by a comparison with the established ranges for each variable and by a comparison of the data charts with the original articles. Any discrepancies were detected and discussed.

Patient populations were classified as surgical, medical, and combined samples.^{26,27} Adjustments for patient age, race, gender, comorbidities, socioeconomic status, provider characteristics, and clustering of patients and providers were extracted from the studies.¹²⁷

Data Synthesis

For questions 1, 2, and 4, the results of individual studies were summarized in an evidence table with relation to the sample size and 95 percent CI in outcomes. Weighted by the number of patients and hospitals, odds ratios and 95 percent CIs were calculated with fixed and random effects models.¹²⁸

We report the nurse to patient ratios as they were used by individual authors; but we have also created two standardized rates for purposes of comparison:

1. The number of patients cared by one nurse per shift³
2. RN FTE per patient day

FTE per occupied bed ratios were calculated based on FTE per mean annual number of occupied bed days (patient days). Therefore, we conducted separated analyses and report the results:

- With definitions the authors used
- Corresponding to an increase by one RN FTE per patient day
- In categories of patients per RN per shift in ICUs, and with surgical and medical patients.²⁷

Different methods have been used to estimate nurse hours per patient day from FTEs. Some investigators assume a 40 hour week and 52 working weeks per year (2,080 hours per year). Others use more conservative estimates (e.g., 37.5 hours per week for 48 weeks = 1,800 hours per year).¹²⁹ In our conversions, we used the latter estimate (Appendix F).

We estimated that:

- Nurse hours per patient day = (FTE * 40)/patient days¹³⁰
- One nurse per patient day = 8 working hours per patient day¹²⁹
- Then the patient per nurse ratio = 24 hours/nurse hours per patient day¹³⁰

We made the following assumptions:

- 37.5 hour work week on average
- 48 working weeks per year (4 weeks vacation, holidays, sick time);
- All FTEs are full-time nurses with the same shift distribution (assume three 8-hour shifts)
- The length of shift does not modify the association between nurse staffing and patient outcomes
- Patient density is the same over the year

The same estimation was used for each nurse job category—RN, LPN/LVN, and UAP.

Meta-analysis was used to assess the consistency of the association between nurse staffing and patient outcomes and improvement in economic outcomes including LOS. The analyses were conducted separately for classes of patient and hospital characteristics. Assumptions underlying meta-analysis included valid measurements of nurse staffing and patient outcomes, similarity in target populations, and similarity in reported and not reported variance.

Sub-analyses were conducted to test whether the direction and strength of the association was independent of study design and financial support.¹²⁷ Consistency in the results was tested comparing the direction and strength of the association in models with nurse staffing variables as continuous (overall trend) and categorical, in studies reporting outcome rates and adjusted

³ We assume an 8-hour shift.

relative risk, and with goodness of fit tests. Chi squared tests were used to assess heterogeneity in study results.^{131,132} Significant heterogeneity means the effects of nurse staffing on patient outcomes were not consistent in the studies (not replicable results). The hypotheses of the associations between outcomes and nurse staffing variables were tested with random effects models (random intercept for each study) to incorporate between variability in the studies and to provide valid pooled estimates weighted by sample size. Individual studies were analyzed with simple linear regression to find slopes for each study when possible. Meta-analysis was used to estimate pooled regression coefficients: changes in outcomes corresponding to incremental changes by one unit in nurse staffing. The analytic framework and algorithms for the meta-analysis are shown in Appendix F.

Meta-regression models analyzed possible interactions with the year of publication, analytic units, hospital units, adjustment for confounding factors, and patient population.^{132,133} The calculations were performed using the following software: STATA,^{134,135} and SAS 9.2 Proc Mixed.¹³⁶ To ascertain whether the relationships were linear, two different forms of staffing variables were tested: continuous and categorical, where the latter was arranged in quartiles. When authors reported outcome rates and relative risks grouped by different exposure cut points and reference, we assigned exposure levels as the mean or median of nurse staffing variables, assuming a normal distribution. We also transformed nurse staffing levels into a risk estimate per unit of exposure and assigned an exposure value to each categorical group, assuming a specific parametric distribution for the exposure in the population.¹³⁷ This method can test a linear dose-response relation and assess the nonlinearity of the dose-response relation.

The research question examining factors that influence nurse staffing policies (question 3) involved the identification of studies that included one or more of the nurse staffing variables. The studies were summarized in evidence tables followed by a synthesis of the studies for each staffing policy.

Chapter 3. Results

Figure 4 traces the flow of our literature search for questions 1, 2, and 4. Of the 2,858 potentially relevant references from eight databases identified, we excluded 97 percent of the studies; 2 percent were case reports; 20 percent – comments and success stories; 2 percent – legal cases; 2 percent – editorials and expert opinions; 5 percent – letters, guidelines, interview, and news that reprinted the results of the original reports; and 4 percent – reviews and secondary data analyses, and one web survey. We excluded 21 percent of the studies that lacked relevant components; 6 percent without eligible outcomes, 30 percent without eligible target populations, and 21 percent that did not test associative hypotheses between nurse staffing and patient outcomes. Among 101 potentially relevant randomized controlled clinical trials, none was eligible; 56 tested ineligible interventions; five reported ineligible outcomes; 38 were conducted in European countries or included nurses in long-term nursing facilities.

We identified 94 eligible studies presented in 96 reports; 7 percent were case control studies; 3 percent were case series; 44 percent were cross sectional studies; 46 percent assessed temporality in the association between nurse staffing and patient outcomes.

The overall quality of the studies averaged 38 (where the maximum possible score was 50) (Table 2). Three studies received <50 percent of the maximum quality score; 24 studies had <66 percent, and 21 studies had >88 percent of the maximum quality score. Within this score, the mean external validity was 3.5 ± 1 (70 percent of the maximum score) with 67 percent for the sampling of the study populations; random sampling was reported in 16 studies (17 percent), and sampling bias was assessed in 15 studies (16 percent). More than 9 percent of the sampled analytic units were excluded from 27 studies. Single hospital studies constituted 25 percent of all eligible studies (23 reports). Geographical locations of eligible hospitals were reported in 49 studies (52 percent). The investigators generally obtained national and state administrative databases to identify eligible populations.

The mean score for adjustment for assessed confounding factors as a characteristic of internal validity was 2.9 ± 1.6 (only 58 percent of the possible maximum score); 17 studies did not provide information on adjustment for confounding factors. Few studies reported the validation to measure nurse staffing variables (11 studies, 12 percent) and patient outcomes (22 studies, 23 percent). Medical records were obtained to measure patient outcomes in 27 studies (29 percent); 58 studies (62 percent) used administrative databases. Thirty-two studies used hospitals as analytic units (34 percent); 43 studies (46 percent) used patients; and 13 studies (17 percent) used hospital units. Medicare populations were used in 11 studies (12 percent).

The majority of the studies were conducted in the United States (84 studies) with no significant differences in quality (80 percent in Canadian studies vs. 76 percent in American, $p = 0.44$). The studies supported by national grants had higher quality (80 percent of maximum) compared with unknown sponsorship (73 percent, $p = 0.02$). The quality scores of the studies did not change over the decades ($p = 0.15$). The test for publication bias was not valid due to a small number of studies for each association and heterogeneity in the results.

Association Between Nursing Hours and Ratios and Patient Outcomes

Distribution of Nurse Staffing Hours and Ratios

Many investigators obtained administrative databases on national, state, and hospital levels. Some relied on surveys of nurse managers to measure nurse staffing variables (Appendix G*, Table G1). The means and distribution of nursing hours and ratios are presented in Table 3. Total nursing hours per patient day were measured in 36 studies (38 percent), RN hours in 27 studies (29 percent), LPN/LVN hours in 12 studies (13 percent), licensed nurse hours in three studies, and UAP hours in three studies. Ratios of patients per RN and RN FTE per patient day were examined in 36 studies (38 percent), LPN/LVN ratios in eight studies (9 percent), licensed nurse ratios in three studies, and UAP ratios in nine studies (10 percent). The distribution of nurse staffing variables in eligible published studies was comparable with that published in literature with higher LPN/LVN hours per patient days in medical patients.^{27,138}

Question 1. Association Between Nurse to Patient Ratios and Hospital-Related Mortality

We identified 26 studies that examined the association between hospital related mortality and nursing hours or ratios (Appendix G, Table G2).^{8-21,23,26-28,30,32-34,139-141} The authors defined hospital related mortality as in-hospital mortality^{8,9,13,14,18-20,26,27,30,33,34} or death within 30 days after hospital admission.^{10,11,15-17,21,32,140} For analysis purposes we combined in-hospital mortality and 30-day mortality. Estimating hospital-related mortality based only on in-hospital deaths may be influenced by hospital discharge practices¹⁴² and could result in lower in-hospital mortality rates that are independent of the quality or effectiveness of hospital care.

One study¹⁴³ compared the relationship of in-hospital and 30-day mortality rates in 13,834 patients with congestive heart failure who were admitted to 30 hospitals and found a significant correlation in standardized mortality ratios sensitive to individual hospital characteristics. The association with nurse ratios or hours was presented as changes in crude death rates and adjusted relative risk of death corresponding to one unit increase in nurse staffing or in nurse staffing categories defined by authors.

Nurses Ratios and Mortality

The pooled results, overall and within ICUs and surgical units, weighted by the sample size (number of hospitals and patients) showed a reduction in the crude death rate in association with increase RN staffing. An additional RN FTE per patient day was associated with a 1.24 percent reduction in death rate.^{12,17,34} The same tendency was shown corresponding to one additional RN per 1,000 patient days.³³ In contrast, one additional patient per RN per shift was associated with an increase in hospital-related mortality by 0.1 percent^{13,16,23} (Table 4).

* Appendixes and Evidence Tables for this report are provided electronically at <http://www.ahrq.gov/clinic/tp/nursesttp.htm>.

A pooled analysis showed that an increase by one RN FTE per patient day was associated with a 1.2 percent reduction in mortality rates in all studies.^{12,13,16,17,20,23,34} The association was consistent in ICUs.^{13,16,23}

A nonlinear quadratic association between patients per RN per shift and the death rate was noted. The rates increased from 1 to 5 patients per RN per shift (p for heterogeneity <0.001). The nadir for the relative risk of death was 1.5 RN FTE per patient day (p for heterogeneity 0.002). Table 5 shows both the effects of increasing staff with the authors' definitions of nurse to patient ratios by one RN FTE per patient day and the relative effects in quartiles of patients per RN per shift distribution in different clinical settings. More RN staffing was consistently associated with a reduction in adjusted relative risk of hospital-related mortality. An increase by one RN FTE per patient day was associated with a smaller but consistent across the studies' reduction in mortality by 6 percent (RR 0.94, 95 percent CI 0.93-0.95).^{8,10-12,17,20}

The relative risk of hospital related death was associated with a decrease by 8 percent corresponding to an additional one RN FTE per patient day in pooled analysis.⁸⁻²¹ For studies analyzed at the hospital level, the associated decrease in relative risk was 4 percent (95 percent CI 0.94-0.98).^{11,12,18-20} For those analyzed at the patient level, it was 8 percent (95 percent CI 0.89-0.95).^{9,10,13-17,21} Among medical patients it was 6 percent (95 percent CI 0.94-0.95)^{8,10,11,17-19} and among surgical patients, 16 percent (95 percent CI 0.8-0.89)^{9,12-16,20,21} (Figure 5). In contrast, an additional patient per RN per shift was associated with an 8 percent increase in mortality risk (RR 1.08; 95 percent CI 1.07-1.09).^{9,13-16,21}

We calculated the relative risk of death in quartiles of patients per RN per shift and found a consistently significant reduction in the relative risk of hospital-related mortality corresponding to a reduced number of patients assigned to an RN (Table 5 and Figure 6). The effect was larger in surgical patients. The pooled relative risk was 0.76 times less when one RN was assigned to less than two patients compared with four to six patients, and 0.62 times less compared with more than six patients per RN. The reduction was 6 percent in ICUs when one RN was assigned to less than three patients vs. three to four patients.

If the relationship between staffing and outcomes was causal, we estimate that an increase by one RN FTE per patient day would save five lives per 1,000 hospitalized patients, five lives per 1,000 medical patients, and six per 1,000 surgical patients (Table 6). Reducing the workload from more than six to two to four patients per RN per shift would save 23 lives per 1,000 hospitalized patients. A reduction from three to four to less than three patients per RN per shift in ICUs would save three lives per 1,000 hospitalized patients. The decrease from more than six to 2-3.5 surgical patients per RN per shift would save 13 lives, and a further reduction to less than two patients per RN would result in 15 avoided deaths per 1,000 hospitalized surgical patients.

Extrapolating these relationships even further to examine the public health impact of RNs per patient ratio, we found that an increase of one RN FTE per patient day would reduce hospital mortality by 8 percent. The effect varies from 4 percent at a hospital level analysis to 8 percent at a patient level analysis. The reduction in a workload from 3 to 4 to less than three patients per RN would eliminate 6 percent of deaths in ICUs. The proportion of deaths attributable to patients per RN per shift ratio is larger in surgical patients; 38 percent of deaths were linked to poorer nurse staffing in hospitals with more than six patients per RN compared to less than two patients in surgical units.

To compare the results from individual studies, we calculated changes in death rates and relative risk of death corresponding to an increase by one unit in nurse staffing (Appendix G

Table G2 and Table 7). The majority of the studies (57 percent) reported a significant reduction in risk of death corresponding to an increase in RN staffing, but the effect size differed in studies that used medical records in contrast to administrative databases to measure mortality among hospital units and patient populations (Appendix G Tables G3 and G4). We calculated from the individual studies^{10,15,16} that about 6-7 percent of deaths were attributable to an increase in patients per RN per shift (Table 8). The observed death rate could be reduced by 9-10 percent when increasing by one RN FTE per 1,000 patient days.^{18,19} A decrease in the nurse to patient ratio in the evening was associated with a 90 percent increase in mortality; 47 percent of deaths in patients after abdominal aortic surgery was attributable to nurse staffing in these hospitals.⁹ Ten percent of avoided deaths in patients with acute myocardial infarction was attributable to an increase from 1.06 to 2.7 RN FTE per patient day.¹⁷ In patients hospitalized with bladder carcinoma, 51 percent of deaths was associated with a reduction from 3.1 to 1.4 RNs per occupied bed ratio.²⁰

Three studies that examined the effect of the LPN/LVN per patient day ratio^{17,34,94} reported inconsistent changes in the death rate. A nonlinear association between patients per LPN/LVN per shift ratio and relative risk of hospital-related mortality was observed in medical patients with the lowest risk corresponding to 9-12 patients per LPN/LVN (p for quadratic association 0.0003). The death rate was lowest when one UAP was assigned to 7-12 medical patients (p for quadratic association 0.0029). One study reported a significant increase in the death rate of 1.9 percent (95 percent CI 1.5-2.5 percent) for every additional patient per UAP (p = <.0001).⁹⁴

We found some evidence that nurse education and experience are associated with hospital-related mortality. Using state level administrative reports on nurse distribution in the United States^{1,144} and the CDC data¹⁴⁸ on fatal injuries related to health care, we found a significant negative correlation between the percentage of nurses with BSN degrees and the incidence of deaths related to health care (r = -0.46, p = 0.02) (Table 9). One study in surgical patients¹⁶ reported a 5 percent reduction in mortality with each 10 percent increase in nurses with BSN degrees (Table 10). Hospitals with a higher proportion of nurses with BSN degrees (36 percent vs. 11 percent) had 19-34 percent less mortality.¹⁰¹ Nursing experience did not impact hospital-related mortality.^{16,140} Nurse job satisfaction was associated with a significant reduction in the risk of death,¹⁰¹ an increase by 17 percent in nurses reporting they were satisfied or very satisfied with their job was associated with a 15 percent decrease in mortality. Hospitals where nurses had the freedom to make important patient care and work decisions experienced 21 percent lower mortality.¹⁰¹ Nurse manager support was negatively correlated with mortality (r = 0.3) in one single hospital study in 21 hospital units.¹⁴⁵

Association Between Nurse to Patient Ratios and Nurse Sensitive Patient Outcomes

Authors used different definitions of nurse sensitive patient outcomes, including a combination of medical^{13,14,23} and surgical^{13,23} complications related to health care, failure to rescue,^{15,16,20,21,35} and secondary diagnoses of patient nosocomial infections, falls, pressure ulcers, pulmonary and cardiac failure, and thrombo-embolic complications related to health care (Appendix G, Table G5). The associations were presented as differences in the rates or relative risk of outcomes by various categories of nurse staffing.

Patient outcomes corresponding to an increase in registered nurse per patient ratio.

Pooled analysis of crude rates (Table 11) showed inconsistent results on patient outcomes. An increase by one patient per RN per shift was associated with a significant increase in failure to rescue by 0.35 percent,¹⁶ and pulmonary failure by 6.54 percent.^{13,14,23} An increase by one RN FTE per patient day was associated with 0.03 percent decrease in atelectasis and pulmonary failure.^{13,14,23,33,35} The effect was larger in surgical patients in ICUs with a 12 percent reduction in pulmonary failure.^{13,14,23} However, a 0.71 percent reduction in urinary tract infection was associated with one additional patient per RN per shift^{22,146} and a 5 percent increase corresponded to one RN FTE per patient day.^{22,23,146} Studies that defined RN FTE per patient day ratio did not show significant changes in outcomes. One unpublished dissertation³³ reported an increase in falls, nosocomial infections, and pressure ulcers corresponding to an increase of one RN FTE per 1,000 patient days (Appendix G, Table G6).

In contrast with the analyses of outcomes rates, pooled analysis of adjusted relative risks (Table 12) detected a significant, generally consistent reduction in patient outcomes corresponding to an increase in RN staffing. An additional patient per RN per shift was associated with a 1.07 times higher risk of hospital acquired pneumonia (95 percent CI 1.03-1.11),^{13,14,22} a 1.08 times higher risk of failure to rescue (95 percent CI 1.07-1.09),^{15,16,21} and a 1.16 times higher risk of cardiac arrest (95 percent CI 1.05-1.29).^{13,23,24} The risk of pulmonary failure was greater by 53 percent and the risk of unplanned extubation by 45 percent corresponding to an additional patient per RN per shift.^{13,14,23-25} We estimated that an increase by one RN FTE per patient day in ICUs was associated with a consistent reduction in the relative risk of hospital acquired pneumonia by 30 percent,^{13,14,22} pulmonary failure by 60 percent,^{13,14,23,24} unplanned extubation by 51 percent,^{13,14,23-25} and cardiac arrest by 28 percent.^{13,14,24} An increase by one RN FTE per patient day in surgical patients was associated with 0.84 times less risk of failure to rescue^{12,15,16,20,21} and 0.64 times less risk of nosocomial bloodstream infections.^{13,22-24,147}

In individual studies, the largest decrease in the relative risk of central line associated bloodstream infection was seen in surgical patients in ICUs corresponding to increased nurse to patient ratio.¹⁴⁷ Surgical patients also experienced greater increase in the risk of failure to rescue (p for interaction 0.04) in a multi-hospital study¹⁵ by 7 percent corresponding to every additional patient per RN (RR 1.07, 95 percent CI 1.02-1.11).

We found nonlinear quadratic associations between the RN FTE per patient day ratio and unplanned extubation in ICUs with the nadir at 1.9 RN FTE per patient day (p for quadratic association 0.04). In surgical patients, the ranges of RN FTE per patient day at 0.9-2.2 were associated with the lowest relative risk of hospital acquired pneumonia (p for quadratic association 0.02) and the ranges of 1.5-2 RN FTE per patient day were associated with the lowest risk of failure to rescue (p for quadratic association 0.005).

Patient outcomes corresponding to an increase by one patient per LPN/LVN per shift (Appendix G, Table G7). The data on LPNs/LVNs is varied and inconclusive. One large study in 1,477 hospitals⁹⁴ examined the association between LPN/LVN per patient ratios and patient outcomes (Figure 7) and reported that one additional patient per LPN/LVN per shift increased the rates of surgical wound infection by 0.02 percent (95 percent CI 0.01-0.05), pulmonary failure by 0.04 percent (95 percent CI 0.02-0.05), pneumonia by 0.06 percent (95 percent CI 0.04-0.07), patient falls by 0.03 percent (95 percent CI 0.02-0.04), and cardiac arrest by 0.03 percent (95 percent CI 0.02-0.04). One study¹⁸ reported a nonsignificant risk of pneumonia and

urinary tract infections (UTI) corresponding to an increase by one LPN/LVN FTE per patient day.

Few studies examined the association between patient outcomes and licensed nurse ratio defining licensed nurses as RN or LPN/LVN. Nonsignificant changes in the rates of pressure ulcers were reported in one study⁶⁴ and in patient falls in two studies^{64,65} corresponding to an additional patient per licensed nurse.

Patient outcomes corresponding to an increase by one patient per UAP per shift. An examination of the association between UAP per patient ratio and patient outcomes (Figure 8) showed that one additional patient per UAP was associated with an increase in the rate of surgical wound infection by 0.01 percent (95 percent CI 0.009-0.03), cardiac arrest by 0.04 percent (95 percent CI 0.02-0.05), and pressure and decubitus ulcers by 0.5 percent (95 percent CI 0.2-0.8). Consistently across three studies^{33,61,75} an increase in the rate of patient falls by 0.03 percent (95 percent CI 0.02-0.04) (heterogeneity not significant [NS]) was detected corresponding to an increase by one patient per UAP per shift (Appendix G, Table G8).

Length of stay corresponding to an increase in nurse staffing ratios. The associations between nurse staffing ratios and LOS in hospitals and in hospital units were reported in days and in relative changes in days adjusted for patients and provider characteristics (Appendix G, Table G9). Pooled analysis^{9,13,14,23,33,35,146,147,150} (Table 13) detected a reduction in length of stay by 0.25 days corresponding to an additional RN FTE per patient day (p value for heterogeneity <0.05). The reduction by 0.25 days per one RN FTE per patient day was significant but not consistent in medical patients. One study⁹⁴ reported that every additional LPN/LVN FTE per 1,000 patient days increased the length of stay by 1.8 days (95 percent CI 1.35-2.25). Random changes in LOS in relation to UAP workload were reported in one study.³³

Pooled analysis of adjusted relative changes in LOS (Figure 9) detected a 20 percent increase in LOS corresponding to one additional patient per RN per shift (95 percent CI 1.08-1.35, heterogeneity NS). The significant reduction in LOS was 31 percent in surgical patients (95 percent CI 0.55-0.86)^{9,13,14} and 24 percent in ICUs (95 percent CI 0.62-0.94)^{8,9,13,14} corresponding to an increase by one RN FTE per patient day. In contrast, one study¹⁹ reported that every patient per LPN/LVN reduced LOS by 22 percent (95 percent CI 0.71-0.86).

Patient outcomes in quartiles of nurse to patient distribution. We analyzed the relative risk of patient outcomes among different quartiles of patients per RN per shift distribution (Figures 10-12). Relative risk of hospital acquired pneumonia was 0.75 times less in surgical patients when an RN was assigned to 4.9 patients compared to more than five patients per shift (Figure 10). In medical patients, the reduction in ratio from more than six to two or less patients per RN per shift was associated with a 41 percent reduction in hospital acquired pneumonia. Relative risk of nosocomial infection was 94 percent less in surgical patients corresponding to a reduction from 2.8 to two or less patients per RN per shift. A significant consistent across the studies reduction in relative risk of nosocomial infection in medical patients was observed by 33-38 percent when one RN was assigned to less than two patients. In contrast, the relative risk of urinary tract infection was higher in medical patients corresponding to an increase in RN staffing.

The effect of reduction in patients per RN per shift on patient outcomes was greater in ICUs and in surgical patients (Figure 11). The relative risk of cardiopulmonary resuscitation was 0.54 and 0.75 times less when one RN was assigned to 3.3 and more than four patients, respectively compared with two patients per RN per shift. Surgical patients experienced cardiac arrest 0.69-

0.75 times less often with less than two patients per RN vs. 2.8 and 4.9 patients per RN respectively. The reduction in RN workload was consistently associated with a decrease in relative risk of failure to rescue in surgical patients by 25-39 percent when one RN was assigned to less than two patients vs. 4.9 and more than five patients, respectively. The same direction of association in ICUs and in surgical patients was shown with the reduction in relative risk of pulmonary failure, and unplanned extubation across quartiles of patients per RN per shift distribution (Figure 12). A nonlinear association between patients per RN ratio and medical complications was observed in ICUs. The reduction from 3-3.6 patients per RN to less than 1.5 patients was associated with a relative decrease by 17 percent ($p = 0.03$, heterogeneity NS) in LOS in ICUs. The LOS was 22 percent shorter with a ratio of 1.6-2.5 patients per RN compared with 3-3.6 patients per RN in ICUs ($p = 0.03$, heterogeneity NS).

In conclusion, despite the substantial heterogeneity in the studies, some consistent evidence from observational studies suggests that increased RN to patient ratio is associated with a reduction in hospital-related mortality, failure to rescue, unplanned extubation, pulmonary failure, and bloodstream infections after adjustment for patient and provider characteristics and reduced LOS of surgical patients. While the effect size is greater in surgical patients and ICUs, the optimal ratio seems to be within the first quartiles of distribution of patients per RN per shift in ICU and in surgical patients. The evidence in medical patients is less consistent and needs further investigation.

Question 2. Association Between Nurse Hours per Patient Day and Patient Outcomes

Total Nurse Hours per Patient Day and Hospital Related Mortality

Four studies examined the association between total nurse hours per patient day and hospital related mortality, three at the hospital level²⁶⁻²⁸ and one at the unit level.¹³⁹ A consistent and significant reduction in death rate by 1.98 percent for every additional nurse hour per patient (95 percent CI 0.96-3 percent) was observed ($p = 0.0005$, heterogeneity NS). The rate was slightly higher (2.1 percent) in three studies analyzed at the hospital level (95 per cent CI 1-3.1 percent, $p = 0.0004$). Every additional nurse hour per patient day reduced the death rate by 1.4 percent (95 percent CI 0.5-2.3) in medical patients²⁶⁻²⁸ and by 2.3 percent (95 percent CI 1.2-3.3) in surgical patients^{26,27} (heterogeneity NS). One large study reported non-significant changes in the relative risk of death corresponding to an increase by one hour in total nursing hours per patient day.²⁷

RN hours per patient day and hospital related mortality. The association with RN hours per patient day did not show significant changes in mortality rates in four studies.^{26-28,139} Pooled analysis that examined the relative risk of death in relation to RN hours per patient day did not detect significant association.^{18,19,26,27,30,141} Random changes in the risk of death were observed by pooling three studies at hospital level analysis^{18,19,26,27,30} in medical units,²⁷ in surgical patients,^{26,27} and in medical patients.²⁶⁻²⁸ One multi-hospital study reported a 2 percent reduction in mortality (RR 0.98, 95 percent CI 0.97-0.99) in medical patients.¹⁵⁰ Another study demonstrated a small but significant increase in the relative risk of death corresponding to one additional RN hour per patient day.¹⁴¹

We conducted combined pooled analysis with RN hours per patient day reported by the authors and estimated from RN to patient ratios. An increase of one RN hour per patient day was associated with a small but consistent reduction in the relative risk of hospital-related mortality. A reduction of 1 percent was observed in ICUs (RR 0.96, 95 percent CI 0.99-1.0),^{8,9,13,14,16} in surgical patients (RR 0.90, 95 percent CI 0.98-1.0),¹²⁻¹⁶ and in medical patients (RR 0.99, 95 percent CI 0.99-1.0).^{8,10,11,17-19}

LPN/LVN and UAP hours per patient day and hospital related mortality. Two studies examined the association between death rates and LPN/LVN hours per patient day^{26,27} and three^{18,19,27} reported the relative risk of death corresponding to increased LPN/LVN hours. After pooling all three studies, every additional LPN/LVN hour per patient day was associated with an increase in the crude death rate of 3.4 percent (95 percent CI 2.1-4.8). One study reported an additional LPN/LVN hour was associated with a 2.5 percent increase in the crude death rate in medical units (95 percent CI 1.8-3.2),²⁷ with a greater increase in surgical patients by 3.3 percent (95 percent CI 2.4-4.2)^{26,27} (heterogeneity NS). Combined analysis of reported and estimated LPN/LVN hours detected inconsistent increases in death rate. The relative risk of hospital-related mortality was not significant in individual studies (Appendix G, Table G10) and pooled analysis. One study examined the association between mortality and UAP hours per patient day reporting random changes in crude death rates and adjusted risk of mortality.²⁷

Patient outcomes corresponding to an increase of 1 total nurse hour per patient day. (Appendix G, Tables G11-G13). The results of pooled analysis of changes in patient outcomes corresponding to one additional nurse hour per patient day are presented in Table 14. The pooled analysis showed a significant consistent reduction in sepsis among surgical patients by 1.33 ± 0.27 percent,^{26,27,46} failure to rescue by 3.53 ± 0.48 percent,^{26,27} urinary tract infection by 4.23 ± 0.97 percent,^{26,27,76,78} hospital acquired pneumonia by 2.2 ± 0.52 percent,^{26,27,151} surgical wound infection by 0.31 ± 0.05 percent,^{26,27} pressure ulcers by 2.26 ± 0.34 percent,^{26,27,76,78,151} shock by 0.77 ± 0.14 percent,^{26,27} pulmonary failure by 2.39 ± 0.49 percent,^{26,27} and deep venous thrombosis by 0.45 ± 0.11 percent.^{26,27} In medical patients an additional nurse hour per patient day was associated with a consistent reduction in failure to rescue by 1.39 ± 0.5 percent,^{26,27} urinary tract infection by 1.88 ± 0.36 percent,^{26-28,76-78,81} hospital acquired pneumonia by 0.89 ± 0.27 percent,^{26-28,45,79,81} shock by 0.34 ± 0.05 percent,^{26,27} and deep venous thrombosis by 0.15 ± 0.05 percent.^{26,27}

An observed increase in nosocomial infection was not consistent across the studies. Differences in patient falls was significant in ICUs only^{49,61,64,75,139} with a reduction by 0.08 ± 0.01 percent corresponding to additional nurse hour per patient day.

Pooled analysis of the adjusted relative risk (Figure 13) detected a significant 12 percent reduction in nosocomial infection corresponding to an increase of one nurse hour per patient day (95 percent CI 0.84-0.92), but the heterogeneity was significant (p for heterogeneity = 0.001).^{33,45,46,63,80} However, a consistent nonlinear quadratic association was detected (p = 0.02) whereby an increase of more than nine total nurse hours per patient day was associated with a 13 percent reduction in the relative risk of nosocomial infection. One study reported a reduction in the risk of shock by 16 percent (95 percent CI 0.71-0.99) and in gastrointestinal bleeding by 1 percent (95 percent CI 0.98-0.99) per one total nurse hour per patient day. Two studies that assessed the relative risk of thrombo-embolic complications reported random changes in risk.^{27,129} Three studies that examined the risk of sepsis found only random changes in relation to nurse hours.^{27,46,62} Four studies that assessed the risk of pressure ulcers and total nurse hours did

not detect significant changes.^{27,62,129,151} Two studies that assessed relative risk of pulmonary failure also showed random change in risk of the outcomes.^{27,62} The relative risk of hospital acquired pneumonia was not associated with total nurse hours.^{27,62,81,129,151} Nursing hours were not associated with failure to rescue in one study.²⁷

Patient characteristics can influence the association between outcomes and nurse hours. (We rely here largely on broad definitions like surgical vs. medical patients.) The adjustment for comorbidities^{28,29,36,65,75,76,139,153,154} attenuated the effect of nursing hours on patient falls (p for interaction <.0001) and the risk of nosocomial infections and nurse hours per patient day (p for interaction = 0.001).^{45,46,81}

Patient outcomes corresponding to an increase by 1 RN hour per patient day. The results of a pooled analysis of the rates of various patient outcomes (Appendix G, Tables G14-G15) corresponding to one additional RN hour per patient day (reported by the authors and estimated from RN FTE per patient day ratios) are presented in Table 15. The associations varied in different clinical settings. In ICUs, an additional RN hour per patient day was associated with a consistent reduction in patient falls by 0.06 ± 0.01 percent^{61,64,75,139} and pulmonary failure by 1.43 ± 0.23 percent.^{13,14,23} In medical patients, a consistent reduction in bloodstream infection by 0.22 ± 0.09 percent was seen^{22,26-28,45,47,79} with a significant but not consistent decrease in pressure ulcers by 1.06 ± 0.32 percent.^{26-28,33,36,61,63,64,76,77,154-156}

Additional RN hours were associated with an increase in rates of urinary tract infection in surgical and medical patients and hospital acquired pneumonia in medical patients (heterogeneity significant for all these associations).

Pooled analysis of the adjusted relative risk is presented in Figure 14 with a significant but not consistent reduction in nosocomial infection by 24 percent (95 percent CI 0.69-0.83) corresponding to one additional RN hour per patient day (p for heterogeneity <0.01).^{45,147} One study reported a significant 21 percent reduction in the relative risk of central line associated bloodstream infections by (p <.0001) corresponding to an increase of one RN hour per patient day in surgical patients in ICUs.¹⁴⁷ The large multi-center study showed a significant reduction by 1 percent in urinary tract infection in medical patients (RR 0.99, 95 percent CI 0.98-1) corresponding to one additional RN hour per patient day and absolute reduction by 3.6 percent in rates of urinary tract infection comparing 25th and 75th percentiles of RN hours. The same study also reported a relative reduction by 2 percent (RR 0.98, 95 percent CI 0.97-0.99) in upper gastrointestinal bleeding in medical patients per additional RN hour per patient day and a 5.2 percent absolute reduction in the rate of this outcome between the 25th and 75th quartiles of RN hours. We conducted a combined pooled analysis using measures reported by the authors and estimated from ratios of RN hours per patient day (Figure 15). Additional RN hours per patient day in ICUs were associated with a reduction in relative risk of hospital acquired pneumonia,^{13,14,22} pulmonary failure,^{13,14,23,24} unplanned extubation,^{13,14,23-25} and nosocomial infection.^{22,45, 47,79,147} In surgical patients, the relative risk of failure to rescue was lower by 1 percent,^{12,15,16,20,26,27, 30,31} unplanned extubation by nine percent,^{13,23,24} and cardiac arrest by four percent^{13,23,24} for every additional RN hour per patient day. Small reductions by 1 percent in relative risk of pulmonary failure^{35,62} and deep venous thrombosis^{27,35} was detected in medical patients.

Patient outcomes corresponding to an increase by one LPN/LVN hour per patient day. Patient outcome rates from pooled analysis corresponding to one additional LPN/LVN hour per patient day are presented in Table 16. The crude rates of most outcomes increased corresponding

to an additional one LPN/LVN hour per patient day; this raise was consistent across the studies (heterogeneity NS for all outcomes). However, additional LPN/LVN hours were associated with lower rates of several outcome in medical patients. Patient falls were lower by 0.21 ± 0.03 and sepsis was lower by 0.29 ± 0.12 percent per 1 LPN hour per patient day (heterogeneity NS).

Pooled analysis of the studies that analyzed relative risk of hospital acquired pneumonia^{26,27,33,157} and studies that assessed the risk of urinary tract infections^{26,27,33,77,157} did not find significant associations with LPN/LVN hours.

One study¹⁵⁸ reported a reduction in the rate of thrombo-embolic complications by -0.3 ± 0.1 percent ($p = 0.01$), of pulmonary failure by -1.2 ± 0.2 percent ($p = 0.002$), and pneumonia by -1.7 ± 0.3 percent ($p = 0.002$) corresponding to one additional LPN/LVN hour per patient day (Appendix G, Table G16). One study detected a significant reduction by 87 percent in the relative risk of hospital acquired pneumonia ($p = 0.004$) for one LPN/LVN hour per patient day.¹⁸

Patient outcomes corresponding to an increase of one licensed hour per patient day. The rate of pressure ulcers,⁶⁴ failure to rescue,^{27,159} falls,^{64,65} and CPR¹⁵⁹ was not associated with licensed hours per patient day. One large study reported a reduction by 11 percent in risk of urinary tract infections (RR 0.89, 95 percent CI 0.8-0.99), by 1 percent in gastrointestinal bleeding (RR 0.987, 95 percent CI 0.98-1.00) and hospital-acquired pneumonia (RR 0.99 95 percent CI 0.98-1.00), and by 3-4 percent in pressure ulcers (RR 0.97, 95 percent CI 0.94-0.99) and bloodstream infections (RR 0.96 95 percent CI 0.95-0.97) corresponding to an additional licensed hour per patient day in surgical patient at hospital level analysis.²⁷ The relative risk of shock,^{27,159} thrombosis,²⁷ combined complications,²⁷ and hospital-acquired pneumonia was not associated with licensed hours per patient day^{27,159}

Patient outcomes corresponding to an increase by 1 UAP hour per patient day. The results of the pooled analysis of patient outcomes corresponding to 1 additional UAP hour per patient day are presented in Figure 16. An increase of 1 UAP hour per patient day was associated with a significant consistent reduction in pressure ulcers by 2.07 percent (0.88-3.26) (heterogeneity NS),^{27,36,76-78} patient falls by 0.2 percent (95 percent CI 0.14-0.26),^{33,36,61,75,76,78} and urinary tract infection by 1.26 percent (95 percent CI 0.16-2.36).^{27,33,76-78} We could find no studies that examined the relative risk of patient outcomes corresponding to UAP hours (Appendix G, Table G17).

Length of stay corresponding to an increase by 1 nurse hour per patient day. The results from a pooled analysis of changes in the length of stay corresponding to 1 additional total nurse hour per patient day are presented in Figure 17. An additional total nurse hour per patient day was associated with a decreased LOS by 1.43 days (95 percent CI 0.31-2.25) in eight studies (heterogeneity NS),^{26-28,36,45,48, 82,83} by 0.45 days in medical patients (95 percent CI 0.19 -0.72, heterogeneity NS),^{26-28,36,45,48,82,83} and by 2.36 days in surgical patients (95 percent CI 1.34-3.39, heterogeneity NS).^{26,27,48,82,83} The association between RN hours per patient day and LOS was not consistent across the studies with random changes in the pooled estimate and significant heterogeneity in the results (p for heterogeneity = 0.05).^{26-28,36,45} The relationship between nurse staffing and LOS in medical patients showed conflicting results (p for heterogeneity = 0.0008).^{26-28,36,45} The studies in surgical patients did not find a significant association with RN hours (p for heterogeneity = 0.013).^{26,27}

The studies that examined the association between LPN/LVN hours and LOS reported a significant increase by 3.21 days (95 percent CI 1.88-4.3) corresponding to an additional

LPN/LVN hour.^{26,27} The effect was larger in surgical patients with an increase by 4.6 days for every LPN/LVN hour per patient day.^{26,27} An increase by 1.53 days (95 percent CI 0.93-2.13) in LOS corresponded to 1 additional UAP hour per patient day (heterogeneity NS).^{27,36,45} The increase in medical patients was 1.6 days (heterogeneity NS)^{27,36,45}

Patient outcomes in quartiles of the distribution of nurse hours per patient day. We analyzed rates of patient outcomes among different quartiles of nurse hours per patient day distribution (Table 17). A decrease in nurse hours per patient day from 12.1 hours to 8.3 hours in ICUs was associated with an increase in the rate of patient falls by 0.76 ± 0.22 percent. A decrease in nurse hours per patient day from more than 11 vs. 9.5 hours in surgical patients was associated with an increase in the rate of failure to rescue by 3.22 ± 0.6 percent, surgical wound infection by 0.29 ± 0.05 percent, upper gastrointestinal bleeding by 0.81 ± 0.19 percent, shock by 0.68 ± 0.16 percent, pulmonary failure by 2.17 ± 0.5 percent, deep venous thrombosis by 0.42 ± 0.1 percent, urinary tract infection by 4.1 ± 0.85 percent, sepsis by 1.3 ± 0.24 percent, and pressure ulcers by 2.31 ± 0.31 percent. A reduction in the total nurse hours from more than 9.6 hours per patient day in medical patients was associated with a 0.36 ± 0.04 percent increase in the rate of shock, 2.49 ± 0.19 percent in urinary tract infection, and 1.35 ± 0.15 percent in hospital acquired pneumonia. The relative risk of failure to rescue was 8 percent higher in medical (RR 1.08, 95 percent CI 1.07-1.1) and 49 percent higher in surgical patients (RR 1.49, 95 percent CI 1.32- 1.69). When we compared the highest and the lowest quartiles of RN hours per patient day (Figure 18), the relative risk of cardiopulmonary resuscitation was 1.52 times higher corresponding to a decrease from more than 16 to 8.2 RN hours per patient day in ICUs. In surgical patients, a reduction from more than 10 to 8.4 RN hours per patient day was associated with a 66 percent increase in the relative risk of cardiac arrest (RR 1.66, 95 percent CI 1.49-1.85). The relative risk of unplanned extubation was three times higher in ICUs (RR 3.12, 95 percent CI 1.97-4.96) corresponding to a decrease in RN hours per patient day from more than 16 to less than six.

In conclusion, the evidence from observational studies suggests that an increase in total nurse hours per patient day was associated with reduced hospital mortality, failure to rescue, nosocomial bloodstream and urinary tract infections, and other adverse events. The effects of RN hours substantially differ among the studies and patient population. A few studies suggest that LPN/LVN hours may increase the rates of sepsis, shock, urinary tract infections, and hospital inquired pneumonia in surgical patients. Additional UAP hours reduced the rate of pressure ulcers, patient falls, and urinary tract infection but not other outcomes. Increasing to more than 16 RN hours per patient day may reduce the risk of cardiopulmonary resuscitation, pulmonary failure, and unplanned extubation in ICUs. Increasing to more than 10 RN hours per patient day in surgical patients is associated with reduced risk of CPR, failure to rescue, and unplanned extubation. The LOS in hospitals is lower along with additional total nursing, but not LPN/LVN and UAP hours.

Evidence of the association between nurse characteristics and patient outcomes. Some evidence (Appendix G, Table G18) suggests that nurse experience and education can influence patient outcomes (Figure 19). The crude rates of complications were reduced by 1.13 percent (95 percent CI 1.9-0.36) for each additional year of nurse experience in surgical patients in the ICU.¹⁶ In the same study, an increase by 1 percent in the proportion of nurses with BSN degrees reduced the rate of failure to rescue by 0.04 percent (95 percent CI 0.06-0.02). The same study reported that an increase in the crude rate of failure to rescue corresponding to 1 year of nurse

experience was not significant after adjustment for confounding factors (RR1.01, 95 percent CI 0.96-1.03). The authors reported a 5 percent reduction in failure to rescue corresponding to a 10 percent increase in the proportion of nurses with BSN degrees (RR 0.95, 95 percent CI 0.91-0.99).¹⁶ The adjusted relative risk of unplanned extubation in neonatal ICUs was not associated with nurse experience (relative risk 1.02, 95 percent CI 0.96-1.08 for an additional year of experience).²⁵ Other studies did not show significant changes in pressure ulcers, patient falls, or urinary tract infections in relation to nurse experience and education.

Several nurse surveys assessed perceived nurses' satisfaction about patient outcomes^{21,36,66,78,88,101,160-164} (Appendix G, Table G19.) One large survey (8,760 nurses)¹⁶³ examined the relative risk of adverse events among Medicare patients in relation to perceived quality of care. Nurses responded to the survey question, "In general, how would you describe the quality of nursing care delivered to patients in your unit on your last shift?" A reduction by 16 percent in the relative risk of patient falls and medication errors corresponded to a 30 percent increase in nurses satisfied with the care provided.¹⁶³ An increase in the proportion of nurses' perceived work related stress by 40 percent increased the rates of patient falls by 1.1 percent.⁶⁶ A 2 percent increase in nurse autonomy accompanied a 0.5 percent reduction in pressure ulcer rates.¹⁶² An increase in nurse turnover by approximately 2 percent increased the rate of patient falls by 0.2 percent.³⁶

There is limited evidence suggesting better nurse staffing is associated with patient satisfaction with nursing care and pain management (Appendix G, Table G-20). In an early study of this phenomenon, larger proportions of patients treated in magnet-designated hospitals were satisfied with provided care compared with conventional (nonmagnet designated) general medical units (85percent vs. 74 percent).¹⁶⁰ Surgical patients in units using a total patient care model (larger proportion of RNs) were more satisfied with pain management compared with a team nursing model (84.6 ± 13 vs. 83.4 ± 13 scores on the Parkside Patient Satisfaction Survey).¹⁶⁵ Medical patients in units with higher proportions of RNs with BSN degrees (54percent) expressed satisfaction with care 1.5 times more often.⁸⁸ An increase by 1 hour in total nurse hours per patient day was associated with an increase by 2.44 ± 0.62 patient satisfaction scores with pain management, an increase by 1 percent in the proportion of nurses with BSN degrees was associated with greater satisfaction by 13.6 ± 3.6 patient satisfaction scores.¹⁵⁴ Some studies, however, did not detect a significant improvement in patient satisfaction in relation to nurse staffing.^{77,78,166}

In conclusion, some evidence from a few observational studies suggests that an increase in nurses with BSN degrees may reduce the risk of hospital-related mortality and failure to rescue. Hospitals with higher proportions of nurses with BSN degrees (36 percent vs.11 percent) have lower mortality. States with larger proportions of BSN degrees report lower rates of fatal injuries related to health care. Nurses' perceived satisfaction may reflect the quality of care.

Question 3. What Factors Influence Nurse Staffing Policies?

Policies related to nurse staffing in hospitals can vary. There may be policies related to the shift length, scheduling nurses to rotate to different shifts, mandatory overtime, weekend staffing, use of agency or temporary nurses, assigning nurses to nursing units other than those they are regularly assigned to work (floating), use of full-time, part-time, and internationally

educated nurses, the nurse-to-patient ratio or nursing hours per patient day for nursing units, and the skill mix (licensed vs. unlicensed staff) of nursing units (Figure 2). Staffing policies can be influenced by patient and patient care unit factors. For example, the fluctuation of patient flow on a nursing unit may determine policies for the length of the shift for nurses. Nurse staffing policies can also be influenced in hospitals in which nurses are unionized or in which nurses have a strong governance structure. The age and/or tenure of nurses in a hospital may have an impact on policies regarding rotating shifts or frequency of working weekends.

Review of the literature to determine factors that can influence nurse staffing policies did not reveal any studies that empirically examined influences on nurse staffing policy. Rather, all studies found for this review examined one or more of the staffing policy variables. Thirty-six studies were identified as eligible and relating to one or more of the staffing policy variables. One hundred forty-seven studies were identified as eligible and relating to one or more of the staffing policy variables (Appendix G, Tables G21-G26). One hundred seventeen studies were excluded for the following reasons: not related to the variable of interest (87); from conference proceedings (2); an integrative review not related to the variables of interest (1); relevant to nursing homes (3); not in peer reviewed journals (17); inadequate presentation of data (6); not research (1). A review of 30 studies for each of the staffing policy variables is provided. For the staffing policy variable *staffing ratio/mix/hours*, the findings from the studies analyzed for questions 1, 2, and 4 are applied. The factors identified in Figure 2 were included in a few of the studies reviewed and will be described in the review for each of the staffing policy variables. Some studies addressed more than one staffing policy variable and are included in more than one evidence table.

Staffing Ratios/Mix/Hours

The research literature related to nurse staffing ratios or hours and staff mix was comprehensively reviewed in the first two questions examined for this review using meta-analytic approaches. None of the studies empirically examined the effect or impact of a staffing policy related to staffing ratios/hours or staff mix. However, several studies examined the impact of the California mandated staffing ratios—an externally imposed staffing policy^{64,109,162} (Appendix G, Table G21). These findings should be cautiously used to inform staffing policies because these studies have limitations in their design and data sources.

Licensed nurses working in California acute care hospitals and nurse staffing in those hospitals were characterized prior to the implementation of mandated nurse staffing ratios.¹⁰⁹ A low percentage of RNs (39 percent) have baccalaureate degrees and the mix of RNs ranged from 30 percent (sub-acute/transitional) to 84 percent (postpartum/labor/delivery) by different types of nursing care units. RN-to-patient ratios varied by type of hospital ownership in California (1:3.2 to 1:7.4)¹⁶² as well as RN skill mix (56.9 percent to 66.6 percent). Following the implementation of the mandated staffing ratios, total RN hours of care per patient day increased by 20.8 percent and the number of patients per RN decreased by 17.5 percent. There was no change in the use of contract staff. However, despite the increased exposure of patients to RN time, there was no reduction in falls, the prevalence of pressure ulcers, or restraint use.⁶⁴

Two recent systematic reviews of nurse staffing and patient, nurse, and hospital outcomes reached basically similar conclusions.^{92,93} Both concluded that the studies reviewed had a number of limitations which implies caution in interpretation of the findings and translating

findings to staffing policies (e.g., data from one unit or hospital, no control for case mix variations, variations in staffing and outcome measures, hospital level data, or data presented as regression coefficients which are difficult to interpret clinically). Other variables likely associated with quality of care should be considered for hospital staffing policies or legislated staffing ratios.⁹² These included acuity of the patients, skill mix, competence of nurses, technological support, and institutional support of nursing. This research supports probable relationships between richer nurse staffing and several patient and nurse outcomes; whereas another study showed strong support for the positive relationship between higher RN skill mix and improved outcomes.⁹³

Studies with implications for staffing policies that were related to nurse-patient ratios or RN skill mix, but found to be ineligible for meta-analysis, are summarized in Appendix G, Table G21. A study conducted in 19 teaching hospitals in Ontario, Canada, supported the relationship between RN skill mix for patient, nurse, and hospital outcomes. The proportion of Regulated Nursing Staff (Canadian equivalent of RNs in the United States) was associated with better patient outcomes in regard to function, pain, satisfaction¹⁶⁷ infections, nurses' perceptions of the quality of care, and fewer medication errors.^{168,169}

Several studies found marginal, and in some cases diminishing effects, of increased RN staffing and patient outcomes. Greater than 15 nursing hours per patient day on medical and medical-surgical units no longer improved the patient fall rate; however, on surgical units, fall rates improved when nursing hours exceeded 15 hours.¹⁷⁰ Diminishing effects of increased RN staffing on reducing the mortality ratio were also found.¹⁸

The findings from the meta-analyses in this report related to nurse-patient ratios/hours and RN skill mix and specifically examined the relationship between nurse staffing and patient and nurse outcomes. These studies did not examine relationships between hospital factors, patient factors, or nursing characteristics on nurse staffing policy variables. However, the findings from the meta-analyses conducted with these studies may have implications for nurse staffing policies regarding RN skill mix or nurse-to-patient ratios. The largest proportion of studies for the meta-analysis was associated with nurse to patient ratios and hospital related mortality. The findings indicate that a higher RN to patient ratio is associated with a decrease in hospital-related mortality. Nurses with baccalaureate degrees in nursing were associated with a reduction in mortality. Negative patient outcomes are also reduced by increasing the RN to patient ratio. There is less evidence for how LPNs/LVNs and UAPs reduce negative patient outcomes; in fact, there is a trend indicating that an increased LPN/LVN and UAP to patient ratio increases negative outcomes. The studies examining the relationship between RN hours per patient day differed substantially; however, there was stronger evidence that total nurse hours per patient day were associated with reduced mortality and negative patient outcomes. Again, there was a trend indicating that LPN/LVN and UAP hours per patient day were associated with increased negative patient outcomes. The findings from the meta-analysis examining nurse staffing ratios suggest hospital staffing policies that provide for a higher RN skill mix. If staffing ratios become part of a hospital staffing policy, they need to consider the type of patient as well as other factors that may impact desired patient and nurse outcomes (e.g., education of nurse, care delivery models, patient factors). Staffing policies that require regular evaluation of staffing effectiveness on patient care units serving different types of patients would seem essential.

Figure 2 suggests that nursing organizational factors have an intervening effect on the relationship between hospital factors and nurse staffing policies. None of the studies reviewed

for question 3 supported this relationship, although several studies examined the direct relationship between hospital factors and nurse staffing policy variables. The technological sophistication of hospitals (technology level) was associated with a higher proportion of RNs on the unit.¹⁷¹ More sophisticated use of technology predicted increased RN hours.¹⁶² For-profit hospitals and for-profit systems had fewer RN productive hours for medical-surgical nursing units; however, this finding seemed to be driven by two large for-profit health systems in the sample.¹⁶² Another study did not find that ownership was related to nurse staffing variables.¹⁷² The two studies were conducted in two different states. They did find that the type of unit (patient care unit factors) affected hospital RN staffing. Intensive care, pediatric, and maternity units had significantly higher RN staffing than medical/surgical or gynecologic units. Controlling for size, rural hospitals also had higher RN staffing. Primary nursing, a nursing care delivery model, explained more than half of the variability in nurse staffing, using about one-third more RNs per occupied bed.¹⁷² While nursing care delivery models were not hypothesized in Figure 2 to be a factor influencing nurse staffing policies, it makes sense that it would be a factor because the primary nursing care delivery model relies on a higher proportion of RNs to be successfully implemented.

Shift work of nurses. Seven studies specifically focused on the length of shift nurses work (8, 10, and 12 hours) and the types of shifts nurses were scheduled to work (days, evenings, nights, or a combination) (Appendix G, Table G22). Two recent survey design studies examined the work patterns of hospital staff nurses. A survey of nurses who were members of the ANA (n=393)¹⁷³ and a randomly selected sample of nurses who participated in the National Institute for Occupational Safety and Health (NIOSH) Nurse Worklife Survey (n = 2,273)¹⁷⁴ both found that nurses were working long hours. Nurses worked, on average, 55 minutes longer than scheduled each day.¹⁷³ Of the 5,317 shifts worked by the respondents during a 28 day period, 38.7 percent of the shifts were 12.5 hours or more. One quarter of the respondents worked 50 hours per week for two or more weeks of the 28-day period. More than half of hospital nurses were working 12 or more hours per day but half as likely to work 6-7 days a week, suggesting that more hospital nurses are working 12 hour shifts. Older nurses (≥ 50 years) were less likely to work long shifts.¹⁷⁴

The likelihood of making medication and procedural errors (actual and near miss errors) increased with longer work hours and was three times higher when nurses worked shifts lasting 12.5 hours or longer.¹⁷³ Age of the nurse (nurse factor), hospital size (hospital factor), or type of unit (unit factor) did not have any affect on errors or near errors. Among 687 RNs and LPNs surveyed in one hospital medication and procedural errors were associated with nurses that rotated shifts.¹⁷⁵ In addition, nurses who rotated shifts had a higher risk of having an automobile accident or other injuries. Among nurses from across the country who worked in critical care units on the day (n = 67) and night shifts (n = 75) the ones who worked permanently on the night shift had significantly more depression and poorer global sleep quality than nurses on the day shift.¹⁷⁶ There was no significant difference between night and day shift nurses in regards to chronic fatigue or anxiety. However, 46 percent of the variance in chronic fatigue was explained by depression and global sleep quality. There was no relationship between physical health and mental depression of nurses working the day, evening, night, and rotating shifts from five hospitals (n = 463).¹⁷⁷ Nurses working 12-hour shifts experienced significantly higher levels of stress than nurses working 8-hour shifts, but the stress levels were similar when controlling for experience.¹⁷⁸ Nurses working rotating shifts experienced higher stress and lower perception of

job performance. Nurses working the night shift reported receiving the least amount of sleep and had the most trouble sleeping.¹⁷⁷

The findings from these seven descriptive studies that used survey methodologies indicate that nurses are working long hours. Because more nurses are working 12-hour shifts (by preference), the risk of working more than 12 hours is high, given that nurses are often not able to finish their work by the end of their scheduled shift. There is beginning evidence that working more than 12 hours and rotating shifts can lead to errors that compromise patient safety as well as accidents, injuries, and higher stress levels of nurses. Implications for staffing policies indicate that the length of nurses' shifts should be no more than 12 hours and strategies should be implemented to limit work hours exceeding 12 hours. Requiring nurses to work rotating shifts should be curtailed.

Contract (agency) nurses. There is little research on the use of agency staff (Appendix G, Table G23). One descriptive study indicates that nurses choosing to work for a staffing agency are not necessarily motivated by nonsalary benefits and hospital nurses are not motivated by the higher salary paid to agency nurses.¹⁷⁹ In that same survey, agency nurses were more likely to work evening and night shifts and weekends. The clinical activities differed by agency and hospital nurses reported having less opportunity to use their clinical skill.¹⁸⁰ Nurse managers do not view agency nurses as cost effective but believe that using agency nurses reduces overtime and provides coverage for weekends, vacations, and absenteeism. Managers' perceptions of quality care of supplemental staff did not differ for hospital pool supplemental staff versus agency staff.¹⁸¹ Float pool nurses had the highest rate of documentation on two clinical aspects of patient care;¹⁸² however, there were significant limitations to the study, including being conducted on only one unit of a hospital and using medical record documentation as a measure of evaluating nursing care quality of agency staff. From a hospital efficiency perspective, agency nurses were associated with higher hospital operating cost.⁵⁰

These studies provide limited insight to guide implications for staffing policies regarding agency nurses. It should be noted that a number of studies were found on the use of agency nurses, but these studies were conducted in countries other than the United States and Canada. Research is needed to evaluate the effectiveness and effective use of agency staff in hospitals as a means to provide adequate staffing for quality patient care.

Full- and part-time nurses. Few studies addressed the full or part time status of nurses (Appendix G, Table G24). There were discrepancies in the demographics reported for full- and part-time nurses. Two large surveys of Canadian nurses demonstrated these differences. In one, part-time nurses were reported to be older,¹⁸³ whereas full-time nurses were older.¹⁸⁴ This difference may be related to a 10-year difference in the time these studies were done. A trend in the studies was that full-time nurses experienced higher role overload,¹⁸⁵ heavier workloads, higher levels of stress, and poorer physical wellbeing.¹⁸⁴ Full-time nurses were statistically more involved in their job¹⁸³ and more likely to be confident, independent, functioning as a leader and professional.¹⁸⁶ Nurses who worked part time reported liking their work schedules more and experienced less interference between their work and nonwork activities. From an organizational perspective,¹⁸⁷ Part-time nurses were associated with lower personnel and hospital costs.⁵⁰

Internationally educated nurses. A strategy to address the nursing shortage and the growing demands of staffing in hospitals has been the utilization of IENs (Appendix G, Table G25). There is a paucity of research on the use and effectiveness of IENs in U.S. hospitals.³⁷ The limited research available includes qualitative exploratory studies^{38,39} and descriptive studies⁴⁰⁻⁴²

that examined IEN use in healthcare. No studies empirically evaluated the interaction of IEN staffing policies with organizational, nurse, or patient care unit factors. Lack of research becomes more notable when it is recognized that IENs represent approximately 3.7 percent of the RN population within the United States.³⁷ Understanding this demographic group may facilitate more effective integration and use of nurses who are educated in and emigrate from other countries.

IENs experience moderate to high levels of stress for up to 10 years after coming to the United States to practice nursing.³⁹ IENs from India experienced racism within the work setting with recommendations for interventions to assist with acculturation.³⁸ Other idiosyncrasies noted about IENs include the tendency to gravitate to critical care,^{40,42} younger in age,^{37,42} the majority from the Philippines,³⁷ more likely to work full-time, night, and evening shifts and more overtime,³⁷ baccalaureate educated,^{37,42} and half as likely to leave the organization.³⁷ No differences were found between IENs and U.S. nurses when comparing perceptions of their control over practice or relationship with the physician,⁴¹ job satisfaction as it relates to time to do the job or quality of care,⁴² or general job satisfaction.^{37,42} Despite the lack of empirical evidence that articulates the relationship of IENs within the organization, the accumulation of these exploratory and descriptive data may assist in understanding human resource demographics more clearly. Further studies are warranted to understand healthful integration of IENs into the acute care system of the United States for the purpose of formulating organization policy.

Nurse overtime. Another staff policy to secure adequate staffing for increasing patient demands and scarce resources is the use of overtime (Appendix G, Table G26). Again, few studies were found in regards to this staffing variable. The prevalence of overtime has been documented in a recent national survey. Seventeen percent of randomly selected nurses reported required mandatory overtime and those whose jobs included mandatory overtime worked significantly longer work hours.¹⁷⁴ Almost two-thirds of nurses, in a survey of RNs who were members of the ANA, worked overtime ten or more times during a 28-day period and more than 25 percent reported working mandatory overtime.¹⁷³

Unionization does not seem to be effective in minimizing overtime. A review of overtime use in New York State hospitals for 5 years found that overtime was 22 percent higher for unionized nurses.⁴³ Occupancy, average hourly wage, and hours in the average work week were not associated with RN overtime within hospitals. When controlling for year-to-year variations in overtime for each hospital, higher RN straight hours was significantly associated with higher RN overtime. Each 1 hour increase in straight time was associated with an 8.7 percent increase in overtime.^{43,44}

RN overtime does not seem to be associated with the location of the hospital, teaching status of the hospital, average hours in a nurse's work week, acute bed occupancy, acute average daily census, or financial margin of the hospital⁴⁴ however, an analysis of nurse overtime over 7 years in New York State hospitals found that overtime increased more in nongovernment unionized hospitals and nonteaching hospitals.⁴³ Working overtime increased the odds of making at least one medication-related error and the risk of making errors increases when nurses work overtime after longer shifts.¹⁷³ Weekend overtime is associated with anticipated turnover.¹⁸⁸ Lost time claim rates were associated with increasing overtime worked by nurses.¹⁸⁹ A few studies suggest that mandatory overtime and overtime in general is prevalent for nurses in U.S. hospitals. There is evidence that overtime and excessively long working hours can compromise patient safety and impact turnover of nurses. These findings suggest that practices related to nurse overtime and associated policies are important.

Question 4. Association Between Nurse Staffing Strategies and Patient Outcomes

We defined eligible nurse staffing strategies as skill mix (proportion of productive [i.e., direct patient care related] hours worked by registered and licensed nurses), the proportion of overtime hours, contract hours, and the proportion of full-time nurses employed in patient care. The distribution of nurse staffing strategies is presented in Table 18. We identified 48 studies that assessed the proportion of RNs; eight studies addressed licensed nurses; 12 studies examined the effects of contract nurse hours on patient outcomes; and only a few studies evaluated overtime hours and the proportion of full-time nurses. The details on the sources used to measure nurse staffing strategies and on study design are presented in Appendix G, Tables G27-G28.

Patient Outcomes Corresponding to an Increase by 1 Percent in the Proportion of RNs

Studies examined the effects of changes in categories of nurse staffing patterns including not only the proportion of RNs, but nurse hours and ratios on a number of outcomes. Pooling these results with random effects models to examine the main effect of the nursing skill mix on patient outcomes detected substantial heterogeneity between studies. For instance, heterogeneity was significant when pooling eight studies that examined the rates of in-hospital mortality (p for heterogeneity = 0.04),^{26,28,33,52,139,140,146,190,191} eight studies that measured the rates of nosocomial infections (p <0.001),^{22,45,81,139,192-194} and 11 studies that evaluated the rates of pressure ulcers in relation to nursing skill mix (p for heterogeneity <0.001).^{26,28,33,36,61,64,76,77,81,151,162}

To estimate whether the direction or strength of the associations can explain the massive differences in the results, we calculated and compared the rates of outcomes in individual studies (Appendix G, Table G28) when possible (Table 19). Three studies reported significant reductions in mortality^{140,190,191} by 0.1-0.4 percent; one unpublished dissertation showed a small but significant increase in mortality⁸⁶ by 0.04 percent; the rest did not find significant associations. The same unpublished study reported a small increase in pulmonary failure and other patient outcomes corresponding to an increase in RNs.³³ Random changes in the rates of nosocomial infections were shown in the majority of the studies. One study detected a reduction in hospital-acquired pneumonia by 0.02 percent (95 percent CI 0.01-0.02).²⁸ A seemingly paradoxical finding was the increase in the rates of urinary tract infections in four studies, with a significant increase by 0.05-0.11 percent for each increase in the percent of RNs in two reports.^{28,33} One study¹³⁹ reported nonlinear association in patient falls and pressure ulcers: the rates increased when more than 87.5 percent of RNs worked in units. Pooled analysis (Figure 20) detected a significant reduction in patient falls by 0.03 percent (95 percent CI 0.03-0.04) corresponding to one additional percent of RNs in ICUs. Rates of patient outcomes were increased in medical and surgical patients per additional percent of RNs.

The analysis of the adjusted relative risks of patient outcomes corresponding to an increase by 1 percent in RN composition is presented in Figure 21. Random changes in the relative risk of all patient outcomes were observed corresponding to each additional percent of RN time. One large study²⁷ contributed the most to the analysis. One study reported a 16 percent reduction in hospital-related mortality in hospitals with 83 percent of RNs compared with 63 percent (RR

0.84 percent CI 0.78-0.92).¹⁹⁵ Three studies reported a tendency to reduce mortality,^{8,26,101} and one large study²⁷ found substantial differences in the association with mortality in different levels of analysis and patient populations, which resulted in significant statistical heterogeneity in the results (p for heterogeneity <0.001) (Figure 22). The same study,²⁷ however, reported a consistent reduction in failure to rescue by 27 percent (RR 0.73, 95 percent CI 0.65-0.83) for an additional percent of RN staffing. Pulmonary failure (Figure 23) was not associated with the proportion of RNs in one study.²⁷ Another study reported a nonsignificant reduction by 25 percent (RR 0.11-4.98) in relative risk of pulmonary failure corresponding to doubling the proportion of RNs.⁶² The relative risk of shock was reduced by 41 percent for each additional percent of RN staffing in a large multi-hospital study.²⁷ The studies did not show significant associations with nosocomial infections, surgical wounds infections, and bloodstream infections. One study reported a significant reduction in the risk of urinary tract infections in surgical patients.²⁷ Overall complications and thrombo-embolic complications increased with the increase in the proportion of RNs.²⁷ An increase by 1 percent in the proportion of RN staffing was associated with a reduction in the risk of upper gastrointestinal bleeding by 42 percent (RR 0.58, 95 percent CI 0.4-0.84) and in pressure ulcers by 76 percent (RR 0.24, 95 percent CI 0.09-0.62) across different settings and patient populations in one study (Figure 24).²⁷ The same study reported a reduction in the relative risk of urinary tract infection in medical (RR 0.48, 95 percent CI 0.38-0.91) and in surgical patients (RR 0.67, 95 percent CI 0.46-0.98), upper gastrointestinal bleeding (RR 0.66, 95 percent CI 0.45-0.96), hospital acquired pneumonia (RR 0.59, 95 percent CI 0.44-0.8), and shock (RR 0.46, 95 percent CI 0.27-0.81) corresponding to an increase by 1 percent in the proportion of RN hours among licensed hours per patient day.²⁷

A higher proportion of RNs was associated with shorter lengths of stay by 0.17 days (95 percent CI 0.03-0.3) but the association was not consistent across studies (p for heterogeneity <0.001). The effect was significant in medical patients only with a decrease by 0.19 days for each 1 percent of RN staffing (95 percent CI 0.1-0.28) but still not consistent (p for heterogeneity <0.05).^{26,28,33,36,45,48,146,150,194}

Patient Outcomes Corresponding to an Increase by 1 Percent in the Proportion of Licensed Nurses

Eight studies attempted to assess the proportion of licensed nurses in relation to patient outcomes^{26,27,30,31,35,63-65,159} (Table 20 and Figures 25-26) but one study²⁷ contributed most of the data for the overall estimates. An increase by 1 percent in the proportion of licensed nurses was associated with a 17 percent reduction in the risk of failure to rescue (RR 0.83, 95 percent CI 0.78-0.87) (Figure 25). Hospital-related mortality was reduced by 3 percent (RR 0.97, 95 percent CI .95-0.98) for every additional percent of licensed nurses. Cardiac arrest occurred 0.59 times less often in association with a 1 percent increase in the proportion of licensed nurses in medical and surgical patients (RR 0.59, 95 percent CI 0.49-0.71) (Figure 26). Pulmonary failure demonstrated random changes in relation to nurse skill mix. Every additional percent of licensed nurses was associated with a 47 percent reduction in the relative risk of shock (RR 0.53, 95 percent CI 0.46-0.61). The risk of hospital acquired pneumonia was reduced by 29 percent (RR 0.71, 95 percent CI 0.63-0.8) in relation to every additional percent of licensed nurses, but the strength of the association differed across patient populations (p for heterogeneity = 0.02).

Among other nosocomial infections, the risk of urinary tract infections was reduced by 13 percent (RR 0.87, 95 percent CI 0.83-0.9), while the risk of surgical wound infection and bloodstream infections was increased by 60 percent as reported in one study.²⁷ The same negative tendency was observed in the risk of thrombo-embolic complications, where a 29 percent increase corresponded to an additional percent of licensed staff (RR 1.29, 95 percent CI 1.08-1.54). One study reported a significant increase in the length of stay by 0.05 days (95 percent CI 0.04-0.05) for each additional 1 percent of licensed nurses.³⁵

Patient Outcomes Corresponding to an Increase by 1 Percent in Overtime Hours

Two studies^{30,193} examined the association between overtime hours and patient outcomes (Appendix G, Table G29). Every additional 10 percent of overtime hours was associated with a 1.3 percent increase in hospital related mortality (RR 1.013, 95 percent CI 1.0001-1.65).³⁰ The association was nonlinear ($p = 0.006$) with an increase in hospital-related mortality by 32 percent corresponding to an increase in overtime hours by 10 percent from nadir (7 percent) to 17 percent.

The rate of nosocomial infections increased by 1.9 percent (95 percent CI 0.3-3.5 percent) with each additional percent of overtime hours.¹⁹³ The relative risk of shock increased by 12 percent in medical but not surgical patients (RR 1.12, 95 percent CI 1.001-1.24) corresponding to a 5 percent increase in overtime hours.³¹ The relative risk for bloodstream infections increased by 11.5 percent in surgical (RR 1.12, 95 percent CI 1.021-1.22) and by 14 percent in medical patients (RR 1.14, 95 percent CI 1.05-1.24).³¹ That study did not find an association between overtime hours and urinary tract infections, failure to rescue, or gastrointestinal bleeding.

Patient Outcomes Corresponding to an Increase by 1 Percent in Contract Hours

The majority of the studies that reported the proportion of contract hours did not examine the main effect of temporary nurses; rather they reported patient outcomes in units and hospitals with different staffing patterns including nursing ratios and hours. Some authors distinguished contract hours from hours worked by float nurses;^{28,46,64,193} others included the hours worked by float nurses as temporary hours.^{45,47} One study showed no association between contract hours and the rates of urinary tract infections, pneumonia, pressure ulcers, surgical wound infections, or bloodstream infections.²⁸ Two studies reported an increase in rates of patient falls corresponding to additional contract hours.^{28,64} A small increase in the rate of nosocomial infections corresponded to an increase in contract hours,¹⁹³ but another study did not find a significant association after adjustment for other factors.⁴⁶ In contrast with contract hours, the proportion of float nurses was positively associated with the risk of nosocomial infection. The risk was 2.61-2.71 times higher in patients cared for in units with more than 60 percent of float nurses.⁴⁷ Another study reported an increase in the rate of bloodstream infection by 5 percent corresponding to a 23 percent increase in the proportion of float nurses.⁴⁵ Summarizing the results from two studies^{46,47} that examined the risk of sepsis in relation to float nurses, the risk was 2.79 time higher for every percent increase in float hours (RR 2.8, 95 percent CI 2.8-2.79).

An increase in the proportion of temporary nurses by 1 percent of contract hours increased the length of stay by 0.1 day (RR 0.11, 95 percent CI 0.03-0.18, heterogeneity NS).^{28,45,48,50}

In conclusion, some evidence from a few multi-hospital studies suggests that a higher proportion of RNs may reduce the risk of failure to rescue, shock, pressure ulcers, and gastrointestinal bleeding. A significant but not consistent reduction on LOS in medical patients was observed pooling the results from 12 studies.

Overtime hours may increase the risk of hospital-related mortality and bloodstream infections. An increase in contract hours may increase in-hospital LOS. A small amount of evidence suggests that an increase in hours worked by float nurses is associated with a large increase in the risk of bloodstream infections.

Figure 4. Flow of study selection for questions 1, 2, and 4

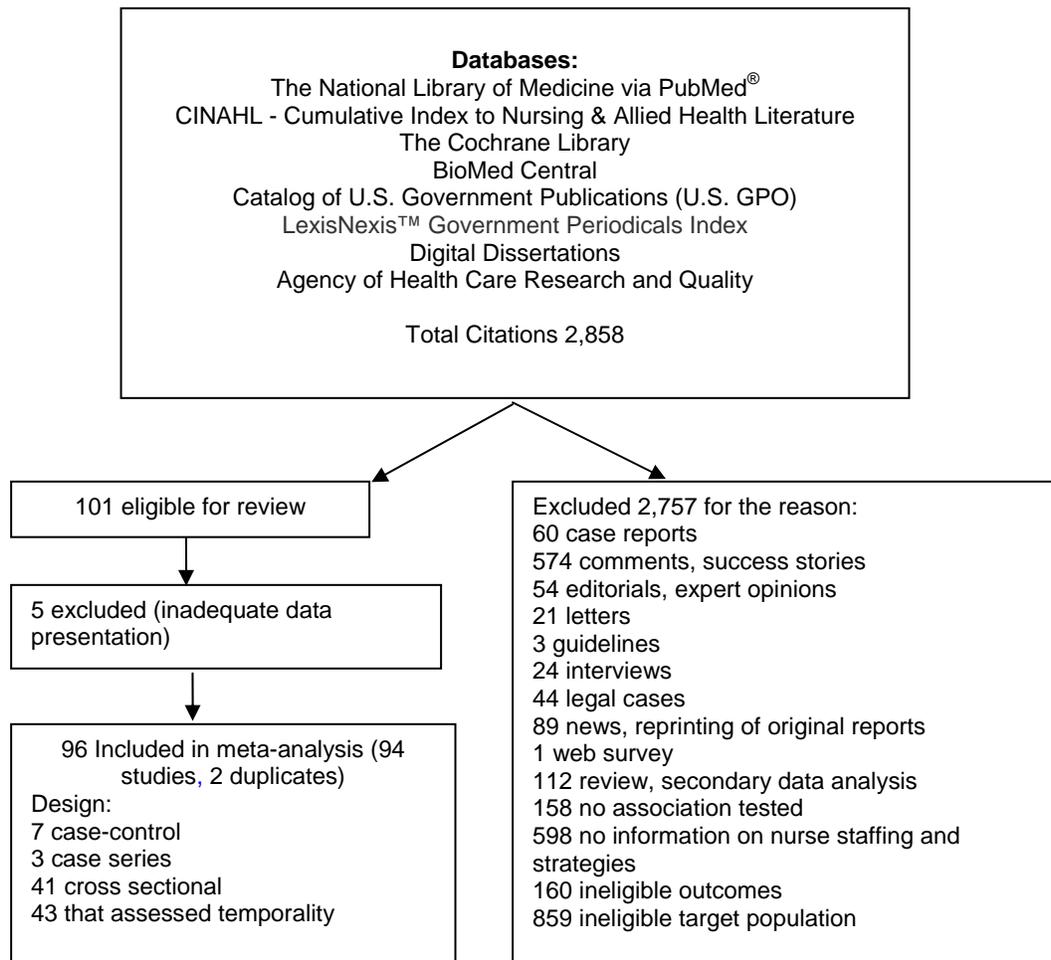


Table 2. Distribution of the studies' quality* (94 studies)

Quality Measures	Mean	Standard Deviation	Median
Study question clearly focused and appropriate	4.69	0.73	5
Clear definition of exposure	3.96	0.65	4
Clear definition of the primary and secondary outcomes	4.41	0.65	4.5
Sampling of study population	3.34	0.81	3
Statistical analysis: assessment of confounding attempted	3.61	1.11	4
Adjustment for the effects of various factors	2.89	1.62	3.5
Statistical methods	3.70	0.94	4
Measure of effect for outcomes	3.66	1.11	4
External validity	3.48	0.97	4
Conclusions	4.01	0.68	4
Total scores	37.76	6.40	38

* Maximum possible score of 5; total of 50 for each study

Table 3. Distribution of nurse hours and ratios (94 studies)

Nurse Staffing	Number of Studies	Mean	Standard Deviation
ICUs			
RN FTE/patient day	15	1.3	0.7
Patients/RN/shift	15	3.1	1.8
Total nursing hours/patient day	15	13.0	5.2
RN hours/patient day	10	12.6	5.3
LPN/LVN hours/patient day	3	0.3	0.6
UAP hours/patient day	4	2.3	1.2
Licensed nurse hours/patient day	1	7.3	0.4
Surgical patients			
RN FTE/patient day	13	1.1	0.8
Patients/RN/shift	13	4.0	2.3
Patients/LPN/shift	2	3.1	2.2
Total nursing hours/patient day	12	8.7	4.3
RN hours/patient day	11	8.1	5.1
LPN/LVN hours/patient day	7	1.3	1.1
UAP hours/patient day	5	2.1	0.6
Medical patients			
RN FTE/patient day	20	1.1	1.0
Patients/RN/shift	20	4.4	2.9
Patients/LPN/shift	6	13.3	8.5
Patients/UAP/shift	4	12.0	8.9
Patients/licensed nurse/shift	2	4.1	1.1
Total nursing hours/patient day	27	8.2	4.4
RN hours/patient day	23	6.1	3.6
LPN/LVN hours/patient day	13	2.3	2.0
UAP hours/patient day	12	2.5	2.1
Licensed nurse hours/patient day	4	3.3	2.9

Table 4. Hospital-related mortality rates corresponding to changes in patients/RN ratio (pooled weighted estimates from published studies)

Level of Analysis	Number of Studies	Change in Death Rate, %	Standard Error	p Value for the Association	p Value for Heterogeneity
Authors' definition of nurse to patient ratio					
Increase by 1 patient/RN/shift	3	0.095	0.03	0.003	0.33
Increase by 1 RN FTE/patient day	3	-1.24	1.13	0.311	0.041
Increase by 1 RN FTE/1,000 patient days	1	-1.29	0.54	0.076	
Estimated Increase by 1 RN FTE/patient day					
All studies	8	-1.18	0.49	0.02	<0.001
ICUs	3	-0.97	0.28	<0.001	0.23
Surgical patients	5	-0.89	0.49	0.08	<0.001
Medical patients	3	-1.18	0.78	0.15	<0.001
Hospital level analysis	3	-3.48	2.68	0.25	0.67
Patient level analysis	5	-1.18	0.55	0.04	<0.001

Table 5. RN to patient ratios and relative risk* of hospital-related mortality (pooled adjusted estimates from published studies)

Level of Analysis	Number of Studies	Relative Risk	95% CI	p Value for the Association	Consistency
Authors' definition of nurse to patient ratio					
Increase by patient/RN/shift	6	1.08	1.07; 1.09	<.0001	No
Increase by 1 RN FTE/patient day	6	0.943	0.93; 0.953	<.0001	Yes
Increase by 1 RN FTE/1,000 patient days	3	0.995	0.95; 1.04	0.8273	Yes
Estimated Increase by 1 RN FTE/patient day					
All studies	14	0.92	0.90; 0.94	<.0001	No
Patient level analysis	8	0.919	0.89; 0.95	0.0002	No
Hospital level analysis	5	0.958	0.94; 0.98	0.0001	Yes
ICUs	5	0.908	0.86; 0.96	0.0321	Yes
Surgical patients	8	0.84	0.80; 0.89	<.0001	Yes
Medical patients	6	0.944	0.94; 0.95	<.0001	Yes
Quartiles of patients/RN/shift ratio					
<2 vs. 2-4	14	0.94	0.92; 0.95	<.0001	Yes
<2 vs. 4-5.5		0.76	0.71; 0.81	<.0001	Yes
<2 vs. >6		0.62	0.59; 0.66	<.0001	Yes
2-4 vs. 4-5.5		0.81	0.76; 0.87	<.0001	Yes
2-4 vs.>6		0.66	0.63; 0.70	<.0001	Yes
4-5.5 vs. >6		0.82	0.76; 0.88	<.0001	Yes
ICUs					
<3 vs. 3-4	5	0.94	0.92; 0.97	0.016	Yes
Medical patients					
<2 vs. 2-4	6	0.94	0.92; 0.96	<.0001	Yes
Surgical patients					
<2 vs. 4-6	8	0.76	0.70; 0.82	0.000	Yes
<2 vs. >6		0.62	0.58; 0.66	<.0001	Yes
2-3.5 vs. 4-6		0.80	0.74; 0.87	0.001	Yes
2-3.5 vs. >6		0.65	0.61; 0.70	<.0001	Yes
4-6 vs. >6		0.81	0.75; 0.88	0.001	Yes

* Relative risk of outcomes - the ratio of the incidence rate of outcomes corresponding to different nurse staffing levels (relative risk =1 means no association, <1 – protective effect of increased nurse staffing, >1 – increased probability of patient outcomes). 95% CI – ranges of relative risk with 95% confidence that we will have the same results repeating the study many times in the same population.

Figure 5. Relative risk of patient hospital-related mortality corresponding to change in registered nurse to patient ratio (pooled estimation from the studies)

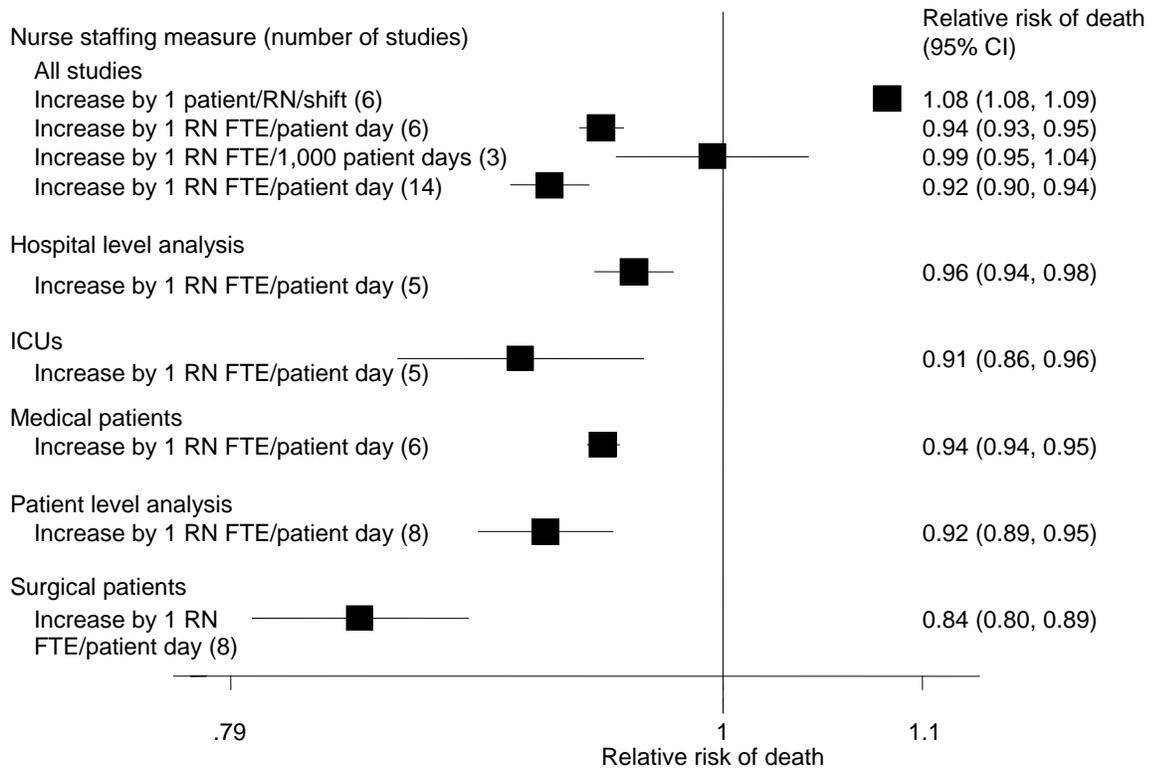


Figure 6. Relative risk of death among different categories of patients/RN/shift (pooled analysis)

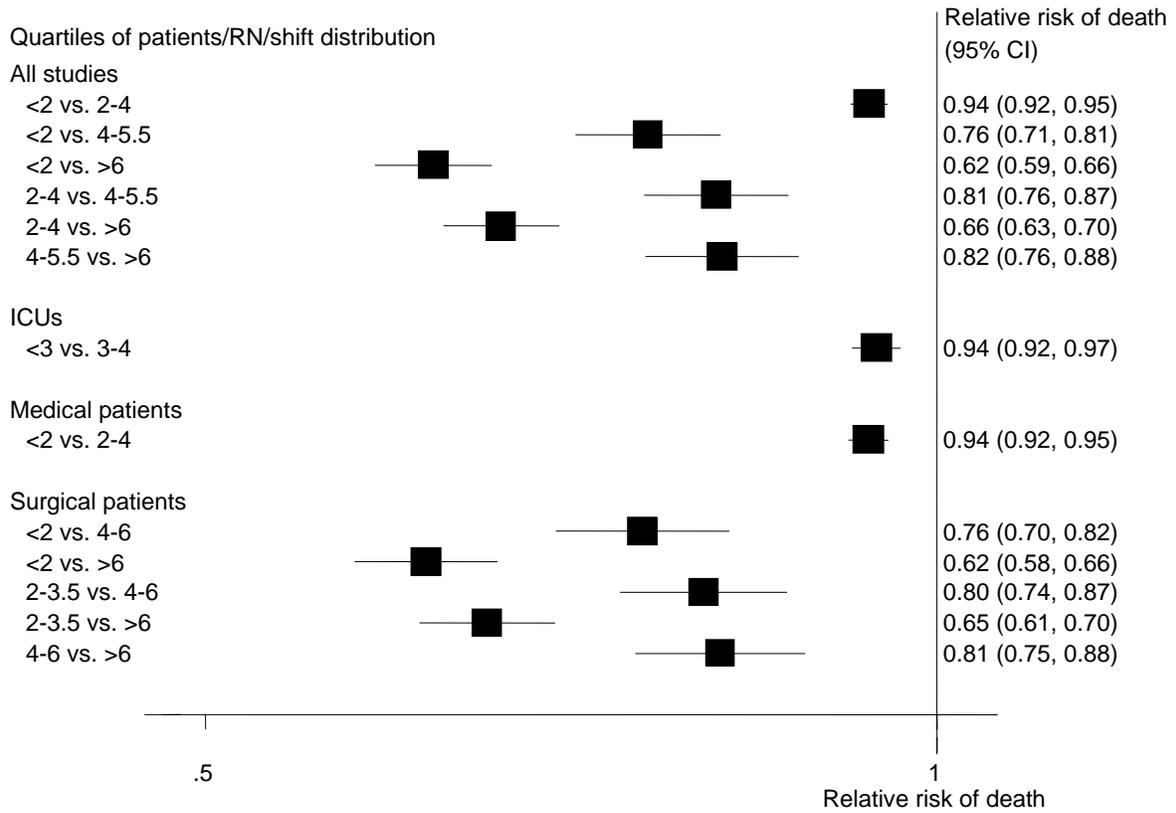


Table 6. Number of avoided deaths/1,000 hospitalized patients attributable to RN FTE/patient day ratio (pooled adjusted estimates from published studies)

Level of Analysis	Studies	RR	95% CI	Attributable to Nurse Staffing, Percentage of Death, 95% CI	NNT*	Number of Avoided deaths/1,000 Hospitalized, 95% CI
Authors' definitions of nurse staffing ratio						
Increase by patient/RN/shift	6	1.08	1.07; 1.09	7.6 (7.07; 8.04)	198	5 (4; 5)
Increase by 1 RN FTE/patient day	6	0.94	0.93; 0.95	6 (7; 5)	162	6 (5; 7)
Estimated increase by 1 RN FTE/patient day						
All studies	14	0.92	0.90; 0.94	8 (10; 6)	191	5 (4; 6)
Patient level analysis	8	0.92	0.89; 0.95	8 (11; 5)	154	7 (4; 9)
Hospital level analysis	5	0.96	0.94; 0.98	4 (6; 2)	342	3 (2; 4)
Intensive care units	5	0.91	0.86; 0.96	9 (14; 4)	187	5 (2; 8)
Surgical patients	8	0.84	0.80; 0.89	16 (20; 12)	164	6 (4; 8)
Medical patients	6	0.94	0.94; 0.95	6 (6; 5)	211	5 (4; 5)
Quartiles of patients/RN/shift ratio						
<2 vs. 2-4	14	0.94	0.92; 0.95	6 (8; 5)	247	4 (3; 5)
<2 vs. 4-5.5		0.76	0.71; 0.81	24 (29; 19)	63	16 (12; 19)
<2 vs. >6		0.62	0.59; 0.66	38 (41; 35)	40	25 (23; 28)
2-4 vs. 4-5.5		0.81	0.76; 0.87	19 (24; 13)	80	12 (9; 16)
2-4 vs. >6		0.66	0.63; 0.70	34 (37; 30)	45	23 (20; 25)
4-5.5 vs. >6		0.82	0.76; 0.88	18 (24; 12)	83	12 (8; 16)
ICUs						
<3 vs. 3-4	5	0.94	0.92; 0.97	6 (8; 3)	308	3 (2; 5)
Medical patients						
<2 vs. 2-4	6	0.94	0.92; 0.96	6 (8; 5)	187	5 (4; 7)
Surgical patients						
≤2 vs. 4-6	8	0.76	0.70; 0.82	24 (30; 18)	107	9 (7; 12)
≤2 vs. >6		0.62	0.58; 0.66	38 (42; 34)	68	15 (13; 16)
2-3.5 vs. 4-6		0.80	0.74; 0.87	20 (26; 13)	132	8 (5; 10)
2-3.5 vs. >6		0.65	0.61; 0.70	35 (39; 30)	75	13 (12; 15)
4-6 vs. >6		0.81	0.75; 0.88	19 (25; 12)	141	7 (5; 10)

* Number needed to treat to generate benefit (saved life)

Table 7. Calculated relative risk of hospital-related mortality corresponding to increased RN staffing (results from individual studies)

Study, Analytic Unit	RR	95% CI	Data, Definition of RN Ratio	Units	Patients	Diagnosis
Hospital						
Mark, 2004 ¹⁸	1.02	0.9; 1.1	Administrative, RN FTE/1,000 patient days	Combined	Combined	Combined
Mark, 2005 ¹⁹	1.005	0.98;1.03	Administrative, RN FTE/1,000 patient days	Combined	Combined	Combined
Robertson, 1999 ¹¹	0.97	0.957; 0.98	Administrative, RN FTE/patient day	Combined	Medical	Chronic obstructive pulmonary disease
Silber, 2000 ¹²	0.93*	p <0.05	Administrative, RN FTE/patient day	Surgical	Surgical	Combined
Elting, 2005 ²⁰	0.61*	p <0.05	Administrative, RN FTE/patient day	Surgical	Surgical	Bladder carcinoma (ICD-9 codes 188.0 - 188.9 and 236.7) after total cystectomy
Patient						
Aiken, 1999 ¹⁰	0.28	0.2; 0.5	Medical records, RN FTE/patient day	Combined	Medical	AIDS
Aiken, 2002 ¹⁵	0.58	0.4; 0.8	Administrative, RN FTE/patient day	Combined	Surgical	General surgical, orthopedic, or vascular operation
Aiken, 2003 ¹⁶	0.89	0.848; 0.934	Administrative, RN FTE/patient day	ICU	Surgical	General surgical, orthopedic, vascular operation
Person, 2004 ¹⁷	0.94	0.9; 1	Administrative, RN FTE/patient day	Combined	Medical	Acute myocardial infarction
Pronovost, 1999 ⁹	0.02*	p <0.05	Administrative, patients/RN/shift	ICU	Medical	Abdominal aortic surgery
Amaravadi, 2000 ¹³	0.39*	NS	Administrative, patients/RN/shift	ICU	Surgical	Esophageal resection
Dimick, 2001 ¹⁴	6.5*	NS	Administrative, patients/RN/shift	ICU	Surgical	Hepatic resection
Halm, 2005 ²¹	1.02*	NS	Administrative, patients/RN/shift	Surgical	Surgical	General, orthopedic, and vascular surgery
Hospital unit						
Shortell, 1994 ⁸	1.13*	NS	Administrative, RN FTE/patient day	ICU	Medical	Combined

* 95% CI were not reported, significance reported by authors

Table 8. Association between RN staffing ratio and mortality and proportion of mortality attributable to nurse staffing (results from individual studies)

Author	Analytic Unit	Hospital Unit	Patients	RN Ratio	Relative Risk of Death (95% CI)	Attributable Proportion, (95% CI)
Pronovost ⁹	P	ICU	S, Abdominal aortic surgery	Nurse to patient ratio <1:2 vs. >1:2 in evening	1.9 (1.2; 3)	0.47 (0.17; 0.23)
Aiken ¹⁰	P	C	M, AIDS	Increase by 1 patient/RN/shift	2.3 (1.3; 4.2)	0.57 (0.76; 0.22)
Aiken ¹⁵	P	ICU	S, general surgical, orthopedic, or vascular operation	Increase in workload of 1 patient/RN/shift	1.06 (1.01; 1.1)	0.06 (0.01; 0.09)
Aiken ¹⁶	P	ICU	S, general surgical, orthopedic, or vascular operation	Increase by 6 patients/RN/shift	1.5 (1.19; 1.97)	0.33 (0.16; 0.49)
				Increase by 1 patient/RN/shift	1.07 (1.03; 1.12)	0.07 (0.03; 0.11)
Person ¹⁷	P	C	M, acute, myocardial, infarction	4 th quartile vs. 1 quartile of RN staffing (~2.7 RN FTE/patient day vs. ~1.6 RN FTE/patient day)	0.91 (0.86; 0.97)	0.10 (0.16; 0.03)
Elting ²⁰	H	S	S, bladder carcinoma after total cystectomy	Hospitals with few RN FTE/occupied bed (median 1.4) vs. many (median 3.1)	2.04 (1.03; 5.3)	0.51 (0.81; 0.03)
Mark ¹⁹	H	C	C	Increase by 1 RN FTE/1,000 patient days in hospitals with high HMO penetration	0.91 (0.86; 0.95)	0.10 (0.16; 0.05)
Robertson ¹¹	H	C	M	Increase by 1 RN in RN FTE/patient day ratio in 1989	0.988	0.01
				1990	0.987	0.01
				1991	0.978	0.02
Mark ¹⁸	H	C	C	75 th quartile of RN FTE/1,000patient-days 7.24 RN hours/patient day	0.96 (0.95; 0.98)	0.04 (0.05; 0.02)
				50 th quartile of RN FTEs/1,000 patient days 6.01 RN hours/patient day	0.97 (0.96; 0.98)	0.03 (0.04; 0.02)
				25 th quartile of RN FTEs/1,000 patient days 4.79 RN hours/patient day	0.98 (0.96; 0.99)	0.02 (0.04; 0.01)
				Increase by 1 RN FTE/1,000 patient days	0.92 (0.87; 0.96)	0.09 (0.15; 0.04)
Silber ¹²	H	S	S	Hospitals with 1.6 vs. 2.7 patients/RN/shift	0.95 (0.93; 0.96)	0.05 (0.08; 0.04)

P = patient; H = hospital; C = combined; S = surgical; M = medical; Attributable Proportion = proportion of deaths attributable to nurse staffing

Table 9. Correlation between nurse staffing and age adjusted fatal adverse events related to medical care at the state level^{1,144,148}

	r	p Value
Excess or shortage	0.08	0.58
Percent of shortage	-0.10	0.50
Total number of nurses	-0.11	0.62
Employed in nursing	-0.11	0.59
Percent employed in nursing	-0.12	0.56
RN/100,000 population	-0.24	0.26
Full-time employed	-0.09	0.66
Percent full-time employed	0.13	0.55
Part-time employed	-0.13	0.55
Percent part-time employed	-0.10	0.62
RN FTE	-0.04	0.84
Number of nurses with diploma	-0.04	0.86
Percent of nurses with diploma	-0.10	0.64
Number of nurses with associate degree	0.33	0.11
Percent of nurses with associate degree	0.33	0.11
Number of nurses with BSN	-0.15	0.48
Percent of nurses with BSN	-0.46*	0.02
Number of nurses with MS and PhD	-0.14	0.52
Percent of nurses with MS and PhD	0.16	0.46

* significant at 95% level
r = correlation coefficient

Table 10. Association between nurse education, experience, and mortality

Author, Unit, Patients	Nurse Education and Experience	Death Rate, %	Relative Risk, 95% CI
Aiken ¹⁶	40% of hospital workforce with BSN or higher	2.17	
ICU	10% increase in nurses with BSN degree*	-0.10	0.95 (0.9; 0.99)
Surgical	Increase by 1 year in nurse experience	0.23	0.09
	Interactions:		
	60% of hospital workforce with BSN or higher, 8 patients/day	1.98	
	40% of hospital workforce with BSN or higher, 4 patient/nurse	1.80	
	20% of hospital workforce with BSN or higher, 4 patients/nurse	1.97	
	60% of hospital workforce with BSN or higher, 6 patients/nurse	1.80	
	40% of hospital workforce with BSN or higher, 6 patients/nurse	1.98	
	20% of hospital workforce with BSN or higher, 6 patients/nurse	2.16	
	60% of hospital workforce with BSN or higher, 4 patients/nurse	1.64	
	20-29% of hospital workforce with BSN or higher, 14 years of nurse experience	2.20	
	<20% of hospital workforce with BSN or higher, 15 years of nurse experience	2.30	
	20% of hospital workforce with BSN or higher, 8 patients/nurse	2.38	
	>50% of hospital workforce with BSN or higher, 12.5 years of nurse experience	1.70	
	40-49% of hospital workforce with BSN or higher, 14.3 years of nurse experience	1.90	
	30-39% of hospital workforce with BSN or higher, 14 years of nurse experience	1.80	
Estabrooks ¹⁰¹	Hospitals with higher proportion of nurses with BSN 36% vs. low (11%)		0.81 (0.68; 96)
Combined	Hospitals with higher proportion of nurses with BSN, 36% vs. low (11%) (random effects model)		0.65 (0.6; 0.71)
Medical			
Tourangeau ¹⁴⁰	Increase by 1 year in nursing experience in teaching hospitals		0.99
Combined	Increase by 1 year in nurse experience		0.99
Medical	Increase by 1 year in nursing experience in nonurban hospitals		1
	30 days mortality in teaching hospitals, 7.85 years of nurse experience	14.02	
	30 days mortality in nonurban community hospitals, 9.47 years of nurse experience	15.27	
	30 days mortality in urban community hospitals, 8.9 years of nurse experience	15.05	

*We calculated death rate corresponding to 10% increase in nurses with BSN and to 1 year increase in nurse experience, significant at 95% level.

Table 11. Patient outcomes rates (%) corresponding to an increase in RN staffing ratios (pooled estimation from the published studies)

Outcomes	Studies	Difference in Rate, %	Standard Error	p Value for the Association	Consistency
Authors' definition of nurse staffing ratio					
Increase by 1 patient/RN/shift					
Failure to rescue	1	0.35	0.12	0.01	
CPR	3	0.45	0.06	0.001	No
Falls	2	3.88	1.26	0.05	Yes
Urinary tract infection	2	-0.71	0.41	0.10	Yes
Pneumonia	2	2.04	1.62	0.43	Yes
Nosocomial Infection	5	-0.03	0.08	0.68	No
Pressure ulcers	2	-1.26	0.41	0.06	No
Pulmonary failure	3	6.54	1.04	0.001	Yes
Unplanned extubation	3	4.20	0.31	0.001	No
Estimated increase by 1 RN FTE/patient day					
Failure to rescue	3	-0.67	0.20	0.001	No
Falls	3	-13.43	1.55	0.001	No
Urinary tract infection	3	5.18	1.94	0.02	Yes
Pneumonia	2	-3.57	2.84	0.43	Yes
Nosocomial Infection	6	0.23	0.40	0.57	No
Pressure ulcers	2	3.94	1.11	0.04	No
Pulmonary failure	4	-0.03	0.02	0.11	Yes
Unplanned extubation	3	-7.35	0.55	0.001	No
Thrombosis	1	-0.05	0.04	0.29	
Estimated increase by 1 RN FTE/patient day in ICUs					
Failure to rescue	1	-3.69	1.26	0.01	
CPR	3	-0.78	0.10	0.002	No
Pulmonary failure	3	-11.45	1.82	0.003	Yes
Unplanned extubation	3	-7.35	0.55	0.001	No
Estimated increase by 1 RN FTE/patient day in surgical patients					
Failure to rescue	2	-3.32	1.25	0.02	Yes
CPR	3	-0.78	0.10	0.002	No
Sepsis	5	-1.15	0.42	0.02	No

Table 12. Relative risk of patient outcomes corresponding to an increase in RN staffing ratios (pooled estimation from the studies)

Outcomes	Studies	Relative Risk	95% CI	p Value for the Association	Consistency
Authors' definition of nurse staffing ratio					
Increase by 1 patient/RN/shift					
Hospital acquired pneumonia	3	1.07	1.03; 1.11	0.001	Yes
Failure to rescue	3	1.08	1.07; 1.09	<.0001	No
Pulmonary failure	4	1.53	1.24; 1.89	0.001	Yes
Unplanned extubation	5	1.45	1.27; 1.67	<.0001	Yes
Nosocomial infection	3	1.03	0.98; 1.07	0.24	No
CPR	3	1.16	1.05; 1.29	0.008	Yes
Medical complications	3	1.17	1.04; 1.31	0.01	Yes
Increase by 1 RN FTE/patient day					
Failure to rescue	2	0.92	0.92; 0.92	0.002	No
Estimated increase by 1 RN FTE/patient day					
ICU					
Hospital acquired pneumonia	3	0.7	0.56; 0.88	0.02	Yes
Pulmonary failure	4	0.4	0.27; 0.59	0.001	Yes
Unplanned extubation	5	0.49	0.36; 0.67	0.001	Yes
CPR	3	0.72	0.62; 0.84	0.002	Yes
Medical complications	3	0.72	0.6; 0.86	0.005	Yes
Surgical patients					
Urinary tract infection	1	1.68	1.06; 2.67	0.05	
Failure to rescue	5	0.84	0.79; 0.9	0.001	Yes
Nosocomial infection	2	0.08	0.04; 0.18	<.0001	No
Surgical wound infection	1	0.15	0.03; 0.82	0.051	
Sepsis	5	0.64	0.46; 0.89	0.015	Yes
Patient level analysis					
Failure to rescue	4	0.91	0.89; 0.94	0.002	Yes
Pulmonary failure	5	0.94	0.94; 0.94	<.0001	Yes

Figure 7. Patient outcomes rates (%) corresponding to an increase by patient per LPN/LVN per shift (calculated from one study)

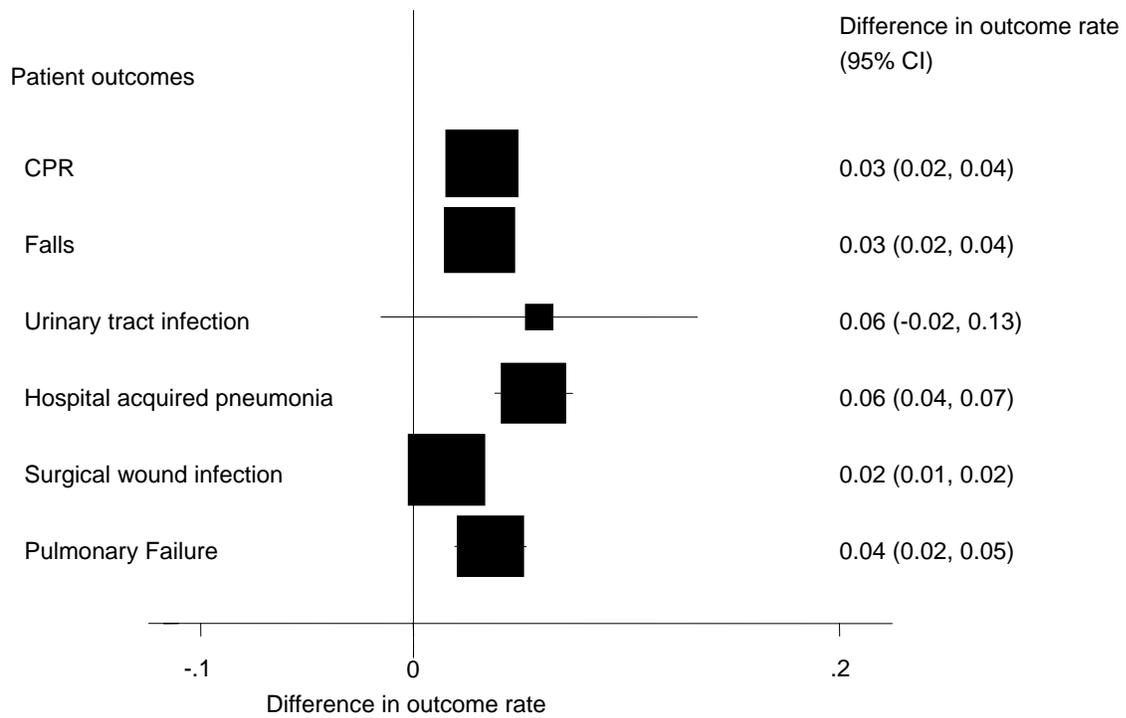


Figure 8. Patient outcomes rates (%) corresponding to an increase by patient/UAP/shift (estimates from individual studies and pooled analysis)

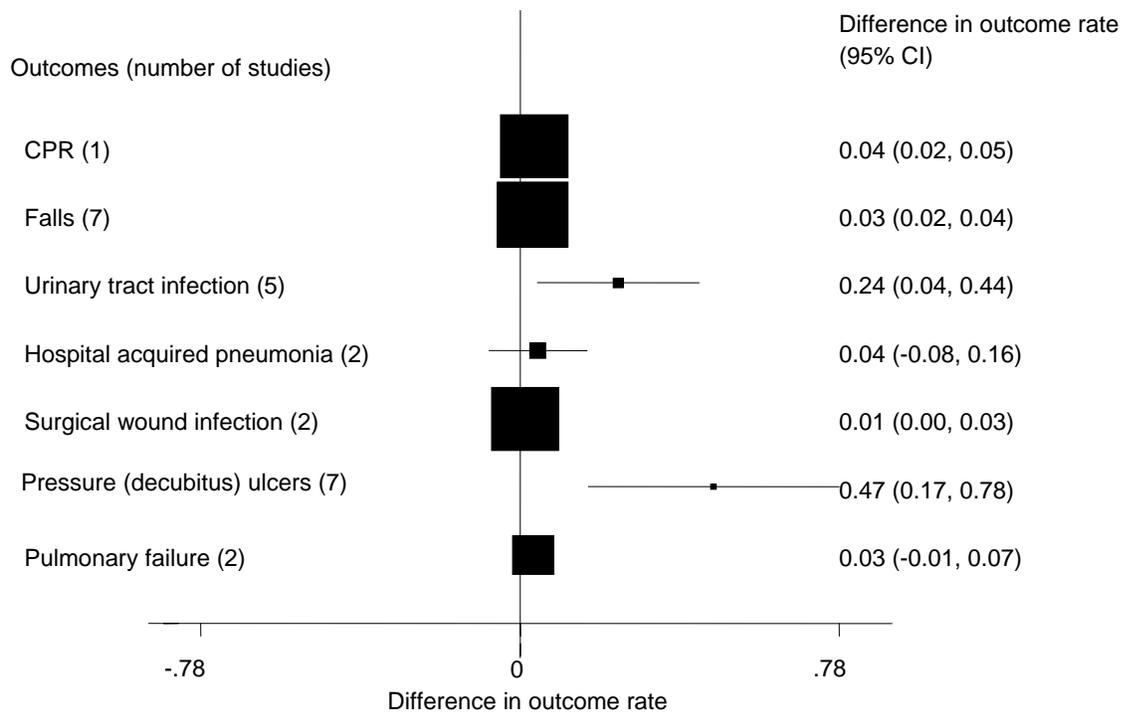


Table 13. Length of stay corresponding to an increase in RN staffing ratios (pooled analysis)

Nurse Staffing	Studies	Change in Length of Stay, Days	Standard Errors	p Value for the Association	Consistency
Authors' definitions					
Increase by 1 patient/RN/shift	6	0.7	0.8	0.4	Yes
Increase by 1 RN FTE/patient day	2	-0.25	0.03	<.0001	Yes
Estimated increase by 1 RN FTE/patient day					
All studies	10	-0.25	0.02	<.0001	No
ICUs	5	-0.70	1.64	0.68	Yes
Surgical patients	5	-0.63	1.50	0.68	Yes
Medical patients	5	-0.25	0.02	<.0001	No

Figure 9. Relative changes in LOS corresponding to an increase in RN staffing ratios (pooled estimation from the studies)

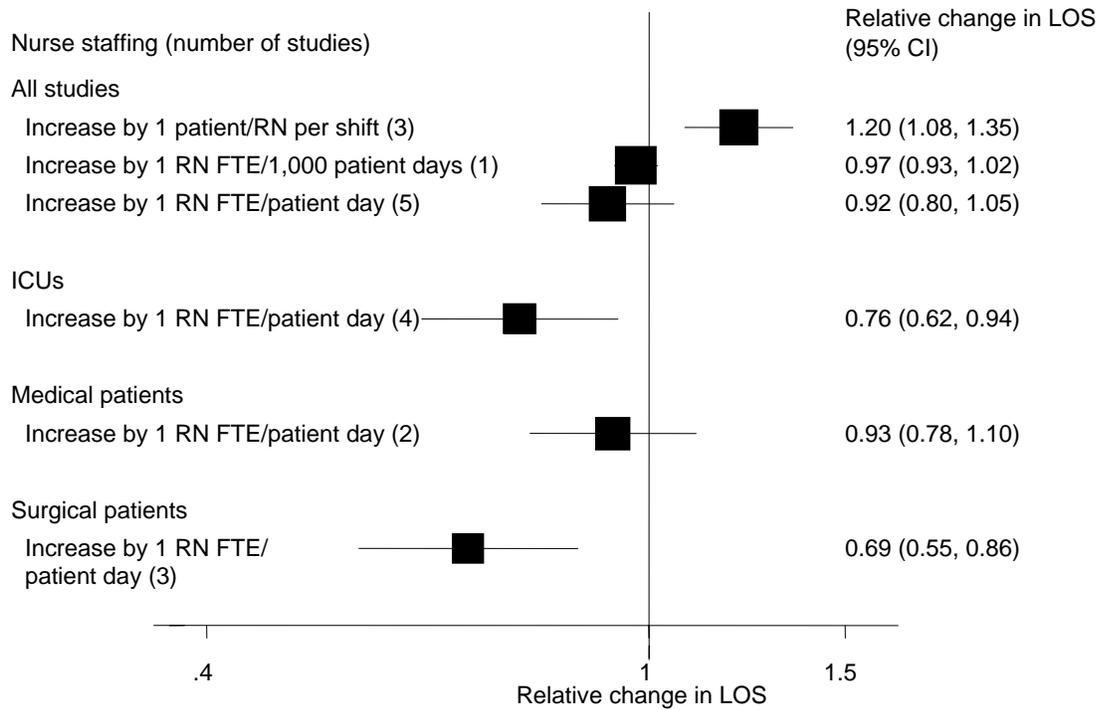
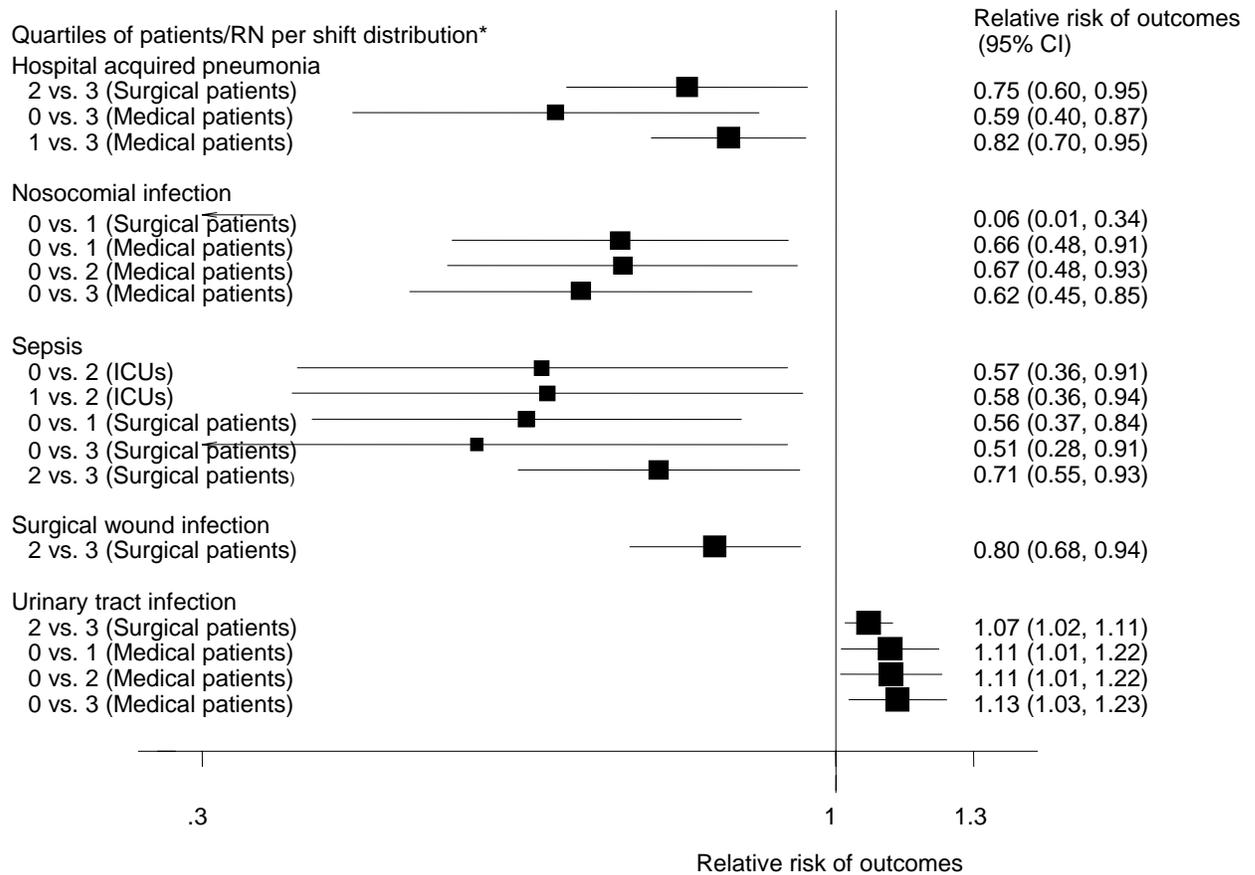


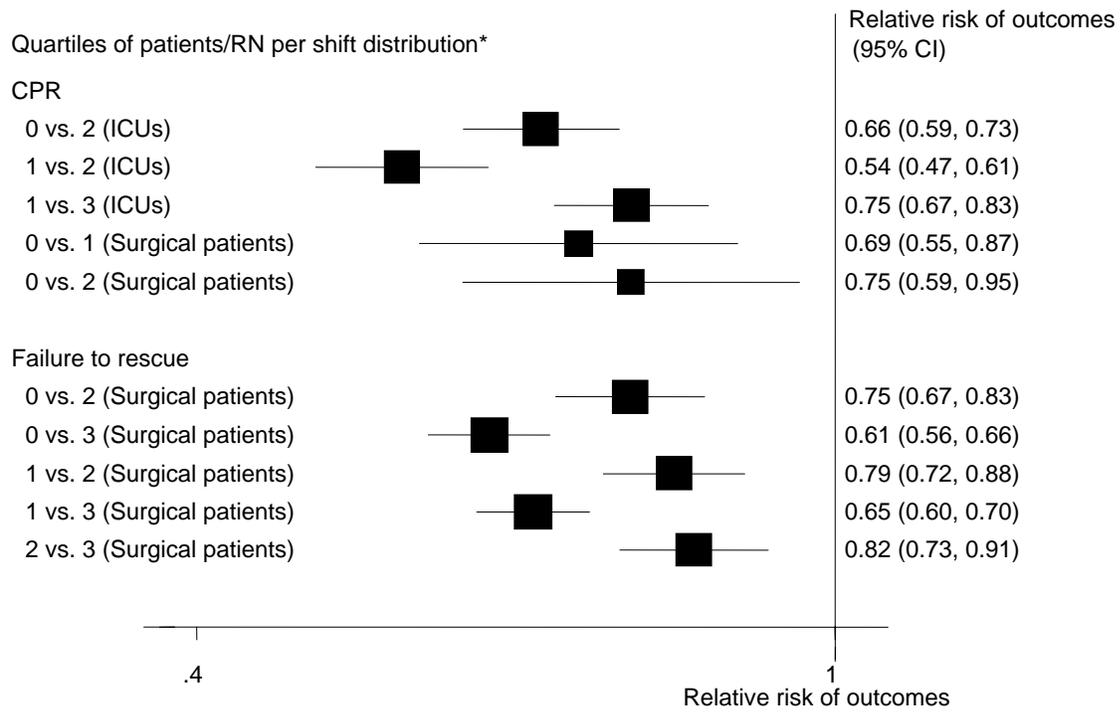
Figure 10. Relative risk of hospital acquired infections in quartiles of patients/RN/shift distribution (pooled analysis)



*The following table shows how the patients/RN/shift quartiles were established.

Quartiles	ICU	Surgical Patients	Medical Patients
0	<1.6	<2	<2
1	2.0	2.8	3.0
2	3.3	4.9	4.8
3	>4	>5	>6

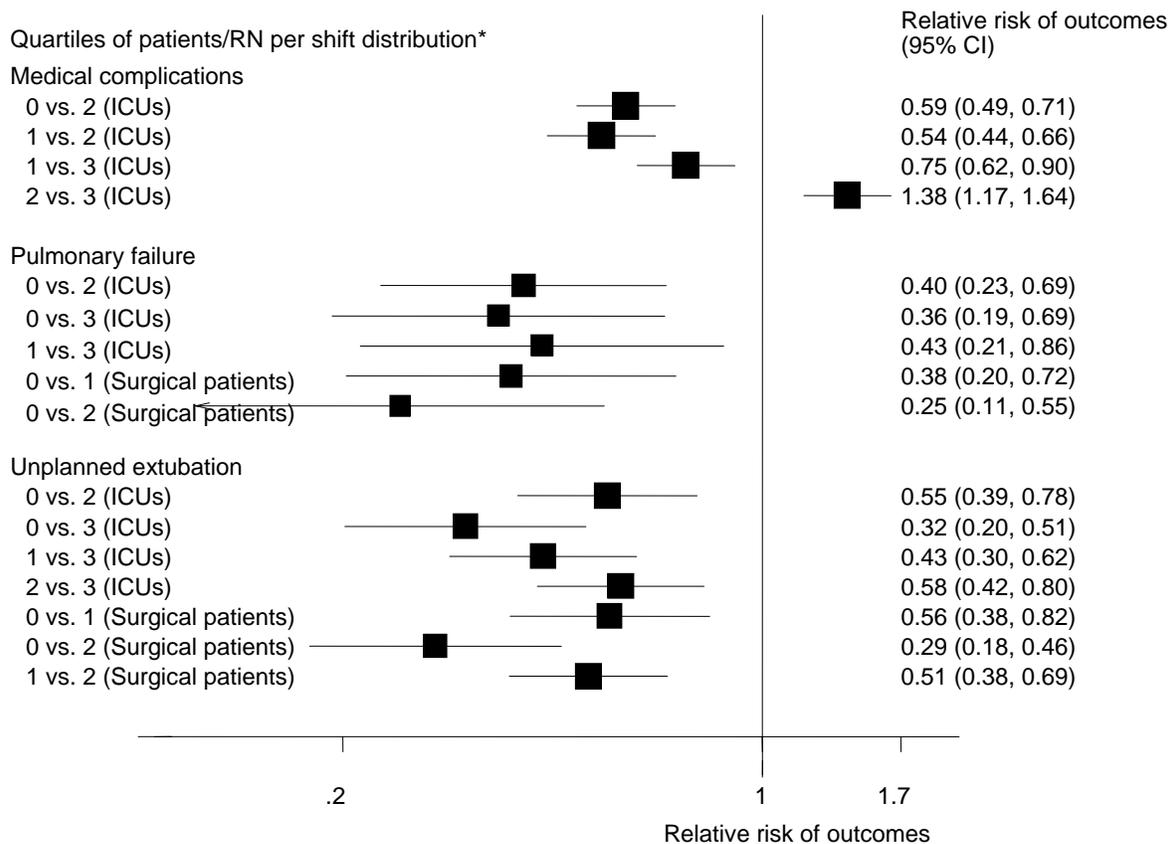
Figure 11. Relative risk of patient outcomes in quartiles of patients/RN/shift distribution (pooled analysis)



*The following table shows how the patients/RN/shift quartiles were established.

Quartiles	ICU	Surgical Patients
0	<1.6	<2
1	2.0	2.8
2	3.3	4.9
3	>4	>5

Figure 12. Relative risk of patient outcomes in quartiles of patients/RN/shift distribution (pooled analysis)



*The following table shows how the patients/RN/shift quartiles were established.

Quartiles	ICU	Surgical Patients
0	<1.6	<2
1	2.0	2.8
2	3.3	4.9
3	>4	>5

Table 14. Patient outcomes rates (%) corresponding to an increase by 1 hour in total nursing hours/patient day (pooled analysis)

Outcomes	Studies	Difference in Outcome Rate, %	Standard Error	p Value for the Association	Consistency
ICUs					
Falls	5	-0.08	0.01	<0.001	Yes
Nosocomial infection	4	-0.83	0.31	0.03	No
Sepsis	3	-0.24	0.47	0.63	Yes
Pressure ulcers	5	-0.90	0.65	0.30	Yes
Surgical patients					
Failure to rescue	2	-3.53	0.48	<.0001	Yes
Falls	3	0.12	0.07	0.16	Yes
Urinary tract infection	4	-4.23	0.97	0.001	Yes
Hospital acquired pneumonia	3	-2.20	0.52	0.002	Yes
Nosocomial infection	2	0.44	0.27	0.19	Yes
Sepsis	3	-1.33	0.27	0.001	Yes
Surgical wound infection	2	-0.31	0.05	0.000	Yes
Pressure ulcers	5	-2.26	0.34	<.0001	Yes
Gastrointestinal bleeding	2	-0.89	0.18	0.001	Yes
Shock	2	-0.77	0.14	0.000	Yes
Pulmonary failure	2	-2.39	0.49	0.001	Yes
Thrombosis	2	-0.45	0.11	0.002	Yes
Medical patients					
Failure to rescue	2	-1.39	0.50	0.02	Yes
Falls	11	-0.17	0.13	0.18	Yes
Urinary tract infection	7	-1.88	0.36	<.0001	Yes
Hospital acquired pneumonia	5	-0.89	0.27	0.004	Yes
Nosocomial infection	5	0.11	0.04	0.01	No
Sepsis	5	-0.06	0.05	0.25	Yes
Pressure ulcers	13	0.33	0.20	0.10	Yes
Gastrointestinal bleeding	2	-0.44	0.10	0.002	Yes
Shock	2	-0.34	0.05	<.0001	Yes
Thrombosis	2	-0.15	0.05	0.008	Yes

Figure 13. Relative risk of patient outcomes corresponding to an increase by 1 hour in total nursing hours/patient day

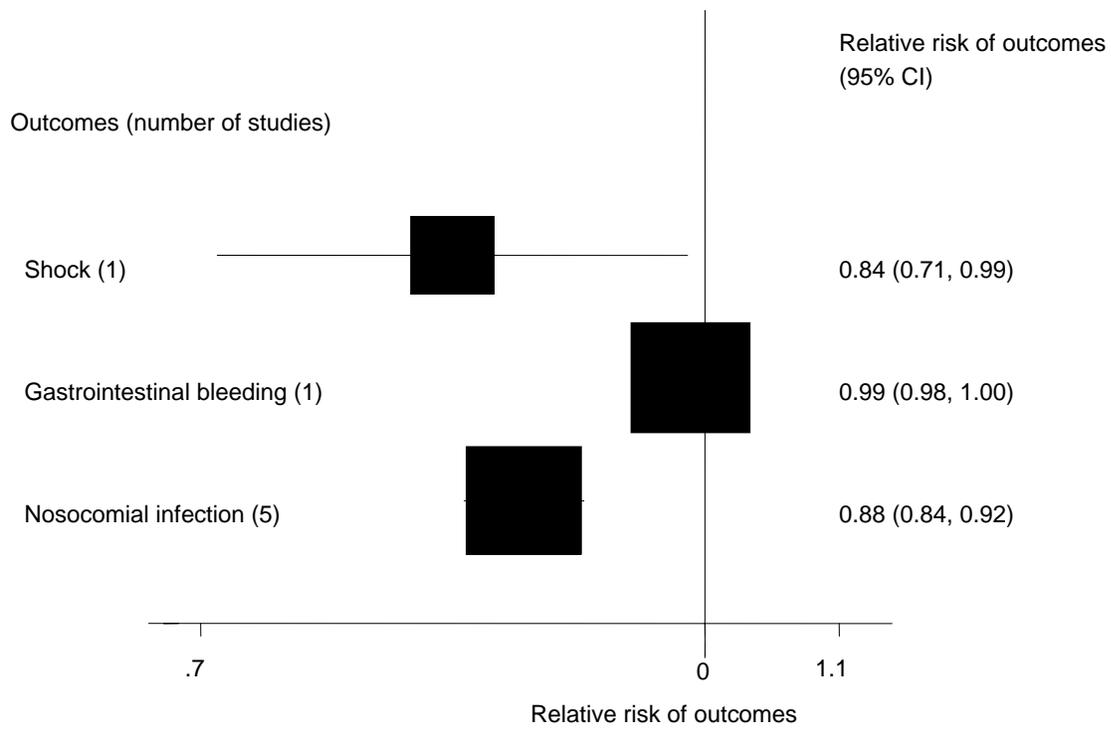


Table 15. Patient outcomes rates (%) corresponding to an increase by 1 hour in RN hours/patient day (pooled analysis reported by the authors and estimated RN hours/patient day)

Outcomes	Studies	Difference in Outcome Rate, %	Standard Error	p Value for the Association	Consistency
ICUs					
Failure to rescue	1	-0.46	0.16	0.013	
CPR	4	-0.10	0.01	0.001	No
Falls	4	-0.06	0.01	0.001	Yes
Urinary tract infection	1	1.55	1.12	0.397	Yes
Hospital acquired pneumonia	3	-0.46	0.25	0.210	Yes
Nosocomial infection	7	0.01	0.18	0.964	Yes
Sepsis	7	-0.10	0.07	0.168	Yes
Pressure ulcers	4	-0.19	0.48	0.760	Yes
Pulmonary failure	3	-1.43	0.23	0.003	Yes
Unplanned extubation	3	-0.92	0.07	0.000	No
Surgical patients					
Failure to rescue	4	-0.73	0.77	0.353	No
CPR	5	-0.10	0.01	0.001	No
Urinary tract infection	7	3.22	1.47	0.039	No
Hospital acquired pneumonia	6	1.15	0.70	0.114	No
Nosocomial infection	3	0.60	0.08	<.0001	Yes
Sepsis	7	0.73	0.45	0.120	No
Surgical wound infection	2	0.10	0.16	0.528	No
Pressure ulcers	4	-0.04	1.02	0.966	No
Gastrointestinal bleeding	2	0.53	0.48	0.303	No
Shock	2	0.43	0.40	0.312	No
Pulmonary failure	7	1.14	0.63	0.081	No
Unplanned extubation	3	-0.92	0.07	0.000	No
Thrombosis	4	0.20	0.15	0.203	No
Medical patients					
Failure to rescue	3	0.05	0.10	0.612	No
CPR	3	0.44	0.03	<.0001	No
Falls	11	0.33	0.05	<.0001	Yes
Urinary tract infection	9	1.61	0.34	<.0001	No
Hospital acquired pneumonia	6	0.66	0.17	0.000	No
Nosocomial infection	7	0.04	0.05	0.461	No
Sepsis	6	-0.22	0.09	0.023	Yes
Pressure ulcers	12	-1.06	0.32	0.002	No
Gastrointestinal bleeding	2	0.18	0.23	0.458	No
Shock	2	0.05	0.16	0.746	No
Pulmonary failure	2	0.01	0.01	0.280	Yes
Thrombosis	3	0.01	0.01	0.105	No

Figure 14. Relative risk of patient outcomes corresponding to an increase by 1 hour in RN hours/patient day (pooled analysis)

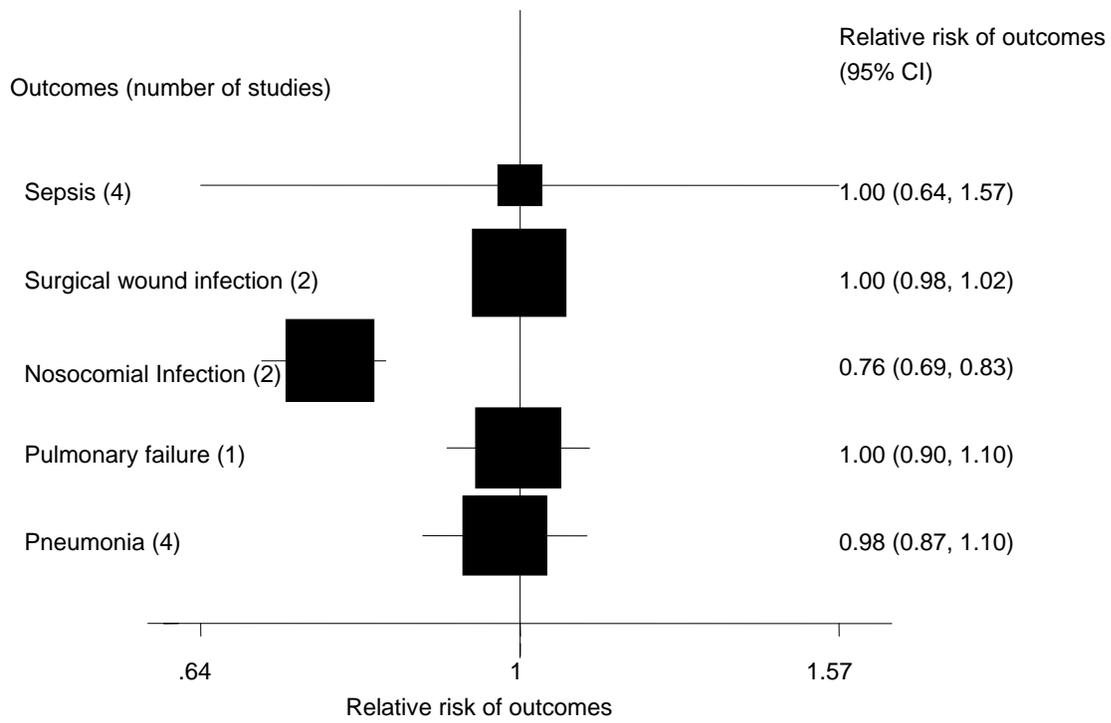


Figure 15. Relative risk of outcomes corresponding to an increase by 1 hour in RN hours/patient day (pooled analysis combined from reported and estimated hours)

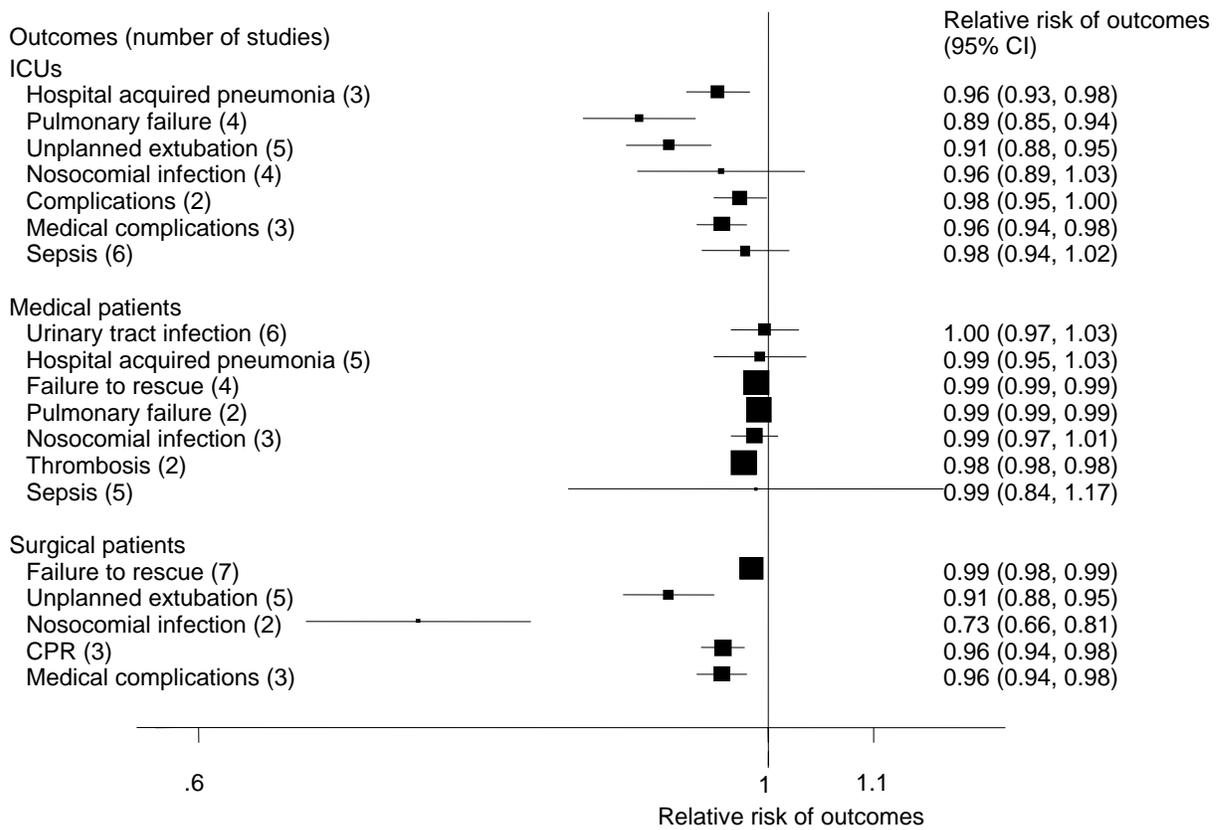


Table 16. Patient outcomes rates (%) corresponding to an increase by 1 hour in LPN/LVN hours/patient day (pooled analysis)

Outcomes	Studies	Difference in Outcome Rate,%	Standard Error	p Value for the Association	Consistency
Surgical patients					
Failure to rescue	2	2.68	1.22	0.05	Yes
Urinary tract infection	3	6.63	0.60	<.0001	Yes
Hospital acquired pneumonia	3	3.48	0.26	<.0001	Yes
Nosocomial infection	1	-2.70	4.61	0.62	
Sepsis	2	1.81	0.27	<.0001	Yes
Surgical wound infection	2	0.35	0.08	0.001	Yes
Pressure ulcers	2	2.60	0.60	0.002	Yes
Gastrointestinal bleeding	2	1.28	0.15	<.0001	Yes
Shock	2	1.04	0.15	<.0001	Yes
Pulmonary failure	3	3.31	0.31	<.0001	Yes
Thrombosis	3	0.67	0.06	<.0001	Yes
Medical patients					
Failure to rescue	2	1.25	0.89	0.19	Yes
CPR	2	-0.26	0.02	<.0001	Yes
Falls	3	-0.21	0.03	<.0001	Yes
Urinary tract infection	3	0.78	0.40	0.06	No
Hospital acquired pneumonia	3	0.81	0.28	0.01	No
Sepsis	2	-0.29	0.12	0.04	Yes
Pressure ulcers	7	-2.53	0.28	<.0001	No
Gastrointestinal bleeding	2	0.56	0.11	0.001	No
Shock	2	0.35	0.10	0.01	Yes
Pulmonary failure	1	-0.26	0.06	0.002	
Thrombosis	2	0.24	0.04	0.000	Yes

Figure 16. Patient outcomes rates (%) corresponding to an increase by 1 hour in UAP hours/patient day (pooled analysis)

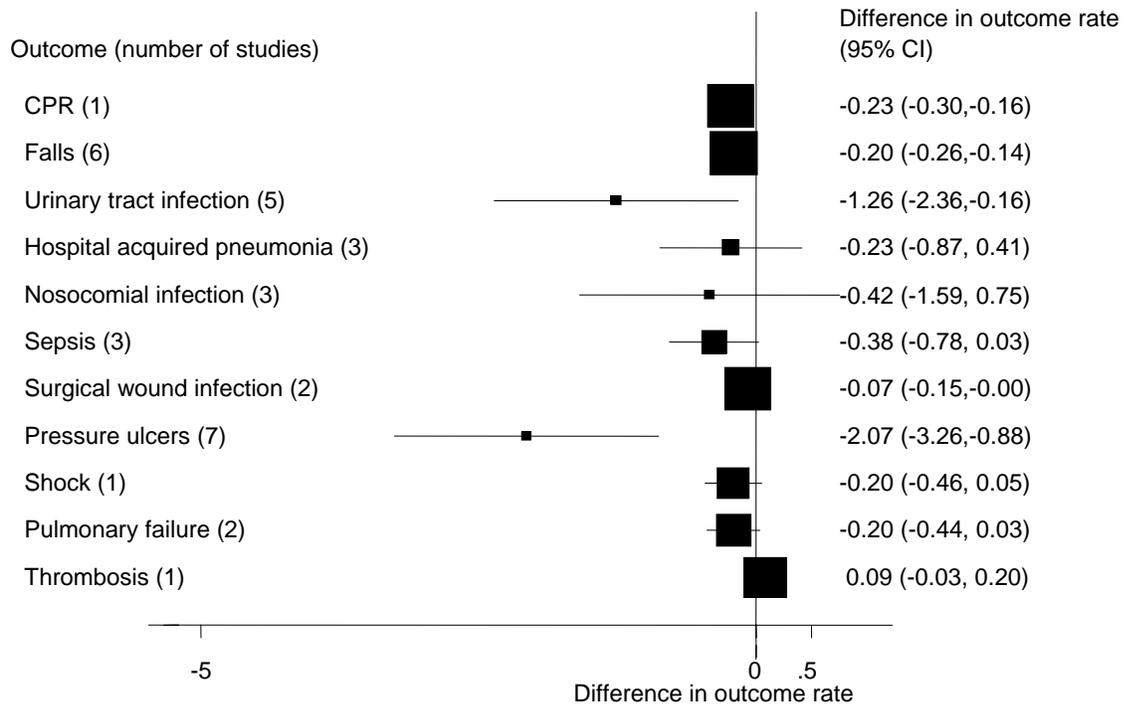


Figure 17. Changes in LOS corresponding to an increase by 1 nursing hour/patient day (pooled analysis)

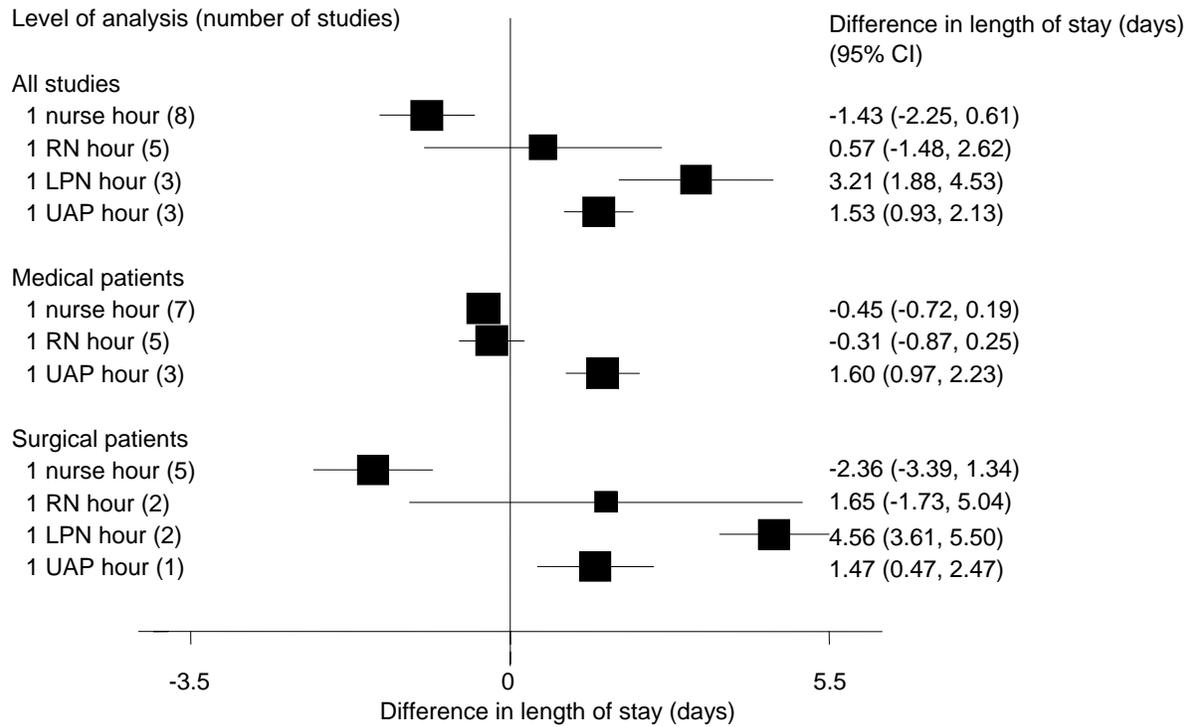


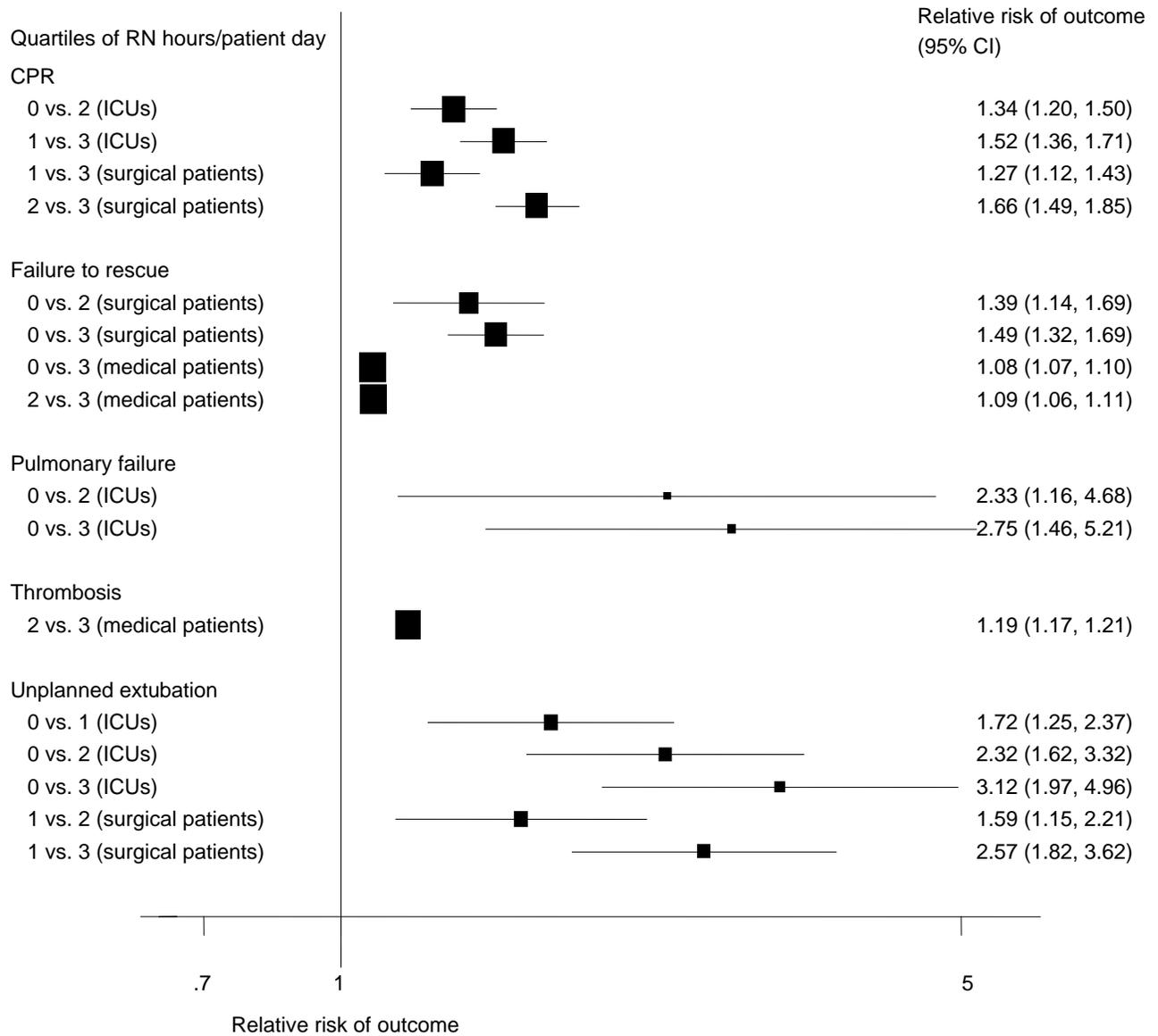
Table 17. Differences in outcomes rates (%) in quartiles of total nursing hours/patient day distribution (pooled analysis)

Quartiles	Outcomes	Difference in Rate, %	Standard Error	p Value for the Association	Consistency
ICUs					
1 vs. 2	Falls	0.76	0.22	0.02	Yes
1 vs. 3	Falls	0.59	0.10	0.002	
1 vs. 2	Nosocomial infection	7.24	1.97	0.01	No
2 vs. 3	Pressure ulcers	1.13	7.33	0.89	No
Surgical patients					
2 vs. 3	Failure to rescue	3.22	0.68	0.001	Yes
2 vs. 3	Surgical wound infection	0.29	0.05	0.00	Yes
2 vs. 3	Gastrointestinal bleeding	0.81	0.19	0.002	Yes
2 vs. 3	Shock	0.68	0.16	0.001	Yes
2 vs. 3	Pulmonary failure	2.17	0.50	0.001	Yes
2 vs. 3	Thrombosis	0.42	0.10	0.002	Yes
2 vs. 3	Falls	0.36	1.51	0.83	Yes
2 vs. 3	Urinary tract infection	4.10	0.85	0.000	Yes
0 vs. 2	Hospital acquired pneumonia	4.39	97.60	0.97	Yes
2 vs. 3	Hospital acquired pneumonia	2.01	0.53	0.003	
2 vs. 3	Sepsis	1.30	0.24	0.000	Yes
2 vs. 3	Pressure ulcers	2.31	0.31	<.0001	Yes
Medical patients					
2 vs. 3	Gastrointestinal bleeding	0.51	0.06	<.0001	Yes
2 vs. 3	Shock	0.36	0.04	<.0001	Yes
2 vs. 3	Thrombosis	0.17	0.03	0.000	Yes
1 vs. 3	Falls	7.62	1.55	<.0001	No
2 vs. 3	Falls	5.90	1.63	0.001	
2 vs. 3	Urinary tract infection	2.49	0.19	<.0001	Yes
2 vs. 3	Hospital acquired pneumonia	1.35	0.15	<.0001	Yes

The following table shows how quartiles of nurse hours were established.

Quartiles	ICU	Surgical Patients	Medical Patients
0	<6.32	<5.1	<5.6
1	8.3	6.2	7.0
2	12.1	9.5	9.6
3	>14.6	>11.37	>10.75

Figure 18. Relative risk of patient outcomes in quartiles of RN hours/patient day (pooled analysis of RN hours reported by the authors and estimated from RN ratios)



The following table shows how quartiles of nurse hours were established.

Quartiles	ICU	Surgical Patients	Medical Patients
0	<6	<4.2	<4
1	8.2	5.4	4.9
2	12.9	8.4	6.9
3	>16	>10.1	>8.1

Table 18. The distribution of nurse skill and experience mix, nurse education, and proportion of temporary and full-time nurse hours

	Number of Studies	Mean	Standard Deviation	Median
% RN	48	69.4	17.1	71.0
% licensed nurses	8	81.1	7.5	86.0
% of nurses with BSN	9	39.7	17.9	41.1
Experience in years	12	10.1	2.8	10.0
% overtime hours	2	11.7	6.5	15.8
% temporary nurses	12	16.2	12.6	13.0
% full-time nurses	3	78.0	11.3	78.0

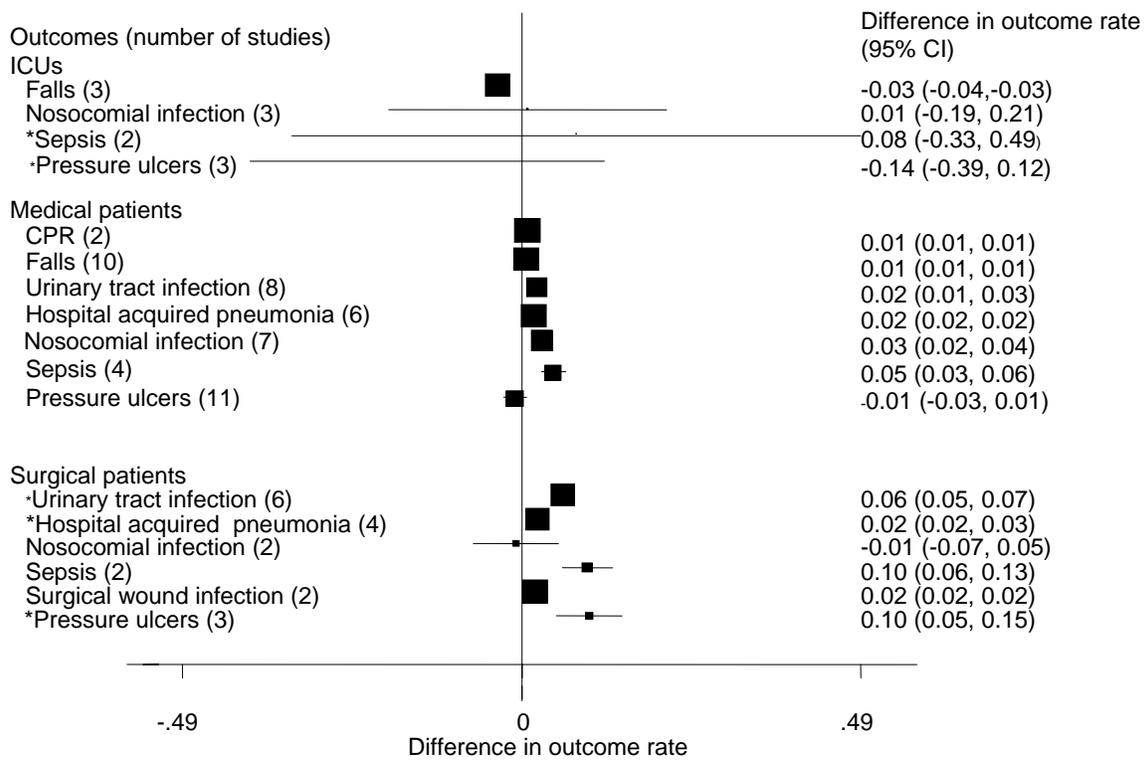
Table 19. Calculated changes in rates of patient outcomes corresponding to an increase by 1% in the proportion of RNs

Author, Analytic Unit	Hospital Unit	Patients	Outcome	Difference in Rate, %	95% CI
Hospital					
Krakauer ¹⁹¹	Combined	Medical	Mortality	-0.095	-0.13; -0.06
Hartz ¹⁹⁰	Combined	Medical	Mortality	-0.387	-0.58; -0.19
Hospital and Patient					
Cho ²⁸	Combined	Medical	Mortality	0.085	-0.03; 0.20
Aiken ⁵²	Combined	Medical	Mortality	-0.001	-0.001; -0.001
Tourangeau ¹⁴⁰	Combined	Medical	Mortality	-0.086	-0.16; -0.01
Cho ²⁸	Combined	Surgical	Surgical wound infection	0.057	-0.01; 0.13
Cho ²⁸	Combined	Medical	Urinary tract infection	0.107	0.09; 0.12
Cho ²⁸	Combined	Medical	Pneumonia	-0.017	-0.02; -0.02
Cho ²⁸	Combined	Medical	Pressure ulcers	-0.024	-0.04; -0.004
Cho ²⁸	Combined	Medical	Falls	-0.001	-0.02; 0.02
Hospital and unit					
Needleman ²⁶	Combined	Medical and surgical	Sepsis	0.065	-0.22; 0.35
Patient					
Unruh ³³	Combined	Combined	Mortality	0.039	0.04; 0.04
Unruh ³³	Combined	Combined	Pulmonary failure	0.009	0.007; 0.01
Unruh ³³	Combined	Combined	Cardiopulmonary resuscitation	0.008	0.01; 0.01
Hope ²²	Medical and surgical	Medical and surgical	Nosocomial infection	0.000	-0.01; 0.01
Hope ²²	Medical and surgical	Medical and surgical	Urinary tract infection	0.082	-0.06; 0.22
Simmonds ¹⁹²	Specialized	Medical	Nosocomial infection	-0.546	-1.28; 0.20
Unruh ³³	Combined	Surgical	Surgical wound infection	0.004	0.004; 0.004
Unruh ³³	Combined	Combined	Pneumonia	0.019	0.02; 0.02
Unruh ³³	Combined	Combined	Urinary tract infection	0.051	0.02; 0.08
Zidek ³⁶	Combined	Medical	Pressure ulcers	0.015	-0.03; 0.06
Zidek ³⁶	Combined	Medical	Falls	0.002	-0.08; 0.08
Unruh ³³	Combined	Combined	Falls	0.007	-0.001; 0.01
Seago ¹⁶⁶	Combined	Medical	Pressure ulcers	0.027	-0.10; 0.16
Seago ¹⁶⁶	Combined	Medical	Falls	0.020	-0.05; 0.09
Seago ¹⁵⁴	Combined	Medical	Falls	-0.047	-0.07; -0.02
Unit					
Blegen ²⁹	Combined, ICU, specialized	Medical and surgical	Mortality	-1.449	-3.4; 0.5
Ritter-Teitel ⁷⁶	Medical and surgical	Medical and surgical	Urinary tract infection	0.124	-0.83; 1.07
Stratton ¹⁹³	Combined, ICU, specialized	Medical and surgical	Nosocomial infection	0.033	0.02; 0.05
Blegen ²⁹	Combined, ICU, specialized	Medical and surgical	Nosocomial infection	-6.302	-8.16; -4.44
Ritter-Teitel ⁷⁶	Medical and surgical	Medical and surgical	Pressure ulcers	-0.111	-0.94; 0.72
Ritter-Teitel ⁷⁶	Medical and surgical	Medical and surgical	Falls	0.006	-0.24; 0.25
Blegen ²⁹	Combined, ICU, specialized	Medical and surgical	Pressure ulcers	-5.308	-6.32; -4.29

Table 19. Calculated changes in rates of patient outcomes corresponding to an increase by 1% in the proportion of RNs (continued)

Author, Analytic Unit	Hospital Unit	Patients	Outcome	Difference in Rate, %	95% CI
Blegen ²⁹	Combined, ICU, specialized	Medical and surgical	Falls	-0.015	-0.51; 0.48
Potter ⁷⁵	ICU	Medical	Falls	-0.048	-0.12; 0.06
Donaldson ⁶⁴	Step-down, Medical and surgical units	Medical and surgical	Pressure ulcers	0.121	-0.13; 0.37
Donaldson ⁶⁴	Step-down, Medical and surgical units	Medical and surgical	Falls	-0.059	-0.17; 0.01

Figure 20. Calculated changes in rates of patient outcomes corresponding to an increase by 1% in the proportion of RNs (pooled analysis)



*consistent across the studies (heterogeneity NS)

Figure 21. Relative risk of patient outcomes corresponding to an increase by 1% in the proportion of RNs (pooled analysis)

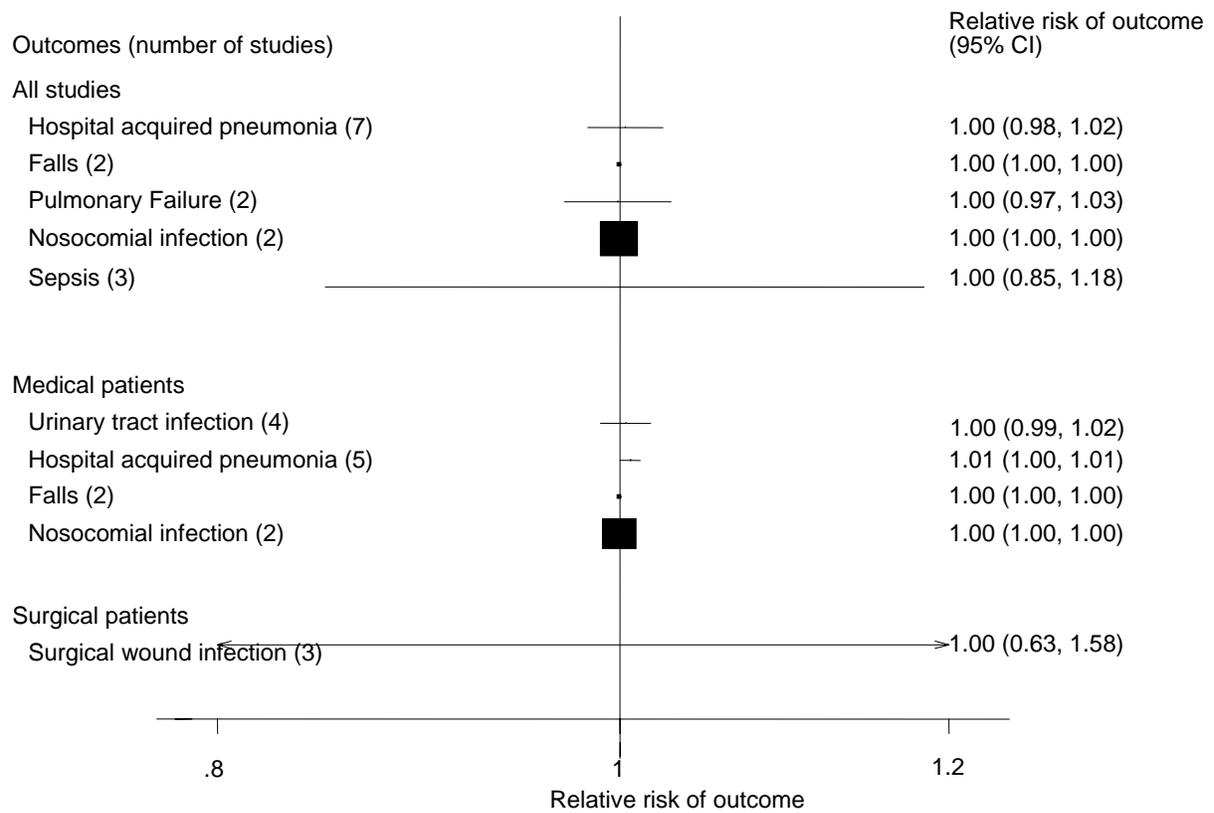


Figure 22. Relative risk of hospital related mortality and failure to rescue corresponding to an increase by 1% in the proportion of RNs (results from individual studies and pooled estimates)

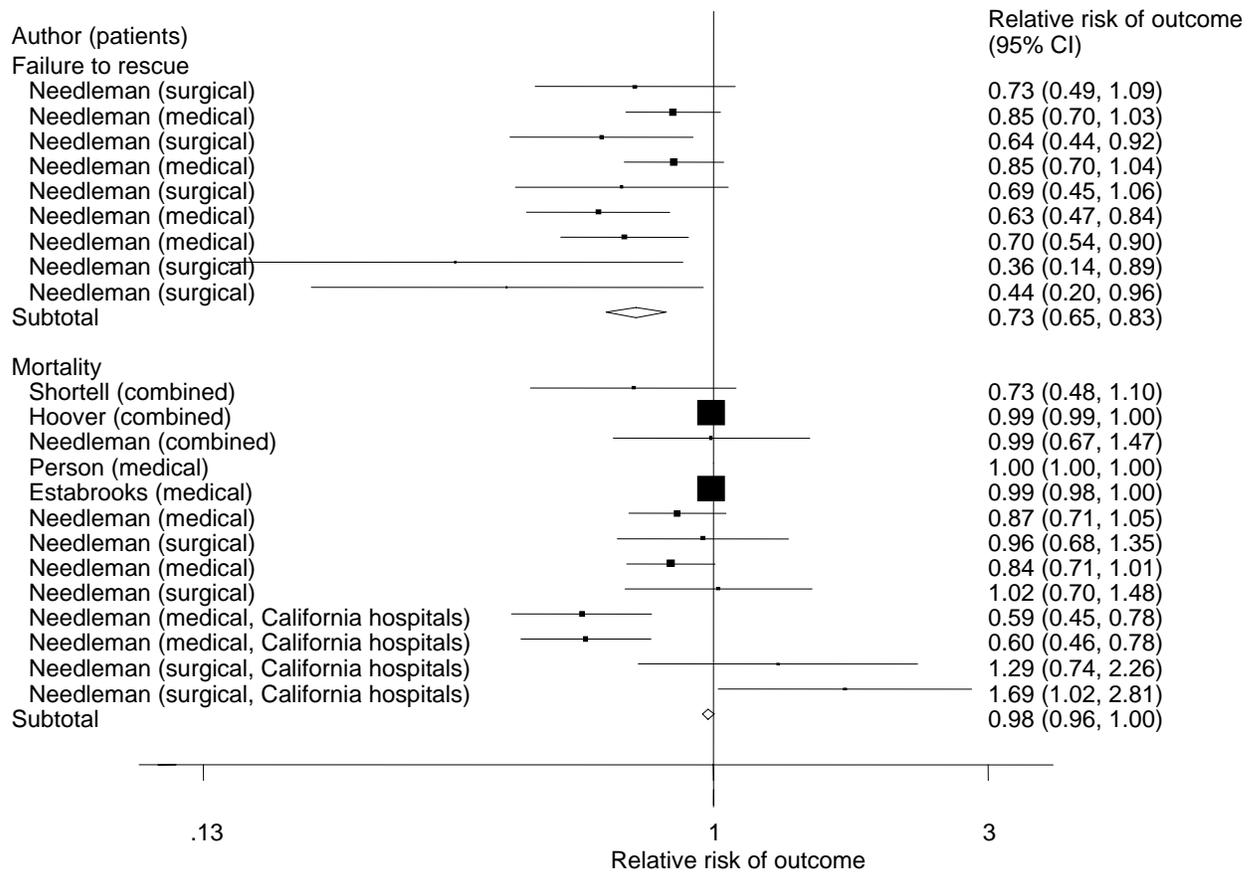


Figure 23. Relative risk of patient outcomes corresponding to an increase by 1% in the proportion of RNs (results from individual studies and pooled estimates)

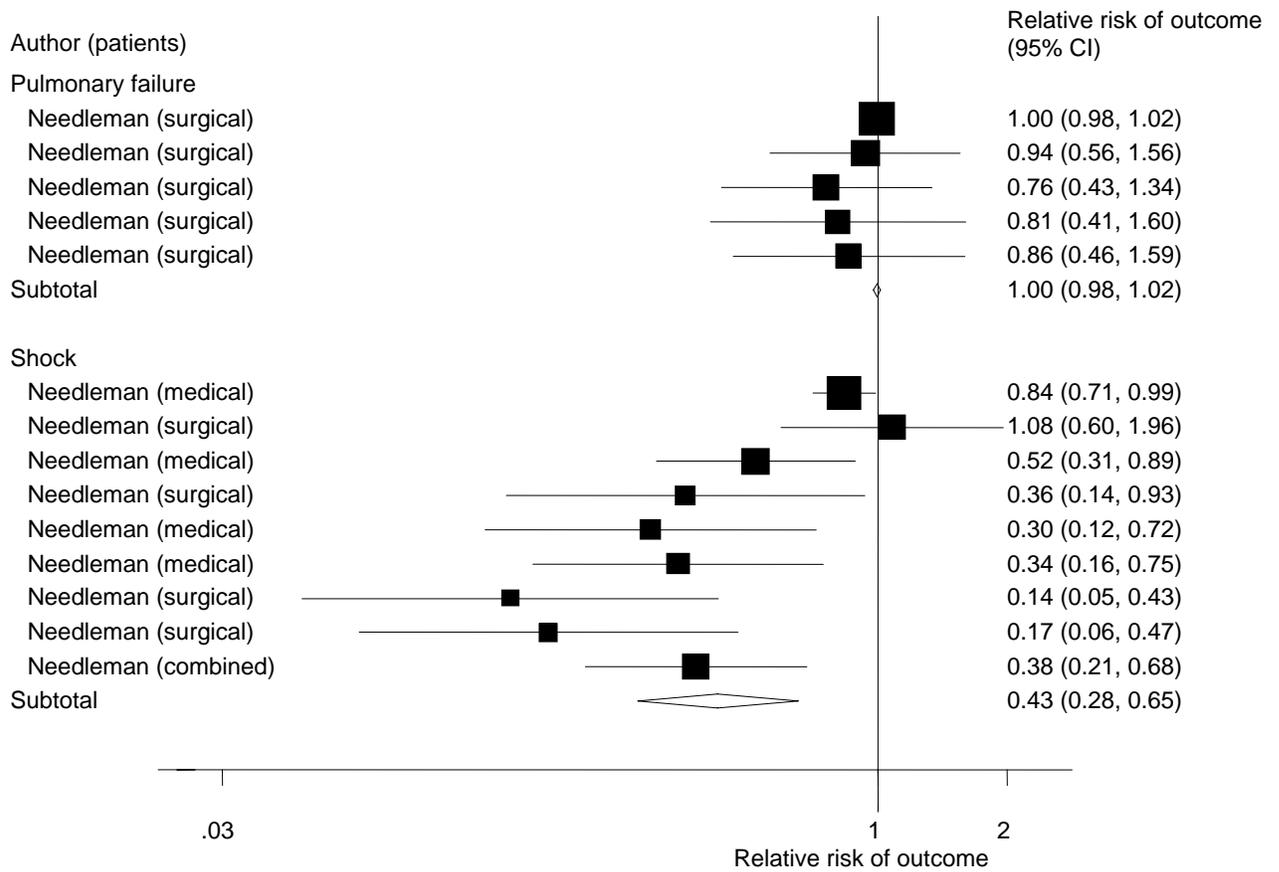


Table 20. Relative risk of patient outcomes corresponding to an increase by 1% in licensed nurse hours

Outcomes	Relative Risk	95% CI
Author (patients)		
Failure to rescue		
Needleman ²⁷ (medical)	0.81	0.66; 1.00
Needleman ²⁷ (surgical)	0.73	0.49; 1.09
Needleman ²⁷ (medical)	0.90	0.80; 1.01
Needleman ²⁷ (surgical)	0.82	0.70; 0.96
Needleman ²⁷ (medical)	0.58	0.40; 0.86
Needleman ²⁷ (medical)	0.69	0.50; 0.95
Needleman ²⁷ (surgical)	0.45	0.22; 0.92
Needleman ²⁷ (surgical)	0.54	0.30; 0.99
Needleman ²⁷ (medical)	0.80	0.64; 0.97
Needleman ²⁷ (surgical)	0.81	0.68; 0.94
Needleman ²⁷ (surgical)	0.70	0.37; 1.03
Needleman ²⁷ (surgical)	0.72	0.42; 1.01
Needleman ⁷ (medical)	0.90	0.80; 1.00
Needleman ²⁷ (medical)	0.81	0.64; 0.99
Needleman ²⁷ (medical)	0.81	0.66; 1.00
Cheung ⁶³ (medical)	1.00	1.00; 1.00
Mortality		
Berney ³⁰ (surgical)	0.97	0.95; 0.98
Needleman ²⁷ (medical)	0.90	0.74; 1.09
Needleman ²⁷ (surgical)	0.99	0.67; 1.47
Needleman ²⁷ (medical)	0.98	0.90; 1.08
Needleman ²⁷ (surgical)	0.88	0.75; 1.03
Needleman ²⁷ (medical)	0.91	0.65; 1.27
Needleman ²⁷ (medical)	0.89	0.68; 1.16
Needleman ²⁷ (surgical)	0.76	0.34; 1.69
Needleman ²⁷ (surgical)	0.87	0.47; 1.61
Needleman ²⁷ (medical)	0.90	0.74; 1.09
CPR		
Needleman ²⁷ (surgical)	0.59	0.42; 0.76
Needleman ²⁷ (surgical)	0.42	0.10; 0.74
Needleman ²⁷ (surgical)	0.60	0.19; 1.00
Needleman ²⁷ (medical)	0.66	0.48; 0.85
Needleman ²⁷ (medical)	0.40	0.18; 0.63
Pulmonary failure		
Needleman ²⁷ (surgical)	1.10	0.63; 1.92
Needleman ²⁷ (surgical)	1.21	0.99; 1.47
Needleman ²⁷ (surgical)	1.00	0.39; 2.60
Needleman ²⁷ (surgical)	1.02	0.45; 2.32
Shock		
Needleman ²⁷ (medical)	0.46	0.27; 0.81
Needleman ²⁷ (surgical)	0.54	0.28; 1.04
Needleman ²⁷ (medical)	0.66	0.50; 0.87
Needleman ²⁷ (surgical)	0.59	0.44; 0.78
Needleman ²⁷ (medical)	0.20	0.08; 0.53
Needleman ²⁷ (medical)	0.40	0.19; 0.86
Needleman ²⁷ (surgical)	0.22	0.09; 0.57
Needleman ²⁷ (surgical)	0.27	0.12; 0.61
Needleman ²⁷ (medical)	0.49	0.21; 0.77
Needleman ²⁷ (surgical)	0.59	0.42; 0.76
Needleman ²⁷ (surgical)	0.42	0.10; 0.74
Needleman ²⁷ (surgical)	0.60	0.19; 1.00
Needleman ²⁷ (medical)	0.66	0.48; 0.85
Needleman ²⁷ (medical)	0.40	0.18; 0.63
Needleman ²⁷ (medical)	0.46	0.27; 0.81

Table 20. Relative risk of patient outcomes corresponding to an increase by 1% in licensed nurse hours (continued)

Outcomes	Relative Risk	95% CI
Nosocomial Infection		
Cheung ⁶³ (medical)	1.00	1.00; 1.00
Pneumonia		
Needleman ²⁷ (medical)	0.60	0.44; 0.80
Needleman ²⁷ (surgical)	0.56	0.31; 1.01
Needleman ²⁷ (medical)	0.83	0.71; 0.98
Needleman ²⁷ (surgical)	0.94	0.76; 1.16
Needleman ²⁷ (medical)	0.52	0.32; 0.87
Needleman ²⁷ (medical)	0.69	0.47; 1.03
Needleman ²⁷ (surgical)	0.66	0.26; 1.69
Needleman ²⁷ (surgical)	0.79	0.37; 1.71
Needleman ²⁷ (medical)	0.61	0.42; 0.79
Needleman ²⁷ (surgical)	0.94	0.74; 1.13
Needleman ²⁷ (surgical)	0.36	0.12; 0.59
Needleman ²⁷ (surgical)	0.52	0.20; 0.84
Needleman ²⁷ (medical)	0.83	0.70; 0.96
Needleman ²⁷ (medical)	0.59	0.39; 0.78
Needleman ²⁷ (medical)	0.59	0.44; 0.80
Surgical wound infection		
Needleman ²⁷ (surgical)	1.91	1.34; 2.48
Needleman ²⁷ (surgical)	0.93	0.24; 1.62
Needleman ²⁷ (surgical)	1.33	0.53; 2.13
Sepsis		
Needleman ²⁷ (medical)	1.39	0.85; 1.94
Needleman ²⁷ (surgical)	1.10	0.85; 1.35
Needleman ²⁷ (surgical)	0.86	0.30; 1.42
Needleman ²⁷ (surgical)	1.11	0.47; 1.74
Needleman ²⁷ (medical)	1.24	0.97; 1.51
Needleman ²⁷ (medical)	1.11	0.65; 1.56
Needleman ²⁷ (medical)	1.01	1.00; 1.01
Berney ³⁰ (surgical)	1.01	1.00; 1.01
Urinary tract infection		
Needleman ²⁷ (medical)	0.48	0.38; 0.61
Needleman ²⁷ (surgical)	0.67	0.46; 0.98
Needleman ²⁷ (medical)	0.77	0.68; 0.86
Needleman ²⁷ (surgical)	0.89	0.75; 1.07
Needleman ²⁷ (medical)	0.44	0.28; 0.70
Needleman ²⁷ (medical)	0.60	0.41; 0.87
Needleman ²⁷ (surgical)	0.64	0.30; 1.37
Needleman ²⁷ (medical)	0.49	0.37; 0.61
Needleman ²⁷ (surgical)	0.88	0.71; 1.04
Needleman ²⁷ (surgical)	0.68	0.40; 0.95
Needleman ²⁷ (surgical)	0.59	0.36; 0.82
Needleman ²⁷ (medical)	0.76	0.67; 0.85
Needleman ²⁷ (medical)	0.54	0.41; 0.66
Needleman ²⁷ (medical)	0.48	0.38; 0.61
Berney ³⁰ (medical)	1.00	0.99; 1.00
Berney ³⁰ (surgical)	1.00	0.99; 1.00
Complications		
Needleman ²⁷ (surgical)	2.43	1.00; 5.93
Needleman ²⁷ (medical)	1.86	1.32; 2.62
Needleman ²⁷ (surgical)	1.62	1.02; 2.56
Needleman ²⁷ (medical)	1.44	0.39; 5.32
Needleman ²⁷ (medical)	1.04	0.32; 3.35
Needleman ²⁷ (surgical)	4.13	0.53; 32.25
Needleman ²⁷ (surgical)	1.83	0.32; 10.49

Table 20. Relative risk of patient outcomes corresponding to an increase by 1% in licensed nurse hours (continued)

Outcomes	Relative Risk	95% CI
Gastrointestinal bleeding		
Needleman ²⁷ (medical)	0.66	0.46; 0.96
Needleman ²⁷ (surgical)	0.57	0.28; 1.15
Needleman ²⁷ (medical)	0.96	0.79; 1.16
Needleman ²⁷ (surgical)	0.78	0.59; 1.03
Needleman ²⁷ (medical)	0.83	0.40; 1.72
Needleman ²⁷ (medical)	0.87	0.48; 1.58
Needleman ²⁷ (surgical)	0.72	0.22; 2.37
Needleman ²⁷ (surgical)	0.63	0.23; 1.71
Needleman ²⁷ (surgical)	0.77	0.56; 0.98
Needleman ²⁷ (surgical)	0.40	0.07; 0.74
Needleman ²⁷ (surgical)	0.53	0.15; 0.90
Needleman ²⁷ (medical)	0.96	0.77; 1.15
Needleman ²⁷ (medical)	0.68	0.42; 0.95
Needleman ²⁷ (medical)	0.66	0.45; 0.96
Berney ³⁰ (medical)	1.00	1.00; 1.01
Berney ³⁰ (surgical)	1.01	1.00; 1.01
Pressure ulcers		
Cheung ⁶³ (medical)	1.00	1.00; 1.00
Needleman ²⁷ (medical)	0.73	0.49; 1.08
Needleman ²⁷ (surgical)	1.38	0.69; 2.78
Needleman ²⁷ (surgical)	0.94	0.74; 1.19
Needleman ²⁷ (medical)	0.35	0.15; 0.79
Needleman ²⁷ (medical)	0.55	0.28; 1.06
Needleman ²⁷ (surgical)	0.68	0.18; 2.52
Needleman ²⁷ (surgical)	0.71	0.26; 1.94
Needleman ²⁷ (medical)	0.77	0.46; 1.07
Needleman ²⁷ (surgical)	0.90	0.68; 1.12
Needleman ²⁷ (surgical)	0.81	0.14; 1.49
Needleman ²⁷ (surgical)	0.83	0.24; 1.41
Needleman ²⁷ (medical)	0.89	0.70; 1.09
Needleman ²⁷ (medical)	0.71	0.40; 1.02
Thrombosis		
Needleman ²⁷⁷ (medical)	1.39	0.92; 2.11
Needleman ²⁷ (surgical)	1.29	0.66; 2.54
Needleman ²⁷ (medical)	1.28	1.02; 1.60
Needleman ²⁷ (surgical)	1.52	1.12; 2.07
Needleman ²⁷ (medical)	1.97	0.84; 4.58
Needleman ²⁷ (Medical)	1.55	0.78; 3.07
Needleman ²⁷ (surgical)	0.03	0.00; 0.66
Needleman ²⁷ (surgical)	1.11	1.04; 1.18

Figure 25. Relative risk of hospital related mortality and failure to rescue corresponding to an increase by 1% in the proportion of licensed nurses

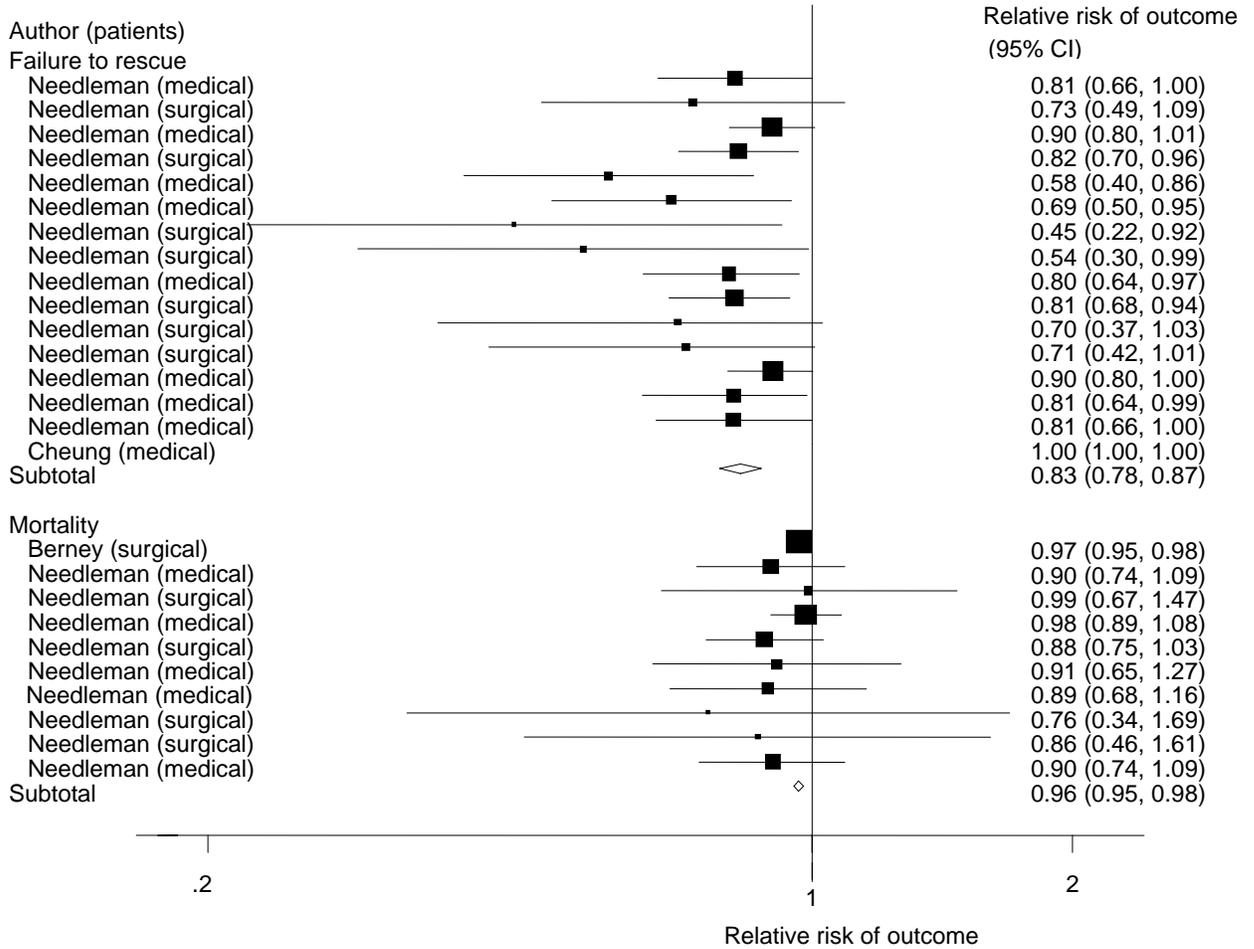
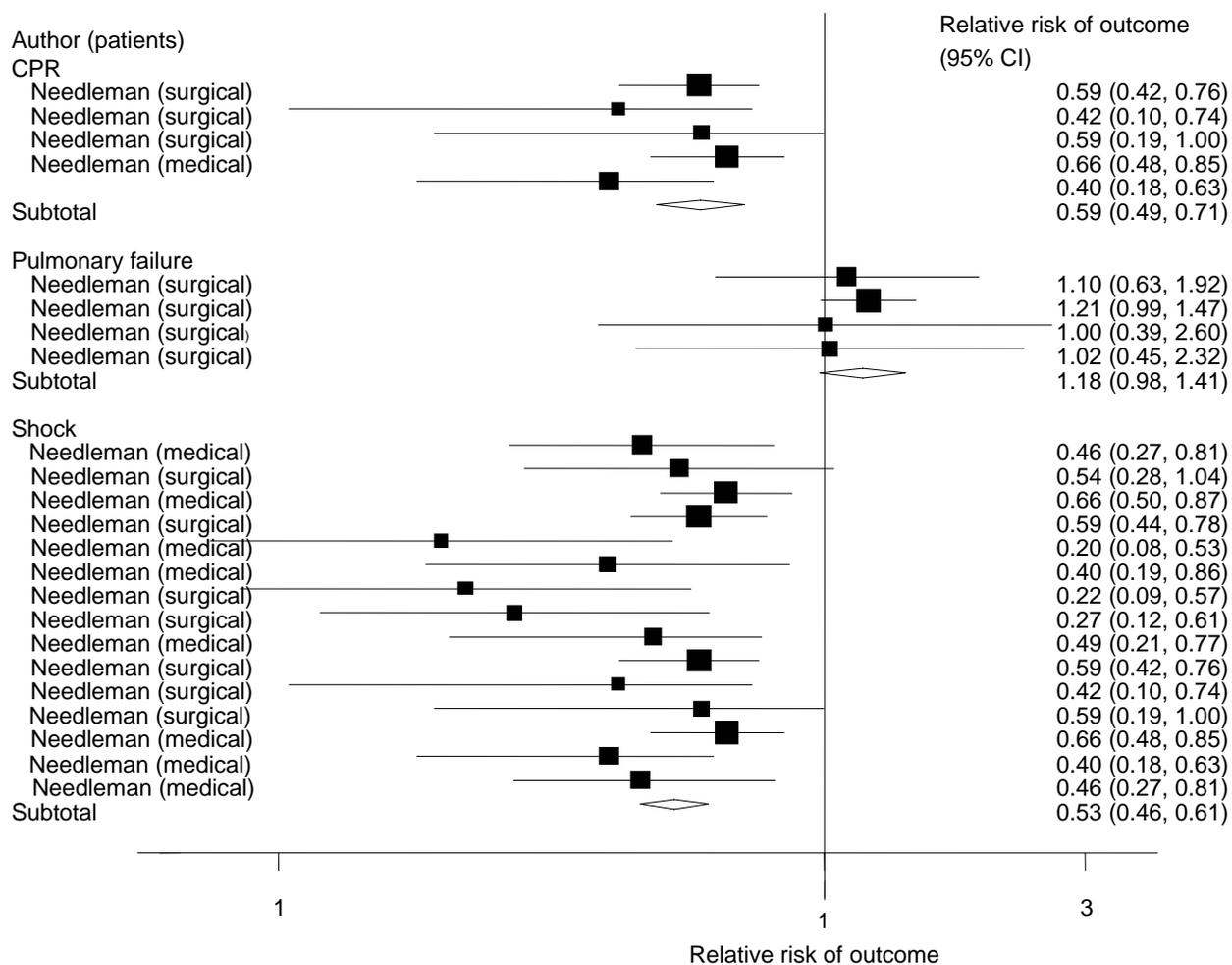


Figure 26. Relative risk of patient outcomes corresponding to an increase by 1% in the proportion of licensed nurses



Chapter 4. Discussion

Association or Cause

The present review and meta-analysis confirm previous contentions that increased nurse staffing in hospitals is associated with better care outcomes.^{27,51,93} A persistent question is whether this association reflects a causal relationship. One test of such a causal relationship should be that higher staffing levels should produce stronger effects for nurse sensitive outcomes than for more general outcomes. The evidence across 14 studies consistently suggests that the risk of hospital related mortality was 9 percent lower in ICUs, 6 percent lower for medical patients, and 16 percent lower for surgical patients for each additional RN FTE per patient day (Figure 27). The risk of nurse-sensitive patient outcomes was comparable with those for mortality independent of study design. The relative risk of failure to rescue was reduced by 16 percent in surgical patients and hospital-acquired pneumonia by 30 percent in ICUs, rates substantially higher than those for mortality.

Another test would be the difference in effect size between longitudinal and cross-sectional designs. The former should more directly reflect the effects of changing staffing patterns by holding more constant other hospital variables. Studies that attempted to assess temporality in the association between nurse staffing and failure to rescue had a lower relative risk per RN FTE per patient day ratio (RR 0.84, 95 percent CI 0.75-0.93) than did those using cross-sectional designs (RR 0.92, 95 percent CI 0.91-0.93), supporting the presence of an association rather than a cause.

We also examined the role of the study characteristics on the association between nurse ratios and patient outcomes. We tested the following study characteristics that could modify the association between nurse ratios and patient outcomes: quality scores, assessment of temporality in the association, analytic units, hospital units, patient populations, the adjustment for patient comorbidities, provider characteristic, and clustering of patients and hospitals. The authors adjusted for patient comorbidities at patient and hospital levels and for provider characteristics including hospital teaching and profit status, size and volume, technology index, HMO penetration, and staffing. We examined the association of four aspects of nurse ratios (total, RN, LPN/LVN, UAP) licensed and the same four for nursing hours with 16 outcomes expressed as rates and 19 expressed as relative risks for a total of 280 (eight effect modifiers times 35 outcomes). Only a small proportion of tested models showed a significant influence of study design on the association with nurse staffing and patient outcomes (Appendix G*, Table G30). Among the possible interactions, only the LPN effects were significant more the 30 percent of the time. The proportion of significant interactions was considerably lower for relative risks.

Hospitals that invest in more nurses may also invest in other actions that improve quality. Empirical evidence suggests that magnet hospitals provide high quality care and report better patient outcomes in relation to nurse staffing.^{10,52,57,198,199}

Several lines of evidence suggest that overall hospital commitment to a high quality of care in combination with effective nurse retention strategies leads to better patient outcomes, patient satisfaction with overall and nursing care, and nurse satisfaction with job and provided care.^{10,52-54,57-59} Hospital volume,²⁰ physician practice patterns, and collaboration with nurses^{8,9} may affect

* Appendixes and Evidence Tables for this report are provided electronically at <http://www.ahrq.gov/clinic/tp/nursesttp.htm>

patient outcomes. Professional practice environments in hospitals, which enable nurses to control their practice through governance also contribute to nurses' job satisfaction and positive perceptions of nurse autonomy. These factors are associated with nurse retention and better patient outcomes in several reports.^{15,21,78,152,161,164,165,200,201} Hospitals with better professional nurse practice environment had improved RN staffing ratios.^{55,56} Magnet hospitals had lower patients per RN ratios, better nurse manager ability and support, and collegial nurse-physician relations.^{53-57,152,202,203} The quality of the nurse professional practice work environment correlated with patient safety outcomes in several studies.^{15,21,66,164,201,204}

The outcomes of hospital care are the result of many factors. The studies reviewed here did not, and perhaps could not, address many salient issues. Patient outcomes are affected by patient characteristics. Case mix, when addressed, was usually handled as a mean number averaged across all patients in a unit or hospital. Such averages can hide a lot of different mixtures. Detailed information on comorbidities and disease severity was not included. Likewise, the nature of core medical treatments was not addressed. The absence of these measures can have varied effects depending on whether one believes they represent noise or bias. Case mix differences may hide areas where nurse staffing makes a bigger difference if it is not associated directly with staffing levels, but if it is, it could lead to bias. Such bias should result from more staff going to patients who need more care and hence would decrease the effects seen. These studies best approximate that correction by examining different types of units, which serve patients in varying levels of severity.

The absence of information on medical care is another important shortcoming of these studies, although it would greatly complicate the study designs. Here too, bias needs to be separated from noise. There is no strong basis to assume that the quality of medical care is necessarily correlated with the level of staffing, but it seems unlikely that it would be inversely correlated. With that assumption, any bias would result from hospitals that invested in more staffing also pressing for better medical care, an assumption that seems feasible.

Marginal Effects

Previous systematic reviews did not estimate the effect size of different nurse staffing measures.^{92,93} Associations were considered to be clinically important when a 10 percent difference in staffing levels was associated with significant changes in outcomes.⁹² When attempting to find optimal nurse staffing ratio and hours, the effect size could not be estimated reliably because of differences in the studies and possible curvilinear associations.⁹³ One study²⁶ examined the overall linear trend in adverse events corresponding to a one unit increase in nurse staffing and differences in the rates of patient outcomes among the lowest and highest quartiles of the nurse staffing distribution to find an optimal staffing pattern.²⁶

Hospital mortality shows a decline with increasing staffing, but the decline is not linear. The risk increases quickly as the patients per RN per shift ratio rises above four to five. The mean increase of 7 percent for each additional patient per RN per shift can be misleading; the goodness of fit of the linear slope varied across the distribution of nurse to patient ratio. The effect size of this nonlinear association was tested to detect the overall trend and relative and absolute changes in patient outcomes among nurse staffing categories using quartiles of the distribution. Comparing the lowest with the highest quartiles of patients per RN per shift ratio, the observed risk of mortality was 61 percent compared to expected 85 percent (1.61 observed vs. 1.85 expected) if the slope was applied to the differences in the ratio. Moreover, we would expect the

risk of mortality to be 19 percent lower when the workload of patients per RN per shift decreased from four to two patients, but in fact it was only 6 percent lower.

We used several ways to analyze strengths and limitations of the individual studies. Applicability of the study was estimated according to a sampling of eligible hospitals and patients with the highest applicability in studies with random population based sampling and random hospital-based sampling and the lowest in the studies with convenient and self-selected sampling. We analyzed the internal validity of the studies by the validation of measured nurse staffing, patient outcomes, and all confounding factors the authors reported. We graded the adjustment for patient characteristics (age, race, comorbidities, socioeconomic status), provider characteristics, and clustering of patients and clinics. We included summarized quality scores and the fact of adjustment for the each of confounding factors in the meta-regression and sensitivity analysis. We compared the direction and the strength of the association from the studies that used different definitions of nurse staffing and patient outcomes (rates and relative risk). We compared the direction and the strength of the association from the studies at patient level analysis that could carefully adjust for patient and nurses characteristics (better internal validity but lower applicability) and large multi-centers studies obtained hospital averages from administrative databases (low internal validity but better applicability). To examine statistically the influence of study quality on tested associations we compared pooled estimates weighted by the sample size and weighted by the quality of the studies and did not detect substantial differences.

Geographical variations in nurse distributions¹⁴⁴ and rates of fatal adverse events¹⁴⁸ may impact the effect size of nurse staffing on patient outcomes. Few multi-hospital studies used random effects models to incorporate geographical differences in the estimation,^{33,49,94} 37 percent of the included studies reported random sampling and assessments of sampling bias. We compared means of nurse staffing in the studies we included in the meta-analysis with published means²⁶ and did not detect substantial differences. However, the report of the Institute of Medicine⁷⁴ suggested that a larger proportion of hospitals have poorer nurse staffing than published in scientific research. Therefore, the effect size of nurse staffing on patient outcomes from the present report can be generalized only to hospitals with similar nurse staffing patterns.

Nurse Staffing and Patient Outcomes in Hospitals

The majority of the studies found that hospitals with more RNs working with patients had a lower level of patient adverse events related to health care. If these associations were causal, Table 21 estimates the effect size in terms of the number of patient adverse events that could be avoided by adding 8 RN hours a patient receives during 24 hours in a hospital. Table 22 shows the proportion of patient adverse events that could theoretically be avoided by reducing the number of patients assigned to an RN during an 8-hour shift.

Staffing Measures

Two general measures of nurse staffing were studied. One looks superficially at hours of care provided by different types of nursing staff averaging FTEs of different nurse categories at the hospital level,^{11,18,19} including only productive hours worked in direct care.^{28,61,62} The other relies on a less precise ratio of total nurse staffing to patient volume derived from administrative databases⁶³⁻⁶⁵ averaging annual nurse-to patient ratios²⁰ at the hospital or unit level. The patients

per RN per shift ratio was more frequently used and provided greater evidence of the effect, but both showed generally the same trends. Inconsistency in nurse staffing operational definitions and methods to measure with an unknown “gold standard” to assess staffing patterns at the patient levels may bias the results of the studies and consequently, pooled analysis.²⁰⁶ Because many of the studies of nurse staffing were based on administrative data, they expressed staffing levels in terms of RN FTEs per patient or similar measures. However, the individuals charged with actually managing staffing are more likely to think in terms of patients per nurse. A simple, back-of-the-envelope transformation would be that 1 RN FTE per patient day would translate to 8 RN hours per patient day or three patients per RN per shift. If the average is 7.8 RN hours per patient day (~3 patients per RN per shift), then increasing staffing by 1 RN FTE per patient day would mean a decrease to 1.5 patients per nurse.

The effect size varied depending on the nurse staffing measure. The reduction in relative risk of hospital related mortality is 16 percent for 1 RN FTE per patient day and 1 percent for an additional RN hour per patient day in surgical patients. Assuming that every additional RN per FTE patient day would provide approximately 8 additional RN hours per patient day, the expected reduction should be more than observed in the studies that examined the risk of mortality in relation to nurse hours (Table 23). The comparison of the effect size on patient outcomes among quartiles of the RN FTE per patient day ratio and nurse hours per patient day detected the same pattern (Table 24); the maximal reduction in relative risk of hospital-related mortality and adverse events occurred when no more than two patients were assigned to an RN in ICUs and in surgical units, and more than 11 nurse hours were spent per one patient day in ICUs and more than 7-8 hours in surgical and medical patients. We did not find consistent evidence that a further increase in RN FTE per patient day ratio can provide better patient safety. Confirming the previous observations,^{29,93,139} we detected a curvilinear association between the RN FTE per patient day ratio and hospital related mortality, nosocomial and bloodstream infections, and hospital acquired pneumonia with the optimal association at 2-2.5 patients per RN per shift in ICUs and surgical patients.

The association between patient outcomes and different definitions of nurse staffing suggest several reasons why nurse hours do not always provide a valid estimation of nurse-to-patient ratios. Nurse hours per patient day reflect average staffing across a 24-hour period and do not reflect fluctuations in patient census, scheduling patterns during different shifts,^{9,13} and periods of the year.^{66,67} They do not account for the time nurses spend in meetings, educational activities, and administrative work. Therefore, “productive hours per patient day” may underestimate nurse staffing levels when a large proportion of worked hours was not spent on direct patient care.^{60,109} These reasons may help to explain why the effect size varied across nurse staffing measures.

The majority of studies reviewed in this report focused on registered nurses working in acute care hospital settings. Evidence on the association between LPN/LVN and UAP personnel is limited and controversial. The authors designed the studies to evaluate the effect of nurse staffing on patient outcomes sensitive to RN rather LPN/LVN and UAP work. Skill mix may not directly reflect the hospital’s commitment to quality of care and financial strategies. Future research should address the role of skill mix and the contributions of LPNs/LVNs, and UAPs on quality of care.

Care Setting

Nurse staffing had a different effect in different care settings. The addition of one unit of nursing care may vary depending on the baseline rate. For example, ICUs have higher staffing levels than typical hospital units. The effect of an additional nurse hour might be quite dissimilar in that context. We evaluated differences in the association between nurse staffing variables and patient outcomes by the type of hospital units (ICU, surgical, medical, neonatal) and by the type of patients (medical vs. surgical).²⁷ We found a greater reduction in the relative risk of hospital-related mortality (16 percent) in surgical patients for an additional one RN FTE per patient day compared to a reduction of 6 percent in medical patients. Given a higher baseline mortality in surgical patients, the reduction in nurse workload would save six surgical compared to five medical patients per 1,000 hospitalized. Consistent with previous studies,^{26,27} the present meta-analysis found consistent evidence that surgical patients would demonstrate a greater cost-benefit from improved nurse staffing. Increasing the care of surgical patients by one RN FTE per patient day would eliminate 16 percent of failure to rescue (26 saved lives per 1,000 hospitalized) compared with 9.2 percent in all patients (medical and surgical). Such consistent and large improvements in patient safety from increasing the RN FTE per patient day ratio in surgical patients and in ICUs suggest health care administrators can improve quality of care in these categories of patients using optimal staffing ratios.²⁰⁷

Other Factors

The primary independent variable examined here is the volume of nursing, tempered by some attention to the education level. But other factors may also be relevant. Numbers alone do not likely explain all that happens. A nurse is not necessarily a nurse.²⁰⁶ Skill, organization, and leadership undoubtedly play a role but are much more difficult to assess. Usually we work in just the opposite direction inferring skill from outcomes after other factors have been accounted for. Because these studies rarely include data on case mix and other factors that help to explain outcomes, they cannot be used to infer differences in skill levels. Included studies did not provide the information on the quality of medical and surgical treatment. The importance of nurses' professional competence and performance have been discussed with regard to developing standards of nurse performance to encourage high quality of care.⁷⁰⁻⁷³

There are also questions about the association between nurse experience and patient outcomes. The independent effects of individual nurse competence in interaction with nurse staffing are not well understood and were not the subject of the present review. However, implementing the results of the present review to improve the quality of hospital care, we need to remember that complex interventions in combination with nurse staffing strategies provided better patient benefits.²⁰⁸⁻²¹² Implementing evidence-based clinical pathways that involve nurse and physician education and collaboration may increase the effectiveness of nursing work and improve patient outcomes.^{213,214} Several randomized clinical trials reported a significant improvement in nurse performance and patient outcomes as a result of quality improvement initiatives.²¹⁵⁻²²⁴

The majority of studies focused on adverse patient events and mortality. However, the estimation of quality of care may include patient satisfaction with nursing and overall medical care and improved quality of life. Future research should address patient positive outcomes,

compliance with prescribed treatments, patient functional status, and education in association with provided care including nurse staffing.

Policy Implications

The case for causation has yet to be made. Nevertheless, if one accepts the results presented as suggesting a causal relationship between nurse staffing and outcomes, the next question is one of practicality. Possible staffing decisions to improve quality of care would involve comparing existing staffing with changes in staffing needed to achieve desirable patient outcomes. The effect sizes depend on rich staffing ratios, which are not feasible in most hospitals. Moreover, defining the best level of nurse staffing requires addressing cost-effectiveness analysis²²⁵ that was beyond the present report. Because hospitals are paid a fixed rate under diagnosis related groups (DRGs) that does not reflect the quality of care they provide, they are not in a position to assume substantial cost burdens. The estimation of the threshold in terms of marginal costs and benefits depends on value placed on survival, patient satisfaction, and quality of life (QOL).⁶

Policymakers can consider several approaches to regulate nurse staffing. Our calculations suggest that it is difficult to set fixed nursing standards. Indeed, fixed minimum nurse-to-patient ratios implemented in several states did not provide the expected patient safety benefits.²²⁶ To maintain a reasonable staffing level, the increasing nurse shortage may force hospitals to reduce capacity rather than increase staffing. Mandatory nurse to patient ratios without legislative agreement to increase reimbursement may result in administrative decisions to reduce support staff positions and investments to other quality initiatives.²²⁵ Patient acuity-based staffing requirements adjust staffing for patient diagnosis and comorbidities but do not regulate shift-to-shift fluctuations in nurse staffing that have an important influence on quality of care.^{175,205} Moreover, no consensus exists about patient classification systems, which are different among hospitals and states.^{113,227-230} Public disclosure of nurse staffing was introduced in one state,²²⁷ but its effect on quality of care is not known.²²⁶ Pay-for-performance has been proposed to provide incentives for quality of care, but its effect on cost effectiveness is not well understood.²²⁶ Ideally we should monitor every hospital in the United States to see how differences in policies and financial performance affect the cost effectiveness of staffing and its effect on quality of health care.^{225,226}

Finally, the number of patients a nurse cares for is not a true measure of the “work” of the nurse. The patient flow (admissions, discharges, return from surgeries, transfers to other units, transfers from other units) can result in nurses providing care for many more patients in a day than what is reflected in the RN hour per patient day or nurse to patient ratio. This significant factor was not addressed in any of the studies reviewed and should be considered as a nurse staffing measure for future studies. Another factor not considered in the studies is the number and type of support personnel available to nurses to assist them with care of patients. A recent trend in hospitals is having Rapid Response Teams (RRTs). This team is usually comprised of an experienced critical care nurse, respiratory therapist, and a physician. The team can be called by any nurse in the hospital if the nurse assesses that the patient’s condition is changing such that it could potentially result in a negative outcome. Nurses also have access to consultation from advanced practice nurses, unit-based nurse educators, charge nurses, assistant nurse managers, and nurse managers. These types of nursing hours are not included in the studies or considered as nurse staffing measures.

In conclusion, the present review found consistent statistically and clinically significant associations between nurse staffing and adjusted relative risk of hospital related mortality, failure to rescue, and other patient outcomes sensitive to nursing care, but we cannot conclude these relationships are causal. Hence, they cannot be interpreted as a basis for recommending specific staffing levels. The effect size is greater in surgical patients and in ICUs. The associations may include other structure and process factors in causal pathway to patient effective and safe care. A commitment to a high quality care at hospital level may provide better patient outcomes in relation to nurse staffing.

Strength of the Evidence

Taken as a whole, there is consistent evidence of an association between the level of nurse staffing and patient outcomes but no clear case for causation. The nature of the study designs precludes any efforts to establish a causal relationship. There are no interventions, let alone controlled trials. The effect on quality of other salient input, such as medical care, is not tested. Adjustments for case mix rely on averages across units or hospitals. The quality of the studies is modest by standard measures, and the coverage of salient variables that could affect quality is weak. The distinction is still far from clear. The association was somewhat stronger with nurse-sensitive outcomes than with more generic ones like mortality, but it was also stronger with cross-sectional rather than longitudinal designs.

Recommendations for Future Research

While it is not feasible to think about research designs that might be more interventional, it may be possible to take advantage of natural experiments where nurse staffing levels are changed holding other factors constant. Future observational studies will need to take cognizance of the many other factors that can affect the outcomes of interest, especially medical care, patient characteristics, and the organization of nursing units and staffs. Larger multi-center studies will be needed. Nonetheless, it is unlikely that all the salient variables can be addressed in any one study. Future work will need to target specific questions and collect and analyze enough information to isolate the effects of nurse staffing levels.

Figure 27. Relative risk of outcomes corresponding to an increase by RN FTE/patient day consistent across the studies

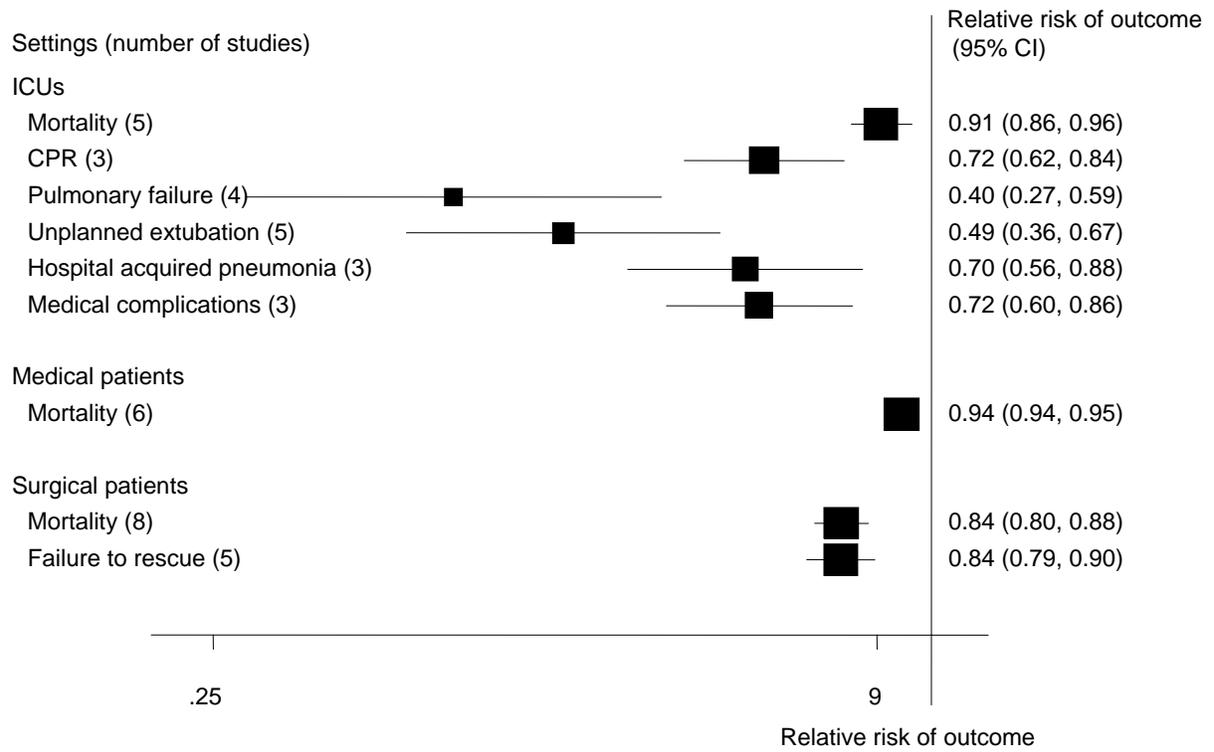


Table 21. The number of patient adverse events that could be avoided by additional 8 RN hours a patient receives during 24 hours in a hospital

Patients' Condition Related to Health Care, Not to a Primary Diagnosis	Number of Avoided Events/1,000 Hospitalized Patients (95% CI)
All patients	
Mortality, overall	9 (6-12)
Mortality, hospital level analysis	3 (2-4)
Mortality, medical patients	5 (4-5)
Hospital acquired pneumonia	5 (1-8)
Failure to rescue	24 (14-34)
CPR	2 (1-2)
ICUs	
Mortality	5 (2-8)
Hospital acquired pneumonia	7 (3-10)
Pulmonary failure	7 (5-9)
Unplanned extubation	6 (4-8)
CPR	2 (1-2)
Nosocomial Infection	10 (6-13)
Surgical patients	
Mortality	6 (4-8)
Failure to rescue	26 (17-35)
Surgical wound infection	7 (1-8)
CPR	1 (1-2)

Table 22. The proportion of patient adverse events (%) that could be avoided by reducing the number of patients assigned to an RN during an 8-hour shift

Patients' Conditions Related to Health Care, Not to a Primary Diagnosis	Number of Patients Assigned to 1 RN During a Shift	Percentage of Patient Adverse Events that Could be Avoided by Reducing the Number of Patients per RN (95% CI)
ICUs		
Mortality	<3 vs. 3-4	5.6 (3.4; 7.7)
Sepsis	<1.6 vs. 3.3	42.7 (8.8; 64.0)
Sepsis	1 vs. 3.3	42.2 (6.0; 64.4)
CPR	<1.6 vs. 3.3	34.4 (26.7; 41.4)
CPR	1 vs. 3.3	46.3 (39.2; 52.6)
CPR	1 vs. >4	25.4 (16.7; 33.2)
Medical complications	<1.6 vs. 3.3	40.8 (28.6; 50.9)
Medical complications	1 vs. 3.3	46.1 (33.6; 56.3)
Medical complications	1 vs. >4	25.4 (10.1; 38.1)
Pulmonary failure	<1.6 vs. 3.3	60.0 (30.9; 76.9)
Pulmonary failure	<1.6 vs. 3	63.7 (31.3; 80.8)
Pulmonary failure	1 vs. >4	57.1 (13.8; 78.6)
Unplanned extubation	<1.6 vs. 3.3	44.8 (22.2; 60.9)
Unplanned extubation	<1.6 vs. 3	68.0 (49.2; 79.8)
Unplanned extubation	1 vs. 3	56.9 (38.2; 69.9)
Unplanned extubation	3.3 vs. >4	42.0 (20.2; 57.9)
Surgical patients		
Mortality	≤2 vs. 4-6	24.3 (17.9; 30.3)
Mortality	≤2 vs. >6	38.4 (34.1; 42.4)
Mortality	2-3.5 vs. 4-6	19.8 (13.3; 25.9)
Mortality	2-3.5 vs. >6	34.7 (30.4; 38.7)
Mortality	4-6 vs. >6	18.6 (11.8; 24.8)
Hospital acquired pneumonia	4 vs. >5	24.6 (5.2; 40.0)
Nosocomial infection	<2 vs. 3	93.6 (65.7; 98.8)
Surgical wound infection	4 vs. >5	20.4 (6.5; 32.3)
Sepsis	<2 vs. 3	44.4 (16.4; 63.0)
Sepsis	<2 vs. >5	49.4 (8.8; 71.9)
Sepsis	4 vs. >5	28.5 (6.6; 45.3)
CPR	<2 vs. 3	30.8 (13.1; 44.9)
CPR	<2 vs. 4	25.4 (5.0; 41.4)
Failure to rescue	<2 vs. 4	25.5 (17.1; 33.0)
Failure to rescue	<2 vs. >5	39.1 (33.6; 44.2)
Failure to rescue	3 vs. 4	20.6 (12.2; 28.3)
Failure to rescue	3 vs. >5	35.2 (29.7; 40.2)
Failure to rescue	4 vs. >5	18.3 (9.1; 26.6)
Pulmonary failure	<2 vs. 3	61.9 (28.2; 79.7)
Pulmonary failure	<2 vs. 4	75.1 (45.4; 88.6)
Unplanned extubation	<2 vs. 3	44.3 (18.4; 62.0)
Unplanned extubation	<2 vs. 4	71.5 (53.8; 82.4)
Unplanned extubation	3 vs. 4	48.7 (30.6; 62.1)

Table 23. Relative risk of mortality and nurse sensitive patient outcomes corresponding to one unit increase in nurse staffing ratios and hours (pooled estimates)

Outcome	N	Increment	RR	95% CI	N	Increment	RR	95% CI
Mortality	14	1 RN FTE/patient day	0.92	0.90; 0.94	1	1 nurse hour/patient day		
	4	1 patient/LPN/shift	0.99	0.99; 1	7*	1 RN hour/patient day	1.00	0.90; 1.12
	1	1 patient/UAP/shift	0.99	0.99; 1.07	3	1 LPN hour/patient day	0.88	0.12; 6.47
		1 patient/licensed nurse			1	1 UAP hour/patient day		
					1	1 licensed hour/patient day		
Length of stay	5	1 RN FTE/patient day	0.92	0.80; 1.05	4*	1 nurse hour/patient day		
	1	1 patient/LPN/shift	0.98	0.97; 0.99	3	1 RN hour/patient day	1.00	0.41; 2.42
		1 patient/UAP/shift			2	1 LPN hour/patient day		
		1 patient/licensed nurse			1	1 UAP hour/patient day		
					2	1 licensed hour/patient day		
Patient falls, injuries	1	1 RN FTE/patient day			2	1 nurse hour/patient day		
	1	1 patient/LPN/shift			1	1 RN hour/patient day		
		1 patient/UAP/shift				1 LPN hour/patient day		
	1	1 patient/licensed nurse				1 UAP hour/patient day		
					1 licensed hour/patient day			
Pressure ulcers		1 RN FTE/patient day			4	1 nurse hour/patient day		
		1 patient/LPN/shift			1	1 RN hour/patient day		
		1 patient/UAP/shift			1	1 LPN hour/patient day		
	1	1 patient/licensed nurse			1	1 UAP hour/patient day		
					1	1 licensed hour/patient day		
Nosocomial infection rate	3	1 RN FTE/patient day	0.88	0.73; 1.06	5*	1 nurse hour/patient day	0.88	0.84; 0.92
		1 patient/LPN/shift			2*	1 RN hour/patient day	0.76	1.05; 0.68
	1	1 patient/UAP/shift			1	1 LPN hour/patient day		
		1 patient/licensed nurse			1	1 UAP hour/patient day		
					2	1 licensed hour/patient day		
Failure to rescue	6	1 RN FTE/patient day	0.91	0.89; 0.94	1	1 nurse hour/patient day		
		1 patient/LPN/shift			3	1 RN hour/patient day		
		1 patient/UAP/shift			1	1 LPN hour/patient day		
		1 patient/licensed nurse			1	1 UAP hour/patient day		
					2	1 licensed hour/patient day		
Urinary tract infection rate	2	1 RN FTE/patient day	1.02	0.94; 1.11	5	1 nurse hour/patient day		
	1	1 patient/LPN/shift	0.96	0.94; 0.99	6	1 RN hour/patient day	1.00	0.64; 1.56
		1 patient/UAP/shift			4	1 LPN hour/patient day	1.04	0.17; 6.26
	1	1 patient/licensed nurse			1	1 UAP hour/patient day		
					2	1 licensed hour/patient day		
Surgical bleeding	1	1 RN FTE/patient day	1.02	0.78; 1.34	4	1 nurse hour/patient day		
		1 patient/LPN/shift			2	1 RN hour/patient day	1.00	0.95; 1.05
		1 patient/UAP/shift			1	1 LPN hour/patient day	0.93	0.00; 233.29
		1 patient/licensed nurse			1	1 UAP hour/patient day		
					2	1 licensed hour/patient day		

Table 23. Relative risk of mortality and nurse sensitive patient outcomes corresponding to one unit increase in nurse staffing ratios and hours (pooled estimates) (continued)

Outcome	N	Increment	RR	95% CI	N	Increment	RR	95% CI				
Upper gastrointestinal bleeding		1 RN FTE/patient day			1	1 nurse hour/patient day						
		1 patient/LPN/shift			3	1 RN hour/patient day						
		1 patient/UAP/shift			1	1 LPN hour/patient day						
		1 patient/licensed nurse			1	1 UAP hour/patient day						
					2	1 licensed hour/patient day						
Post surgical thrombosis	1	1 RN FTE/patient day			2	1 nurse hour/patient day						
		1 patient/LPN/shift			1	1 RN hour/patient day						
		1 patient/UAP/shift			2	1 LPN hour/patient day						
		1 patient/licensed nurse			1	1 UAP hour/patient day						
					1	1 licensed hour/patient day						
Atelectasis and pulmonary failure	5	1 RN FTE/patient day	0.94	0.93; 0.94	2	1 nurse hour/patient day	1.08	0.85; 1.37				
		1 patient/LPN/shift			2	1 RN hour/patient day						
		1 patient/UAP/shift			2	1 LPN hour/patient day						
		1 patient/licensed nurse			1	1 UAP hour/patient day						
					1	1 licensed hour/patient day						
Accidental extubation	5	1 RN FTE/patient day	0.49	0.36; 0.67		1 nurse hour/patient day						
		1 patient/LPN/shift				1 RN hour/patient day						
		1 patient/UAP/shift				1 LPN hour/patient day						
		1 patient/licensed nurse				1 UAP hour/patient day						
						1 licensed hour/patient day						
Hospital acquired pneumonia	4	1 RN FTE/patient day	0.81	0.67; 0.98	5	1 nurse hour/patient day						
		1 patient/LPN/shift			4	1 RN hour/patient day						
		1 patient/UAP/shift			3	1 LPN hour/patient day						
		1 patient/licensed nurse			1	1 UAP hour/patient day						
					2	1 licensed hour/patient day						
Postoperative infection	1	1 RN FTE/patient day	1.01	0.70; 1.45	4	1 nurse hour/patient day	1.00	0.99; 1.01				
		1 patient/LPN/shift			2	1 RN hour/patient day			1.00	0.95; 1.05		
		1 patient/UAP/shift			1	1 LPN hour/patient day					0.93	0.00; 233.29
		1 patient/licensed nurse			1	1 UAP hour/patient day						
					2	1 licensed hour/patient day						
Cardiac arrest/shock	3	1 RN FTE/patient day	0.72	0.62; 0.84		1 nurse hour/patient day						
		1 patient/LPN/shift				1 RN hour/patient day						
		1 patient/UAP/shift				1 LPN hour/patient day						
		1 patient/licensed nurse				1 UAP hour/patient day						
					1	1 licensed hour/patient day						
Complications (medical)	3	1 RN FTE/patient day	0.72	0.60; 0.86	2	1 nurse hour/patient day						
		1 patient/LPN/shift				1 RN hour/patient day						
		1 patient/UAP/shift				1 LPN hour/patient day						
		1 patient/licensed nurse				1 UAP hour/patient day						
					1	1 licensed hour/patient day						

* significant heterogeneity between studies

Table 24. Consistent across the studies, significant association between nurse staffing and patient outcomes (results from pooled analysis), attributable to nurse staffing proportion of events, and number of avoided events per 1,000 hospitalized patients

Outcome	Nurse Staffing	Studies	RR	95% CI	Attributable to Nurse Staffing Fraction, %	95%CI	Number of Avoided (excessive) Events/1,000 Hospitalized	95%CI
All Patients								
Mortality	Increase by 1 patient/RN/shift	6	1.08	1.08; 1.09	7.56	7.07; 8.04	5	4; 5
Mortality, hospital level analysis	Increase by 1 RN FTE/patient day	5	0.96	0.94; 0.98	4.2	6; 2.4	3	2; 4
Mortality, ICUs	Increase by 1 RN FTE/patient day	5	0.91	0.86; 0.96	9.2	14.4; 3.7	5	2; 8
Mortality, surgical patients	Increase by 1 RN FTE/patient day	8	0.84	0.8; 0.89	16	20.2; 11.5	6	4; 8
Mortality, medical patients	Increase by 1 RN FTE/patient day	6	0.94	0.94; 0.95	5.6	6.3; 4.8	5	4; 5
Mortality, ICUs	Increase by 1 RN hour/patient day	5	0.99	0.99; 0.99	0.5	0.7; 0.3	0	0.2; 0
Mortality, surgical patients	Increase by 1 RN hour/patient day	9	0.99	0.98; 1	1.4	2.5; 0.3	1	0; 1
Mortality, medical patients	Increase by 1 RN hour/patient day	10	0.99	0.99; 1	0.7	0.8; 0.5	1	0; 1
Hospital acquired pneumonia	Increase by 1 patient/RN/shift	3	1.07	1.03; 1.11	6.5	2.9; 9.9	2	1; 3
Failure to rescue	Increase by 1 patient/RN/shift	3	1.08	1.07; 1.09	7.4	6.5; 8.3	12	11; 13
Pulmonary failure	Increase by 1 patient/RN/shift	4	1.53	1.24; 1.89	34.6	19.4; 47.1	6	3; 10
Unplanned extubation	Increase by 1 patient/RN/shift	5	1.45	1.27; 1.67	31.0	21.3; 40.1	5	3; 8
CPR	Increase by 1 patient/RN/shift	3	1.16	1.05; 1.29	13.8	4.8; 22.5	1	1; 2
Medical complications	Increase by 1 patient/RN/shift	3	1.17	1.04; 1.31	14.5	3.8; 23.7	37	9; 64
Hospital acquired pneumonia	Increase by 1 RN FTE/patient day	4	0.81	0.67; 0.98	19.1	33.1; 2.1	1	0; 2
Pulmonary failure	Increase by 1 RN FTE/patient day	5	0.94	0.94; 0.94	6	6.4; 5.6	1	1; 1
CPR	Increase by 1 RN FTE/patient day	5	0.72	0.62; 0.84	27.6	37.9; 15.6	2	1; 2
ICUs								
Hospital acquired pneumonia	Increase by 1 RN FTE/patient day	3	0.7	0.56; 0.88	30.2	44.3; 12.4	7	3; 10
Pulmonary failure	Increase by 1 RN FTE/patient day	4	0.4	0.27; 0.59	60.3	73.4; 40.6	7	5; 9
Unplanned extubation	Increase by 1 RN FTE/patient day	5	0.49	0.36; 0.67	50.9	63.7; 33.5	6	4; 8
CPR	Increase by 1 RN FTE/patient day	3	0.72	0.62; 0.84	27.6	37.9; 15.6	2	1; 2
Nosocomial Infection	Increase by 1 hour in total nurse hours/patient day	3	0.87	0.82; 0.92	12.9	17.6; 8	10	6; 13
Relative change in LOS	Increase by 1 RN FTE/patient day	4	0.76	0.62; 0.94	24	38; 6	7	2; 11
Surgical patients								
Failure to rescue	Increase by 1 RN FTE/patient day	5	0.84	0.79; 0.9	16	21.4; 10.3	26	17; 35
Surgical wound infection	Increase by 1 RN FTE/patient day	1	0.15	0.03; 0.82	84.5	97.1; 18.1	7	1; 8
Sepsis	Increase by 1 RN FTE/patient day	5	0.64	0.46; 0.89	36	54; 11	4	2; 6
Relative change in LOS	Increase by 1 RN FTE/patient day	3	0.69	0.55; 0.86	31	45; 14	14	6; 21

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List of Acronyms/Abbreviations

AHRQ	Agency for Healthcare Research and Quality
ANA	American Nurses Association
AONE	American Organization of Nurse Executives
BSN	Bachelor of Science in Nursing
CDC	Centers for Disease Control and Prevention
CI	Confidence Interval
CPR	Cardiopulmonary Resuscitation
DHHS	Department of Health and Human Services
DRGs	Diagnosis Related Groups
FTE	Full Time Equivalent
HPD	Hours per Patient Day
ICD-9	International Classification of Diseases (9th revision)
ICU	Intensive Care Unit
IEN	Internationally Educated Nurse
JCAHO	Joint Commission on Accreditation of Healthcare Organizations
LOS	Length of Stay
LPN	Licensed Practical Nurse
LVN	Licensed Vocational Nurse
MOOSE	Meta-analysis Of Observational Studies in Epidemiology
MS	Master of Science
NIOSH	National Institute for Occupational Safety and Health
NQF	National Quality Forum
NS	Not Significant
PhD	Doctor of Philosophy
QOL	Quality of Life
RRT	Rapid Response Team
RN	Registered Nurse
RR	Relative Risk
TEP	Technical Expert Panel
UAP	Unlicensed Assistive Personnel
UTI	Urinary Tract Infection

Nurse Staffing and Quality of Patient Care

Appendixes

Appendix A: Exact Search Strings

Appendix B: List of Excluded Studies

Appendix C: Technical Expert Panel Members and Affiliation

Appendix D: Sample Abstraction Forms

Appendix E: Quality of the Studies

Appendix F. Analytic Framework

Appendix G: Evidence Tables

Appendix A: Exact Search Strings

Search Strategy for Questions 1, 2, and 4

The following data bases were searched:

- Med Line (PubMed)
- CINAHL
- The Cochrane Database of Systematic Reviews
- The Cochrane Central Register of Controlled Trials
- EBSCO Research Database
- BioMed Central
- Government agencies and nurse's associations' websites are searched to identify unpublished reports of the conducted surveys and regulatory documents of nursing hospital staffing:
 - United States Department of Health and Human Services
 - Agency for Healthcare Research and Quality
 - National Database of Nursing Quality Indicators
 - National Center for Health Workforce Analysis
 - American Nurses Association
 - American Academy of Nurse Practitioners
 - Government publications.
 - Database <http://www.marcive.com/webdocs>
 - Catalog of U.S. Government Publications (U.S. GPO)
 - Digital Dissertations
 - Internet (www.google.com) with the key words identical MeSH terms
 - Manual search of the references in articles to identify eligible studies published before 1990

The following MeSH terms and key words (in databases other than Medline) and their combinations were used to search the data bases from 1990 through June 2006:

- “Nurses” [MeSH] (Q 1-4)*
- “Nursing staff, hospital” [MeSH] (Q 1-4)
- “Nursing administration research” [MeSH] (Q 1-4)
- “Nursing audit” [MeSH] (Q 1-2, 4)
- “Nursing education research” [MeSH] (Q 1-2, 4)
- “Clinical competence” [MeSH] (Q 1-2)
- “Health care quality, access, and evaluation” [MeSH] (Q1-2, 4)
- “Health services research” [MeSH] (Q1, 2, 4)
- “Outcome assessment (health care)” [MeSH] (Q1-2, 4)
- “Health care category” [MeSH] (Q1, 2, 4)
- “Patients” [MeSH] (Q1-2, 4)
- “Length of stay” [MeSH] (Q1-2, 4)
- “Patient satisfaction” [MeSH] (Q1-2, 4)

“Hospital units” [MeSH] (Q1, 2, 4)
“Personnel staffing and scheduling” [MeSH] (Q1-3)
“Patient centered care” [MeSH] (Q4)
“Nurse patient relations” [MeSH] (Q1-2, 4)
“Hospital patient relations” [MeSH] (Q1-2, 4)
"Models, nursing" [MeSH] (Q 4)
“Labor unions” [MeSH] (Q 4)
“Malpractice” [MeSH]
“Hospitals” [MeSH] (Q4)
Nurse to patient ratio (keyword) (Q1-3)
“Skill mix” [MeSH] (Q3)
“Part time employment [MeSH] (Q3)
“Foreign nurses [MeSH] (Q3)
“Registry personnel” [MeSH] (Q3)
Overtime (keyword) (Q3)
Flexible scheduling (keyword) (Q3)
Shift work (key word) (Q3)

* The numbers in parentheses refer to the question for which this term was relevant

Search Strategy for Question 3

(Inclusion criteria for all studies: North American hospitals, research in peer reviewed journal, published between 1990-2006)

Shift work staffing policy variable

58 eligible for review

51 excluded:

- 41 Not relevant (not related to variable of interest)
- 1 Integrative review not related to study variable
- 2 Conference abstract
- 2 Nursing home
- 3 Not peer reviewed journal
- 2 Inadequate data presentation

7 included

Overtime staffing policy variable

20 eligible for review

14 excluded:

- 9 Not relevant (not related to variable of interest)
- 1 Inadequate data presentation
- 4 Not peer reviewed journal

6 included

Full and part time staff use variable

28 eligible for review

22 excluded:

- 15 Not relevant (not related to variable of interest)
- 6 Not peer reviewed journal
- 1 Inadequate data presentation

6 included

Foreign educated nurses variable

20 eligible for review

14 excluded

- 12 Not relevant (not related to variable of interest)
- 1 Not research
- 1 Not peer reviewed journal

6 included

Agency/contract nurses variable

21 eligible for review

16 excluded:

- 10 Not relevant (not related to variable of interest)
- 1 Nursing home
- 2 Inadequate data presentation
- 3 Not peer reviewed journal

5 included

Total studies on staffing policy variables

147 eligible for review

117 excluded:

- 87 Not relevant (not related to variable of interest)
- 2 Conference proceedings
- 1 Integrative review not related to variable of interest
- 3 Nursing home
- 17 Not peer reviewed journal
- 6 Inadequate presentation of data
- 1 Not research

30 included

Literature Search Strings

MeSH terms	Studies
The National Library of Medicine via PubMed:	
“Nurses” [MeSH]	51,730
"Nursing staff, hospital"[MeSH]	28,092
"Nursing administration research"[MeSH]	1,218
"Nursing audit"[MeSH]	2,349

MeSH terms	Studies
"Nursing education research"[MeSH]	3,285
"Clinical competence"[MeSH]	33,806
"Health care quality, access, and evaluation"[MeSH]	3,090,640
"Health services research"[MeSH]	64,621
"Outcome assessment (health care)"[MeSH]	286,369
"Health care category"[MeSH]	4,438,573
"Personnel administration, hospital"[MeSH]	4,968
"Patients"[MeSH]	35,872
"Length of stay"[MeSH]	33,382
"Patient satisfaction"[MeSH]	28,736
"Hospital units"[MeSH]	48,491
"United States/epidemiology"[MeSH]	77,520
"Personnel staffing and scheduling"[MeSH]	9,484
"Models, nursing"[MeSH]	7,513
"Foreign professional personnel"[MeSH]	3,523
("Safety management"[MeSH] OR "risk management"[MeSH])	82,840
("Safety management"[MeSH] OR "risk management"[MeSH]) Limits: English, humans	70,596
("Safety management"[MeSH] OR "risk management"[MeSH]) NOT review NOT letters NOT editorials Limits: English, humans	48,105
"Nurses"[MeSH] NOT review NOT letters NOT editorials	43,370
"Nursing staff, hospital"[MeSH] NOT review NOT letters NOT editorials	25,773
"Nursing administration research "[MeSH] NOT review NOT letters NOT editorials	994
"Nursing audit"[MeSH] NOT review NOT letters NOT editorials Limits: English, humans	1,450
"Nursing education research "[MeSH] NOT review NOT letters NOT editorials Limits: humans	2,723
"Clinical competence"[MeSH] NOT review NOT letters NOT editorials Limits: humans	22,181
"Health care quality, access, and evaluation"[MeSH] NOT review NOT letters NOT editorials Limits: English, humans	1,798,295
"Health services research"[MeSH] NOT review NOT letters NOT editorials Limits: humans	43,486
"Outcome assessment (health care)"[MeSH] AND "health services research" [MeSH] NOT review NOT letters NOT editorials Limits: humans	15
"Health care category"[MeSH] NOT review NOT letters NOT editorials Limits: English, humans	2,320,378
"Personnel administration, hospital"[MeSH] NOT review NOT letters NOT editorials Limits: English, humans	1,601
"Patients"[MeSH] NOT review NOT letters NOT editorials Limits: English, humans	23,507
"Length of stay"[MeSH] NOT review NOT letters NOT editorials Limits: English, humans	22,937

MeSH terms	Studies
"Patient satisfaction"[MeSH] NOT review NOT letters NOT editorials Limits: English, humans	20,849
"Hospital units"[MeSH] NOT review NOT letters NOT editorials Limits: English, humans	27,731
"United States/epidemiology"[MeSH] NOT review NOT letters NOT editorials Limits: English, humans	57,481
"Personnel staffing and scheduling"[MeSH] NOT review NOT letters NOT editorials Limits: English, humans	5,335
"Models, nursing"[MeSH] NOT review NOT letters NOT editorials Limits: English, humans	4,544
"Foreign professional personnel"[MeSH] NOT review NOT letters NOT editorials Limits: English, humans	1,375
"Nurses"[MeSH] NOT review NOT letters NOT editorials AND "patients"[MeSH] Limits: English, humans	396
"Nurses"[MeSH] NOT review NOT letters NOT editorials AND "clinical competence" Limits: English, humans	6
"Nurses"[MeSH] NOT review NOT letters NOT editorials AND "health care quality, access, and evaluation"[MeSH] Limits: English, humans	49
"Nurses"[MeSH] NOT review NOT letters NOT editorials AND "health services research" Limits: English, humans	2
"Nurses"[MeSH] NOT review NOT letters NOT editorials AND "outcome assessment (health care)" Limits: English, humans	1
"Nurses"[MeSH] NOT review NOT letters NOT editorials AND "personnel administration, hospital" Limits: English, humans	0
"Nurses"[MeSH] NOT review NOT letters NOT editorials AND "length of stay" Limits: English, humans	2
"Nurses"[MeSH] NOT review NOT letters NOT editorials AND "patient satisfaction" Limits: English, humans	2
"Nurses"[MeSH] NOT review NOT letters NOT editorials AND personnel staffing and scheduling Limits: English, humans	2
"Epidemiologic studies"[MeSH] Limits: English, humans	728,060
"Epidemiologic studies"[MeSH] AND "nurses"[MeSH] Limits: English, humans	1,210
"Epidemiologic studies"[MeSH] AND "nursing staff, hospital"[MeSH] Limits: English, humans	731
"Epidemiologic studies"[MeSH] AND "nursing administration research "[MeSH] Limits: English, humans	99
"Epidemiologic studies"[MeSH] AND "nursing audit"[MeSH] Limits: English, humans	210
"Epidemiologic studies"[MeSH] AND "nursing education research "[MeSH] Limits: English, humans	187
"Epidemiologic studies"[MeSH] AND "clinical competence"[MeSH] Limits: English, humans	2,169
"Epidemiologic studies"[MeSH] AND "health care quality, access, and evaluation"[MeSH] Limits: English, humans	728,210

MeSH terms	Studies
"Epidemiologic studies"[MeSH] AND "health services research "[MeSH] AND "nurses"[MeSH] Limits: English, humans	85
"Epidemiologic studies"[MeSH] AND "nurses"[MeSH] AND "outcome assessment (health care)"[MeSH] Limits: English, humans	108
"Epidemiologic studies"[MeSH] AND "nurses"[MeSH] AND "personnel administration, hospital" [MeSH] Limits: English, humans	0
"Epidemiologic studies"[MeSH] AND "nurses"[MeSH] AND "patients" [MeSH] Limits: English, humans	23
"Epidemiologic studies"[MeSH] AND "nurses"[MeSH] AND "length of stay"[MeSH] Limits: English, humans	38
"Epidemiologic studies"[MeSH] AND "nurses"[MeSH] AND "patient satisfaction"[MeSH] Limits: English, humans	56
"Epidemiologic studies"[MeSH] AND "models, nursing" Limits: English, humans	190
"Epidemiologic studies"[MeSH] AND "nursing staff, hospital"[MeSH] AND "safety management" Limits: English, humans	1
"Nursing staff, hospital"[MeSH] AND "patients"[MeSH] Limits: English, humans	506
"Nursing staff, hospital"[MeSH] AND "length of stay"[MeSH] Limits: English, humans	192
"Nursing staff, hospital"[MeSH] AND "patient satisfaction"[MeSH] Limits: English, humans	324
"Nursing staff, hospital"[MeSH] AND "safety management"[MeSH] Limits: English, humans	188
"Safety management"[MeSH] AND "nursing administration research "[MeSH] Limits: English, humans	17
"Safety management"[MeSH] AND "nursing audit"[MeSH] Limits: English, humans	18
"Safety management"[MeSH] AND "clinical competence"[MeSH] Limits: English, humans	125
"Safety management"[MeSH] AND "health care quality, access, and evaluation"[MeSH] Limits: English, humans	3,253
"Safety management"[MeSH] AND "health services research"[MeSH] Limits: English, humans	465
"Safety management"[MeSH] AND "outcome assessment (health care)"[MeSH] Limits: English, humans	111
"Safety management"[MeSH] AND "models, nursing" Limits: English, humans	27
"Outcome assessment (health care)"[MeSH] AND "nursing staff, hospital"[MeSH] Limits: English, humans	344
CINAHL - Cumulative Index to Nursing & Allied Health Literature:	
“Personnel staffing and scheduling”	9,271
“Nursing staff, hospital/manpower”	57
"Length of stay"	5,269
“Patient safety”	14,395

MeSH terms	Studies
"Nurses"	72,321
"Personnel staffing and scheduling" or "nursing staff, hospital/manpower" AND "length of stay" or "patient safety"	1,025
"Personnel staffing and scheduling" or "nursing staff, hospital/manpower" AND "length of stay" or "patient safety" limit on English, NOT review or letter	86
The Cochrane Library:	
"Nursing staff, hospital" and "outcome assessment (health care)"	0
"Nurse" AND "patient"	4
BioMed Central :	
"Nursing staff, hospital" AND "patient safety"	0
"Nursing staff, hospital" AND "patient outcomes"	0
Nursing staff, hospital AND health services research	287
Nursing staff, hospital AND adverse events	79
Google scholar: "nursing staff, hospital" AND "patient outcomes" NOT long- term care, published after 1990	1,700
<u>Catalog of U.S. Government Publications (U.S. GPO):</u>	
Nursing Staff, Hospital	9
LexisNexis™ Government Periodicals Index:	
"Nurses and nursing" AND "Hospitals"	25
Digital Dissertations:	
Nurse AND patient	1,863
Nursing staff, hospital	0
Nurse AND staffing AND hospital AND patient	20
Agency of Health Care Research and Quality:	
Nurse staffing and Patient	893

Positive Likelihood of MeSH Terms and Keywords (*) to Identify Studies Eligible for Questions 1, 2, and 4

Algorithm:

$$\text{Sensitivity} = \text{TP}/(\text{TP}+\text{FN})$$

$$\text{Specificity} = \text{TN}/(\text{FP}+\text{TN})$$

$$\text{Positive Likelihood} = \text{SENS}/(1-\text{SPEC})$$

$$\text{Negative Likelihood} = (1-\text{SENS})/\text{SPEC}$$

Study status	Eligible	Excluded	Total
Keyword Present	TP	FP	
Keyword absent	FN	TN	
	96	2,762	2,858

A. Highest Positive Predictive Likelihood

MeSH terms and keywords	Sensitivity, %	Specificity, %	Positive Likelihood
*Burnout professional	3.13	99.96	86.31
Decubitus ulcer/epidemiology	6.25	99.93	86.31
Nurses/*supply & distribution	3.13	99.96	86.31
United States Centers for Medicare and Medicaid Services	5.21	99.93	71.93
Accidental falls s & numerical data	9.38	99.86	64.73
*Mortality	2.08	99.96	57.54
Comorbidity	2.08	99.96	57.54
Medicare/*statistics & numerical data	2.08	99.96	57.54
Nursing service	2.08	99.96	57.54
Urinary tract infection	2.08	99.96	57.54
California/epidemiology	5.21	99.89	47.95
Health services research/methods	3.13	99.93	43.16
*Anesthesiology	1.04	99.96	28.77
*Economic competition	1.04	99.96	28.77
*Economics	1.04	99.96	28.77
*Outcome and process assessment (health care)	5.21	99.82	28.77
Acquired immunodeficiency syndrome	1.04	99.96	28.77
Bacteremia/epidemiology	1.04	99.96	28.77
Bacteremia/epidemiology/etiology	1.04	99.96	28.77
Burn units/*manpower	1.04	99.96	28.77
Contract services/organization & administration	1.04	99.96	28.77
Cross infection/*prevention & control	2.08	99.93	28.77
Cross infection/epidemiology	1.04	99.96	28.77
Cross infection/epidemiology/*etiology/ prevention & control	1.04	99.96	28.77
Delivery of health care/*organization & administration	1.04	99.96	28.77
Disease outbreak	1.04	99.96	28.77
Economics hospital	1.04	99.96	28.77
Education nursing	1.04	99.96	28.77
Health maintenance organizations	1.04	99.96	28.77
Health maintenance organizations *organization & administration	1.04	99.96	28.77
Hospital restructuring	1.04	99.96	28.77
Hospitals pediatric	1.04	99.96	28.77
Hospitals university	1.04	99.96	28.77
Hospitals urban	1.04	99.96	28.77
Hospitals/*standards	1.04	99.96	28.77
Hospitals/classification	1.04	99.96	28.77
Hospitals/*standards/statistics & numerical data	1.04	99.96	28.77
Iatrogenic disease	1.04	99.96	28.77
Insurance claim	1.04	99.96	28.77

MeSH terms and keywords	Sensitivity, %	Specificity, %	Positive Likelihood
Intensive care units neonatal/economics	1.04	99.96	28.77
Intensive care units pediatric/*organization & administration	1.04	99.96	28.77
Medicare	2.08	99.93	28.77
Nurses' aides/supply & distribution	2.08	99.93	28.77
Nursing staff hospital/*economics/organization & administration	1.04	99.96	28.77
Nursing staff hospital/*education/*standards	1.04	99.96	28.77
Nursing staff hospital/organization & administration/statistics	1.04	99.96	28.77
Outcome assessment	1.04	99.96	28.77
Pediatrics	1.04	99.96	28.77
Pennsylvania/epidemiology	1.04	99.96	28.77
Personnel management	1.04	99.96	28.77
Pneumonia/epidemiology	1.04	99.96	28.77
Postoperative complications/epidemiology	1.04	99.96	28.77
Quality of health care	1.04	99.96	28.77
Quality of health care/*classification	1.04	99.96	28.77
Restraint physical	1.04	99.96	28.77
Safety management	1.04	99.96	28.77
Surgical procedures operative/*statistics & numerical data	1.04	99.96	28.77
United States Agency for Healthcare Research and Quality	1.04	99.96	28.77
Urinary tract infections/epidemiology/etiology	1.04	99.96	28.77
Workload/ psychology	2.08	99.93	28.77
Workload/standards	2.08	99.93	28.77
*Hospital mortality	13.54	99.49	26.72
Cross Infection/epidemiology	3.13	99.86	21.58
Medication error	6.25	99.71	21.58
Iatrogenic disease	2.08	99.89	19.18
Morbidity	2.08	99.89	19.18
Nursing care/psychology	2.08	99.89	19.18
Probability	2.08	99.89	19.18
Odds ratio	5.21	99.67	15.98
United States/epidemiology	14.58	99.02	14.92
*Educational standards	1.04	99.93	14.39
*Treatment outcome	1.04	99.93	14.39
Catheterization	1.04	99.93	14.39
Databases factual	1.04	99.93	14.39
Diagnosis related groups/statistics & numerical data	1.04	99.93	14.39
Education nursing baccalaureate	2.08	99.86	14.39

MeSH terms and keywords	Sensitivity, %	Specificity, %	Positive Likelihood
Hospital units/*organization & administration/ standards	1.04	99.93	14.39
Hospitals public	1.04	99.93	14.39
Hospitals teaching	1.04	99.93	14.39
Length of stay/epidemiology	1.04	99.93	14.39
Maryland	2.08	99.86	14.39
Matched-pair analysis	1.04	99.93	14.39
Minnesota/epidemiology	1.04	99.93	14.39
Nursing service	2.08	99.86	14.39
Nursing staff hospital	1.04	99.93	14.39
Patient isolation	1.04	99.93	14.39
Personnel hospital	1.04	99.93	14.39
Referral and con	1.04	99.93	14.39
Sentinel surveillance	1.04	99.93	14.39
Workload/psychology	1.04	99.93	14.39
*Outcome assessment (health care)	15.63	98.84	13.49
Nurses' aides/*	2.08	99.82	11.51
*Education nursing	1.04	99.89	9.59
Nursing staff hospital/*organization & administration/standards	1.04	99.89	9.59
Accidental falls	1.04	99.89	9.59
Chronic disease	2.08	99.78	9.59
Health services research/*method	1.04	99.89	9.59
Hospital costs/*statistics & numerical data	1.04	99.89	9.59
Hospital restructuring	1.04	99.89	9.59
Hospitals teaching/standards	1.04	99.89	9.59
Hospitals teaching/statistics & numerical data	1.04	99.89	9.59
Mortality	1.04	99.89	9.59
Nursing assessment/organization & administration	1.04	99.89	9.59
Nursing staff hospital/*organization & administration/*standard	1.04	99.89	9.59
Nursing staff hospital/economic/psychology/* supply & distribution	1.04	99.89	9.59
Ontario/epidemiology	1.04	99.89	9.59
Patient discharge	1.04	99.89	9.59
Personnel staffing and scheduling/*legislation & jurisprudence/*standards	1.04	99.89	9.59
Personnel staffing and scheduling/*standards/ statistics & numerical data	1.04	99.89	9.59
Poisson distribution	1.04	99.89	9.59
Psychology industrial	1.04	99.89	9.59
Quality of health care/standards	1.04	99.89	9.59
Risk adjustment	1.04	99.89	9.59

MeSH terms and keywords	Sensitivity, %	Specificity, %	Positive Likelihood
Statistics	1.04	99.89	9.59
Personnel staffing and scheduling/*statistics & numerical data	5.21	99.46	9.59
Multivariate analysis	9.38	98.95	8.93
Diagnosis related	3.13	99.64	8.63
*Quality indicators, health care	5.21	99.38	8.46
Logistic models	9.38	98.84	8.09
Pennsylvania	4.17	99.46	7.67
Hospital mortality	7.29	99.02	7.46
Continuity of patient care/standards	1.04	99.86	7.19
Medication error	1.04	99.86	7.19
Models theoretical	1.04	99.86	7.19
Outcome and process assessment (health care)/*organization &	1.04	99.86	7.19
Ownership	1.04	99.86	7.19
Patient education	1.04	99.86	7.19
Patient readmission	1.04	99.86	7.19
Personnel staffing and scheduling/economics/* standards	1.04	99.86	7.19
Personnel staffing and scheduling/statistics & numerical data/*trends	1.04	99.86	7.19
Risk	1.04	99.86	7.19
Administration/utilization	1.04	99.86	7.19
Acute disease/nursing	3.13	99.57	7.19
Linear models	3.13	99.53	6.64
Research support	23.96	96.16	6.24
Research support	4.17	99.31	6.06
*Licensure nursing	1.04	99.82	5.75
American Hospital Association	1.04	99.82	5.75
Confidence intervals	1.04	99.82	5.75
Feasibility studies	1.04	99.82	5.75
Hospital bed capacity	1.04	99.82	5.75
Least-squares analysis	1.04	99.82	5.75
Likelihood function	1.04	99.82	5.75
Medical staff hospital/statistics & numerical data	1.04	99.82	5.75
Nurses	1.04	99.82	5.75
Nursing staff hospital/*standards/supply & distribution	1.04	99.82	5.75
Population surveillance	1.04	99.82	5.75
Postoperative care	1.04	99.82	5.75
Proportional hazard	1.04	99.82	5.75
Salaries and fringes	1.04	99.82	5.75
Tennessee	1.04	99.82	5.75
Health care survey	6.25	98.91	5.75

MeSH terms and keywords	Sensitivity, %	Specificity, %	Positive Likelihood
Benchmarking	4.17	99.28	5.75
Case-control study	4.17	99.24	5.48
Outcome and process assessment (health care)	3.13	99.42	5.39
Sampling studies	2.08	99.60	5.23
Workload/*statistics	2.08	99.60	5.23
Midwestern United States	3.13	99.38	5.08
Health services	10.42	97.94	5.05

B. MeSH Terms and Keywords in Eligible Studies (Sensitivity >0)

MeSH terms	Sensitivity	Specificity	Positive Predictive Likelihood
*Models statistics	1.04	99.78	4.80
Alberta	1.04	99.78	4.80
Critical pathway	1.04	99.78	4.80
District of Columbia	1.04	99.78	4.80
Nursing staff hospital/*legislation & jurisprudence/*supply &	1.04	99.78	4.80
Patient care planning	1.04	99.78	4.80
Patients	1.04	99.78	4.80
Length of stay	10.42	97.79	4.72
Regression analysis	9.38	97.97	4.62
Intensive care units	4.17	99.09	4.60
Length of stay/standards	5.21	98.84	4.50
Quality indicators health care	4.17	99.06	4.43
Hospital bed capacity	2.08	99.53	4.43
Length of stay/economics	2.08	99.53	4.43
Cohort studies	3.13	99.28	4.32
*Patients	1.04	99.75	4.11
Bed occupancy	1.04	99.75	4.11
Consumer satisfaction	1.04	99.75	4.11
Hospital costs/standards	1.04	99.75	4.11
Hospital-patient relations	1.04	99.75	4.11
Hospitalization	1.04	99.75	4.11
Intensive care units/*organization & administration	1.04	99.75	4.11
Medical errors	1.04	99.75	4.11
Patient satisfaction	1.04	99.75	4.11
Southeastern union	1.04	99.75	4.11
Nursing supervisory	2.08	99.49	4.11
American Nurses' Association	2.08	99.46	3.84
Personnel turnover	2.08	99.46	3.84
Outcome assessment (health care)	9.38	97.54	3.81
*Length of stay	1.04	99.71	3.60

MeSH terms	Sensitivity	Specificity	Positive Predictive Likelihood
*Models organizational	1.04	99.71	3.60
Choice behavior	1.04	99.71	3.60
Forms and records	1.04	99.71	3.60
Nurses' aides/*organization & administration	1.04	99.71	3.60
Safety	2.08	99.42	3.60
Risk assessment	2.08	99.38	3.38
*Patient care team	1.04	99.67	3.20
Education nursing	1.04	99.67	3.20
Hospital bed cap	1.04	99.67	3.20
Hospitals public	1.04	99.67	3.20
Medical staff hospital/standard	1.04	99.67	3.20
Missouri	1.04	99.67	3.20
Nursing staff hospital/education*organization	1.04	99.67	3.20
Physician-nurse relations	1.04	99.67	3.20
Hospital restructuring/*organization & administration	2.08	99.35	3.20
Patient satisfaction/*statistics & numerical data	2.08	99.35	3.20
Predictive value	3.13	98.99	3.08
Risk factors	15.63	94.71	2.96
*Intensive care	1.04	99.64	2.88
*Personnel staff	1.04	99.64	2.88
Health policy	1.04	99.64	2.88
Nursing care/*organization	1.04	99.64	2.88
Nursing service	1.04	99.64	2.88
Safety management	1.04	99.64	2.88
Administration/standards	1.04	99.64	2.88
*Quality of health care	10.42	96.16	2.71
Quality of health care	8.33	96.92	2.71
Nursing administration research	14.58	94.61	2.70
Severity of illness	4.17	98.44	2.68
*Efficiency organization	1.04	99.60	2.62
Hospitals/*standards	1.04	99.60	2.62
Length of stay/*statistics & numerical data	1.04	99.60	2.62
Stress psychological	1.04	99.60	2.62
Personnel staffing and scheduling/standards	3.13	98.77	2.54
Personnel turnover	3.13	98.73	2.47
Acute disease	2.08	99.13	2.40
*Clinical competition	3.13	98.70	2.40
Clinical nursing	1.04	99.57	2.40
Connecticut	1.04	99.57	2.40
Night care/*manpower	1.04	99.57	2.40
Nursing staff hospital/psychology/supply & distribution	1.04	99.57	2.40

MeSH terms	Sensitivity	Specificity	Positive Predictive Likelihood
Numerical data	2.08	99.09	2.30
Nursing care/*standards	3.13	98.62	2.27
*Quality assurance health care	1.04	99.53	2.21
Absenteeism	1.04	99.53	2.21
Nursing staff hospital/organization & administration	1.04	99.53	2.21
Pain measurement	1.04	99.53	2.21
Case management	1.04	99.49	2.06
Nursing care/statistics	1.04	99.49	2.06
Outcome assessment	1.04	99.49	2.06
Nursing staff hospital/economic	2.08	98.91	1.92
Internal-external control	1.04	99.46	1.92
Organizational case studies	1.04	99.46	1.92
Prevalence	2.08	98.88	1.86
*Nursing staff	1.04	99.42	1.80
Total quality management	1.04	99.42	1.80
Treatment outcome	2.08	98.81	1.74
Costs and cost assessment	1.04	99.38	1.69
Patient discharge	1.04	99.38	1.69
Health services	2.08	98.73	1.64
Models organizational	2.08	98.73	1.64
Ontario	2.08	98.73	1.64
*Personnel management	1.04	99.35	1.60
Nursing research	1.04	99.35	1.60
Nursing staff hospital/*supply distribution	16.67	89.54	1.59
Aged	14.58	90.55	1.54
Pilot projects	4.17	97.28	1.53
Personnel staffing and scheduling/*standards	7.29	95.22	1.53
*Occupational health	1.04	99.31	1.51
Evidence-based	1.04	99.31	1.51
Hospital costs	1.04	99.31	1.51
Statistics nonparametric	1.04	99.31	1.51
Incidence	2.08	98.59	1.48
*Professional autonomy	1.04	99.28	1.44
Hospital bed capacity	1.04	99.28	1.44
Hospital units	1.04	99.28	1.44
Research support	23.96	83.09	1.42
*Leadership	1.04	99.24	1.37
Educational status	1.04	99.24	1.37
Distribution	3.13	97.68	1.35
Retrospective studies	5.21	96.13	1.34
Risk management	1.04	99.20	1.31
Administration	1.04	99.20	1.31

MeSH terms	Sensitivity	Specificity	Positive Predictive Likelihood
Prospective studies	7.29	94.28	1.27
California	3.13	97.54	1.27
Workload	7.29	94.24	1.27
*Decision making	1.04	99.17	1.25
Analysis of variance	3.13	97.50	1.25
Data	1.04	99.17	1.25
Michigan	1.04	99.13	1.20
Longitudinal studies	3.13	97.36	1.18
Nurse-patient relations	4.17	96.45	1.17
Organizational innovation	4.17	96.45	1.17
Age 80 and over	4.17	96.38	1.15
Male	25.00	78.17	1.15
Job satisfaction	6.25	94.42	1.12
Quality assurance	1.04	99.06	1.11
administration/psychology	1.04	99.06	1.11
Patient satisfaction	6.25	94.32	1.10
United States	15.63	85.37	1.07
Cross-sectional	7.29	93.16	1.07
Cost control	1.04	98.99	1.03
Patient care team	1.04	98.99	1.03
Time factors	4.17	95.87	1.01
Factor analysis	1.04	98.95	0.99
Power (psychology)	1.04	98.95	0.99
*Patient satisfaction	4.17	95.80	0.99
Canada	1.04	98.91	0.96
Nursing evaluation on research	6.25	93.41	0.95
Middle age	14.58	84.43	0.94
Nurse administrators	1.04	98.88	0.93
Texas	1.04	98.88	0.93
Female	25.00	72.88	0.92
Evaluation studies	1.04	98.84	0.90
Personnel staffing and scheduling	7.29	91.64	0.87
Child	4.17	95.22	0.87
Data collection	2.08	97.57	0.86
*Job satisfaction	3.13	96.31	0.85
*Inpatients	1.04	98.77	0.85
*Personnel staff	7.29	91.24	0.83
Cost-benefit	1.04	98.62	0.76
Humans	71.88	2.75	0.74
Efficiency organization	1.04	98.59	0.74
Comparative study	6.25	90.84	0.68
Adult	14.58	77.62	0.65
Infant	1.04	98.37	0.64

MeSH terms	Sensitivity	Specificity	Positive Predictive Likelihood
Medical staff hospital	1.04	98.33	0.63
Nursing audit	1.04	98.30	0.61
Attitude of health	5.21	91.31	0.60
Child preschool	1.04	98.23	0.59
Inpatients/*psychology	1.04	98.19	0.58
Job description	1.04	98.12	0.55
Organizational care	2.08	96.20	0.55
Professional autonomy	1.04	98.04	0.53
Reproducibility	1.04	98.04	0.53
Adolescent	2.08	96.05	0.53
Hospitals teach	1.04	97.97	0.51
*Nursing staff hospital	4.17	91.67	0.50
Nurse's role	2.08	95.58	0.47
*Nurse's role	1.04	97.72	0.46
Personnel staffing and scheduling/*organization & administration	3.13	93.12	0.45
Personnel staffing and scheduling/*legislation & jurisprudence	1.04	97.61	0.44
Social support	1.04	97.61	0.44
Clinical competence	1.04	97.57	0.43
*Models nursing	2.08	95.11	0.43
Clinical compete	1.04	97.47	0.41
Questionnaires	6.25	82.48	0.36
Infant newborn	1.04	97.07	0.36
Interprofessional relations	1.04	96.85	0.33
Needs assessment	1.04	96.02	0.26
Models nursing	1.04	95.37	0.22

C. MeSH Terms and Keywords in Excluded Studies (Sensitivity = 0)

MeSH Terms

- *Absenteeism
- *Accidental fall
- *Accidental falls/economics
- *Accidents
- *Accidents occupational
- *Accidents occupational/prevention & control/statistics & numerical data
- *Accreditation
- *Aftercare/statistics & numerical data
- *Allied health personnel
- *American Nurses Association
- *Ancillary services hospital/statistics & numerical data
- *Automatic data processing

- *Automation
- *Bed occupancy
- *Bed occupancy/economics
- *Benchmarking
- *Bereavement
- *Burnout professional/epidemiology/etiology/psychology
- *Burnout professional/etiology/prevention & control
- *Burnout professional/etiology/ prevention & control/psychology
- *Burnout professional/prevention & control/psychology
- *Caregivers
- *Case management
- *Cause of death
- *Clinical nursing research
- *Clinical protocols
- *Communication
- *Communication barriers
- *Consumer satisfaction
- *Continuity of patient care
- *Contract services
- *Contract services/economics
- *Cost of illness
- *Cost-benefit analysis
- *Counseling/education/standards
- *Credentialing
- *Cross infection
- *Cross infection/nursing/transmission/virology
- *Cross-cultural comparison
- *Data collection
- *Data interpretation statistical
- *Death
- *Decision making
- *Decision support
- *Decision support systems management
- *Decision support techniques
- *Decision trees
- *Delivery of health care
- *Diagnosis-related groups
- *Diagnostic errors
- *Disease transmission professional-to-patient
- *Documentation
- *Drug combinations
- *Drug compounding
- *Drug delivery systems
- *Drug labeling
- *Drug therapy computer-assisted
- *Economics hospital

- *Economics nursing
- *Education medical continuing
- *Education nursing baccalaureate
- *Education nursing continuing
- *Educational measurement
- *Efficiency
- *Emergency medicine/organization & administration*emergency nursing
- *Emergency nursing/organization & administration
- *Emergency service hospital
- *Emergency service hospital/organization & administration
- *Employee discipline
- *Employee incentive plans
- *Employee performance appraisal
- *Employment
- *Episode of care
- *Ethics
- *Ethics business
- *Ethics clinical
- *Ethics institutional
- *Ethics nursing
- *Evidence-based medicine
- *Expert testimony/*legislation & jurisprudence
- *Foreign professional personnel
- *Foreign professional personnel/education/psychology
- *Foreign professional personnel/standards
- *Health care rationing
- *Health care reform
- *Health care surveys
- *Health education
- *Health education/methods
- *Health facility closure
- *Health facility environment
- *Health facility environment/ethics/organization & administration*health facility merger
- *Health knowledge attitudes practice
- *Health manpower
- *Health services accessibility
- *Health services needs and demand
- *Health services statistics & numerical data
- *Health services research
- *Hospital administration
- *Hospital communication systems/organization & administration
- *Hospital costs
- *Hospital design and construction*hospital information systems
- *Hospital information systems/organization & administration
- *Hospital restructuring
- *Hospital units

- *Hospital-patient relations
- *Hospitalization
- *Hospitalization/economics
- *Hospitalization/statistics & numerical data
- *Hospitals
- *Infection control practitioners
- *Inpatients/education/psychology
- *Inpatients/psychology
- *Inpatients/psychology/statistics & numerical data
- *Intensive care units/manpower
- *Intensive care units/statistics
- *Interpersonal relations
- *Inter professional relations
- *Joint Commission on Accreditation of Healthcare Organizations
- *Labor unions
- *Labor unions/trends
- *Legislation hospital
- *Legislation nursing
- *Length of stay/legislation & jurisprudence/statistics & numerical data
- *Liability legal
- *Linear models
- *Malpractice
- *Medical errors/adverse effects
- *Medical staff hospital
- *Medical staff hospital/education/psychology
- *Medical staff hospital/psychology/statistics & numerical data
- *Medication errors/adverse effects
- *Medication errors/classification
- *Medication errors/methods/nursing/prevention & control/statistics &
- *Medication errors/statistics & numerical data
- *Models nursing
- *Models organizational
- *Monitoring intra operative/methods/nursing
- *Nurse administrators
- *Nurse administrators/education/psychology
- *Nurse administrators/organization & administration/psychology
- *Nurse practitioners
- *Nurse practitioners/economics
- *Nurse's role/psychology
- *Nurse-patient relations
- *Nurseries hospital
- *Nurses
- *Nurses' aides
- *Nurses' aides/education
- *Nurses' aides/education/organization & administration/psychology*nursing
- *Nursing administration research

- *Nursing assessment
- *Nursing assessment/methods/standards
- *Nursing audit
- *Nursing care
- *Nursing care/manpower
- *Nursing care/organization & administration/psychology
- *Nursing care/psychology/standards
- *Nursing care/psychology/statistics & numerical data
- *Nursing diagnosis
- *Nursing methodology research
- *Nursing process
- *Nursing process/standards
- *Nursing records
- *Nursing research
- *Nursing service hospital
- *Nursing staff
- *Nursing staff hospital
- *Nursing staff hospital/economics/standards
- *Nursing staff hospital/economics statistics & numerical data
- *Nursing staff hospital/economics/supply & distribution
- *Nursing staff hospital/education
- *Nursing staff hospital/education/organization
- *Nursing staff hospital/education/organization & administration
- *Nursing staff hospital/education/psychology
- *Nursing staff hospital/education/psychology/supply & distribution
- *Nursing staff hospital/education/standards
- *Nursing staff hospital/education/supply & distribution
- *Nursing staff hospital/legislation & jurisprudence/supply & distribution
- *Nursing staff hospital/organization & administration/standards
- *Nursing staff hospital/organization & administration/statistics &
- *Nursing staff hospital/organization & administration/supply &
- *Nursing staff hospital/psychology
- *Nursing staff hospital/psychology/standards
- *Nursing staff hospital/psychology/statistics & numerical data
- *Nursing staff hospital/psychology/supply & distribution
- *Nursing staff hospital/statistics & numerical data
- *Nursing staff hospital/supply & distribution
- *Nursing staff hospital/utilization
- *Nursing staff/education/organization & administration/psychology
- *Nursing theory
- *Nursing practice
- *Nursing supervisory
- *Nursing team
- *Nutrition assessment
- *Nutrition/education
- *Outcome assessment (health care)/economics (health care)

- *Outcome and process assessment (health care)/methods
- *Outcome and process assessment (health care)/statistics & numerical data
- *Personnel administration hospital
- *Personnel management/*methods
- *Personnel selection
- *Personnel selection/*organization & administration
- *Personnel selection/trends
- *Personnel staffing and scheduling/*legislation & jurisprudence
- *Personnel staffing and scheduling/ economics/legislation &
- *Personnel staffing and scheduling/legislation & jurisprudence
- *Personnel staffing and scheduling/organization
- *Personnel staffing and scheduling/organization & administration
- *Personnel staffing and scheduling/standards
- *Personnel staffing and scheduling/statistics & numerical data
- *Personnel turnover
- *Personnel turnover/statistics & numerical data
- *Personnel turnover/statistics & numerical data/ trends
- *Professional-patient relations
- *Program development
- *Program evaluation
- *Programmed instruction/standards
- *Progressive patient care
- *Qualitative research
- *Quality indicators health care/standards
- *Quality of health care/legislation & jurisprudence
- *Quality of health care/legislation & jurisprudence/statistics & numerical
- *Quality of life
- *Restraint physical
- *Restraint physical/adverse effects
- *Resuscitation
- *Risk assessment
- *Risk management
- *Risk management/methods/organization & administration
- *Safety
- *Safety management
- *Salaries and fringe benefits
- *Staff development
- *Staff development/methods
- *Total quality management
- *Work schedule tolerance
- *Work schedule tolerance/psychology
- *Workload
- *Workload/economics
- *Workload/psychology
- *Workload/statistics & numerical data
- *Workplace

*Workplace/organization & administration/psychology
*Workplace/psychology
Academic medical centers/*manpower
Academic medical centers/*organization & administration
Academic medical centers/*organization & administration/*statistics &
Academic medical centers/economics/*manpower/organization & administration
Academic medical centers/economics/standards/statistics & numerical data
Academic medical centers/manpower
Access to information/*legislation & jurisprudence
Accidental falls/*prevention & control
Accidental falls/* statistics & numerical data
Accidental falls/economics/statistics & numerical data
Accidental falls/prevention & control
Accidental falls/prevention & control/*statistic/prevention & control/*statistics & numerical data
Accidental falls/prevention & control/*statistic/*statistics & numerical data
Accidents occupational/*prevention & control
Accidents occupational/*statistics & numerical data
Accidents occupational/economics/*prevention & control/statistics
Accidents occupational/economics/prevention & control/*statistics
Accidents occupational/prevention & control
Accidents/*statistics & numerical data
Accreditation
Accreditation/*legislation & jurisprudence
Accreditation/*methods
Accreditation/*standards
Administrative personnel
Adverse drug reaction reporting systems
Adverse drug reaction reporting systems/*statistics & numerical data
Adverse drug reaction reporting
Systems/*utilization
Adverse drug reaction reporting systems/standard
Adverse drug reaction reporting
Systems/statistics & numerical data
Adverse drug reaction reporting systems/utilization
Allied health personnel
Allied health personnel/*psychology
Allied health personnel/*supply & distribution
Allied health personnel/*utilization
Allied health personnel/economics/statistics & numerical data
Allied health personnel/organization & administration
Allied health personnel/psychology
Allied health personnel/standards/supply & distribution
Allied health personnel/statistics & numerical data/supply & distribution
Allied health personnel/supply & distribution
American Nurses' Association/organization & administration
Analgesia/*nursing

Analgesia/methods/*nursing
Analgesia/nursing/*standards
Analgesia/nursing/*utilization
Ancillary services hospital/*trends
Ancillary services
Bed occupancy/classification
Bed occupancy/economics
Bed occupancy/statistics & numerical data
Bed rest/*adverse effects/nursing
Bed rest/adverse effects/nursing
Benchmarking/*methods
Benchmarking/*methods/standards
Benchmarking/*organization & administration
Benchmarking/methods
Benchmarking/organization & administration
Benchmarking/standards
Burnout professional
Burnout professional/*diagnosis/*psychology
Burnout professional/*epidemiology/*psychology
Burnout professional/*epidemiology
Burnout professional/*etiology
Burnout professional/*etiology/psychology
Burnout professional/*etiology/psychology
Burnout professional/*prevention & control
Burnout professional/*prevention & control/*psychology
Burnout professional/*prevention & control/psychology
Burnout professional/*psychology
Burnout professional/classification/diagnosis/etiology/*prevention
Burnout professional/complications/*epidemiology
Burnout professional/diagnosis/*epidemiology/prevention &
Burnout professional/diagnosis/*epidemiology/psychology
Burnout professional/diagnosis/epidemiology/*psychology
Burnout professional/diagnosis/epidemiology/psychology
Burnout professional/diagnosis/etiology/*prevention & control
Burnout professional/diagnosis/etiology/prevention & control/*psychology
Burnout professional/diagnosis/physiopathology/*prevention &
Burnout professional/epidemiology
Burnout professional/epidemiology/*etiology
Burnout professional/epidemiology/etiology/*psychology
Burnout professional/epidemiology/etiology/prevention &
Burnout professional/epidemiology/etiology/psychology
Burnout professional/epidemiology/psychology
Burnout professional/etiology/prevention & control
Burnout professional/etiology/prevention & control/psychology
Burnout professional/etiology/psychology
Burnout professional/prevention control

Burnout professional/prevention & control/*psychology
Burnout professional/prevention & control/psychology
Burnout professional/psychology
Cardiac surgical procedures/*adverse effects/*nursing
Cardiac surgical procedures/*nursing
Cardiac surgical procedures/*nursing/standards
Cardiac surgical procedures/adverse effects/mortality/*nursing
Cardiac surgical procedures/economics/*nursing
Cardiac surgical procedures/nursing
Cardiology service hospital/*manpower
Cardiology service hospital/economics/manpower/*organization &
Cardiopulmonary resuscitation/*education/*methods/nursing
Cardiopulmonary resuscitation/education/*nursing
Cardiovascular diseases/*nursing
Case management
Case management/*trends
Case management/organization & administration*
Causality
Cause of death
Censuses
Centralized hospital services
Centralized hospital services/*organization & administration
Cerebrovascular accident/*nursing/rehabilitation
Cerebrovascular accident/classification/nursing
Cerebrovascular accident/nursing
Cerebrovascular disorders/*nursing
Cerebrovascular disorders/*nursing/*rehabilitation
Cerebrovascular disorders/*nursing/rehabilitation
Certificate of need/legislation & jurisprudence
Certification/*organization & administration
Certification/*standards
Cesarean section/*nursing/psychology
Clinical competence/*legislation & jurisprudence/*standards
Clinical competence/*legislation & jurisprudence/standards
Clinical competence/*standards
Clinical competence/*statistics & numerical data
Clinical competence/legislation & jurisprudence
Clinical competence/legislation & jurisprudence/*standards
Clinical competence/legislation & jurisprudence/standards
Clinical competence/standards/*statistics & numerical data
Clinical competence/statistics & numerical data
Clinical nursing research/*methods
Clinical nursing research/*organization & administration
Clinical nursing research/method
Clinical nursing research/organization & administration/*standards
Clinical protocols

Clinical protocols/standards
Collective bargaining
Collective bargaining/*legislation & jurisprudence
Collective bargaining/*organization & administration
Collective bargaining/organization & administration
Confounding factors (epidemiology)
Confusion/*nursing
Confusion/*nursing/psychology
Confusion/etiology/nursing/*psychology
Conscious sedation/*nursing
Conscious sedation/adverse effects/*nursing
Conscious sedation/nursing/*psychology
Consumer satisfaction/*statistics & numerical data
Continuity of patient care
Continuity of patient care/*organization & administration
Continuity of patient care/*standards
Continuity of patient care/organization & administration
Continuity of patient care/organization & administration/statistics &
Contract services
Contract service/*organization & administration
Contract services/*standards
Contract services/legislation & jurisprudence
Contract services/statistics & numerical data/*utilization
Contracts
Coronary disease/*nursing
Coronary disease/*nursing/surgery
Cost control/methods
Cost control/trends
Cost of illness
Costs and cost analysis/*methods
Costs and cost analysis/economics
Costs and cost analysis/statistics & numerical data
Critical care/*manpower/methods
Critical care/*manpower/standard
Critical care/*methods
Critical care/*organization & administration
Critical care/economics/*manpower
Critical pathways
Critical pathway/*standards
Cross infection/*epidemiology/*etiology
Cross infection/*epidemiology/microbiology
Cross infection/*epidemiology/transmission
Cross infection/*microbiology
Cross infection/diagnosis/drug therapy/*prevention & control/*transmission
Cross infection/economics/*epidemiology/*etiology/prevention & control
Cross infection/epidemiology/*microbiology/*transmission

Cross infection/epidemiology/*microbiology/prevention &
 Cross infection/epidemiology/*microbiology/transmission
 Cross infection/epidemiology/*prevention & control
 Cross infection/epidemiology/*prevention & control/virology
 Cross infection/epidemiology/etiology/*prevention & control
 Cross infection/epidemiology/microbiology/*prevention &
 Cross infection/epidemiology/microbiology/*transmission
 Cross infection/etiology
 Cross infection/etiology/*prevention & control
 Cross infection/microbiology/*prevention &
 Cross infection/microbiology/*prevention & control/transmission
 Cross infection/mortality/*prevention & control
 Cross infection/nursing/*prevention & control/*psychology
 Cross infection/prevention & control
 Cross infection/prevention & control/*transmission
 Data collection
 Data collection/*methods/*standards
 Data collection/ methods/standards
 Data collection/*methods/standards/*statistics & numerical data
 Data collection/methods
 Data collection/ methods/*standards
 Data collection/methods/standards
 Data display
 Data interpretation statistical/statistics & numerical data
 Day care/manpower/*organization & administration/statistics & numerical
 Decision making
 Organizational decubitus ulcer *classification/nursing/pathology
 Decubitus ulcer/*economics/epidemiology/*therapy
 Decubitus ulcer/*epidemiology/*prevention & control
 Decubitus ulcer/*etiology/*prevention & control
 Decubitus ulcer/*etiology/nursing/*prevention & control
 Decubitus ulcer/*nursing
 Decubitus ulcer/*nursing/*psychology
 Decubitus ulcer/*prevention & control
 Decubitus ulcer/economics/ epidemiology/*prevention & control
 Decubitus ulcer/epidemiology/etiology
 Decubitus ulcer/epidemiology/etiology/*prevention & control
 Decubitus ulcer/etiology
 Decubitus ulcers/prevention & control
 Decubitus ulcer/etiology/*prevention & control
 Decubitus ulcer/nursing/*prevention & control
 Delivery of health care
 Delivery of health care integrated
 Delivery of health care integrated/*manpower
 Delivery of health care integrated/*organization & administration
 Delivery of health care integrated/*standards

Delivery of health care integrated/organization & administration
Delivery of health care/*economics
Delivery of health care/*history
Delivery of health care/*manpower
Delivery of health care/*standards
Delivery of health care/economics/standards/*trends
Delivery of health care/organization & administration
Delivery obstetric/*methods
Delivery obstetric/*nursing/statistics & numerical data
Diabetes mellitus/*nursing
Diagnosis-related groups/*classification
Direct service costs/*statistics & numerical data
Direct service costs/statistics & numerical data
Disease management
Disease outbreaks/*prevention & control/statistics & numerical data
Disease transmission professional-to-patient
Disease transmission professional-to-patient/*prevention & control
Disease transmission professional-to-patient/*statistics & numerical data
Disease transmission professional-to-patient/prevention & control
Disease transmission professional-to-patient/statistics & numerical data
Drug administration schedule
Drug monitoring/*nursing
Drug monitoring/nursing/standards
Drug monitoring/methods/nursing
Drug monitoring/nursing/standards
Economics nursing education continuing
Education continuing/*methods
Education nursing associate/*trends
Education nursing baccalaureate/*methods
Education nursing baccalaureate/*organization & administration
Education nursing baccalaureate/*standards
Education nursing baccalaureate/*trends
Education nursing baccalaureate/standards
Education nursing baccalaureate/statistics & numerical data
Education nursing continuing
Education nursing continuing/*manpower
Education nursing continuing/*methods
Education nursing continuing/*organization & administration
Education nursing continuing/*standards
Education nursing continuing/methods
Education nursing continuing/methods/*standard
Education nursing continuing/organization & administration
Education nursing continuing/standards
Education nursing continuing/statistics & numerical data
Education nursing diploma programs
Education nursing diploma programs/*standards

Education nursing graduate/*manpower
Education nursing graduate/*organization & administration
Education nursing graduate/*trends
Education nursing/*organization & administration
Education nursing/*statistics & numerical data
Education nursing/economics
Education nursing/economics/legislation & jurisprudence
Education nursing/history
Education nursing/methods
Education nursing/standards
Education nursing/standards/trends
Education nursing/trends
Efficiency organizational/standards
Emergencies/*nursing
Emergency nursing
Emergency nursing/*education
Emergency nursing/*education/*methods
Emergency nursing/*education/standards
Emergency nursing/*manpower
Emergency nursing/*methods
Emergency nursing/*methods/standards
Emergency nursing/*organization & administration
Nursing/*standards
Emergency nursing/*standards/trends
Emergency nursing/*statistics & numerical data
Emergency nursing/education/*methods
Emergency nursing/education/*methods/standards
Emergency nursing/education/*organization & administration
Emergency nursing/education/*standards
Emergency nursing education/organization & administration
Emergency nursing/manpower
Emergency nursing/manpower/*standards
Emergency nursing/manpower/standards
Emergency nursing/standards
Emergency service hospital/economics/*manpower
Emergency service hospital/economics/*manpower/organization &
Employee discipline
Employee performance appraisal/*methods/standards
Employment/*legislation & jurisprudence
Employment/*organization & administration
Employment/*psychology
Epidemiologic studies
Ethics nursing evidence-based medicine/*organization & administration
Evidence-based medicine/organization & administration
Evidence-based medicine/standards
Foreign medical graduates

Foreign medical graduates/*legislation & jurisprudence/supply &
Foreign medical graduates/psychology/statistics & numerical data
Foreign professional personnel
Foreign professional personnel/*education
Foreign professional personnel/*education/*psychology/supply &
Foreign professional personnel/*education/psychology
Foreign professional personnel/*education/psychology/supply & distribution
Foreign professional personnel/*education/supply & distribution
Foreign professional personnel/*history
Foreign professional personnel/*legislation & jurisprudence
Foreign professional personnel/*legislation & jurisprudence/supply &
Foreign professional personnel/*psychology
Foreign professional personnel/*psychology/supply & distribution
Foreign professional personnel/*standards
Foreign professional personnel/*supply & distribution
Foreign professional personnel/*utilization
Foreign professional personnel/education
Foreign professional personnel/education/*psychology
Foreign professional personnel/education/*psychology/supply & distribution
Foreign professional personnel/education/*supply & distribution
Foreign professional personnel/education/legislation &
Foreign professional personnel/education/psychology/*supply & distribution
Foreign professional personnel/legislation & jurisprudence/supply
Foreign professional personnel/standards
Foreign professional personnel/standards/statistics & numerical
Foreign professional personnel/supply & distribution
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Health care reform/*trends
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Health services accessibility/*organization & administration
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Health services needs and demand*statistics & numerical data
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Heart failure congestive/*nursing
Heart failure congestive/classification/nursing
Heart failure congestive/complications/*nursing
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Hospital administration/*methods
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Hospital administration/manpower/*statistics & numerical data
Hospital administration/methods
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Hospital administrators/*organization & administration
Hospital administrators/*supply & distribution

Hospital administrators/organization & administration/psychology
Hospital administrators/psychology/*supply & distribution
Hospital administrators/supply & distribution
Hospital departments/*organization & administration
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Hospital design and construction economics/*legislation & jurisprudence
Hospital design and construction/standards
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Hospital distribution systems/*standards
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Hospital mortality/*trends
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Hospital restructuring/manpower/standards
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Hospital units/*economics/organization & administration
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Hospital units/*manpower
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Hospital units/*organization & administration
Hospital units/*standards
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Hospital units/*utilization
Hospital units/classification/*standards
Hospital units/classification/manpower
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Hospital units/economics/manpower/organization & administration
Hospital units/economics/organization & administration/*standards
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Hospital units/manpower/*organization & administration
Hospital units/manpower/*organization & administration/statistics &
Hospital units/organization & administration
Hospital units/organization & administration/*standards

Hospital units/organization & administration/*statistics & numerical data
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Hospital/*manpower/standards/utilization
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Hospitalization/statistics & numerical data
Hospitals
Hospitals community
Hospitals community/*legislation & jurisprudence
Hospitals community/*manpower/organization & administration
Hospitals community/*organization & administration
Hospitals community/legislation & jurisprudence
Hospitals community/manpower
Hospitals community/manpower/organization & administration
Hospitals community/organization & administration
Hospitals community/organization & administration/*standards
Hospitals community/standards
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Hospitals general/classification/*manpower
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Hospitals pediatric/*standards
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Hospitals private
Hospitals private/*manpower
Hospitals private/economics/manpower
Hospitals private/organization & administration
Hospitals psychiatric/*manpower
Hospitals psychiatric/manpower/*statistics & numerical data
Hospitals psychiatric/manpower/statistics & numerical data
Hospitals psychiatric/organization & administration/*standards
Hospitals public/*manpower
Hospitals public/*organization & administration
Hospitals public/*organization & administration/statistics & numerical
Hospitals public/*standards
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Hospitals public/economics/manpower
Hospitals public/manpower/*standards
Hospitals public/manpower/organization & administration
Hospitals public/organization & administration
Hospitals public/organization & administration*
Hospitals public/organization & administration/standards
Hospitals public/organization & administration/standards/*utilization
Hospitals public/standards
Hospitals public/utilization
Hospitals rural
Hospitals rural/*organization & administration
Hospitals special/organization & administration/standards
Hospitals state/manpower/*statistics & numerical data
Hospitals state/manpower/statistics & numerical data
Hospitals teaching/*organization & administration
Hospitals teaching/*organization & administration/utilization
Hospitals teaching/*standards
Hospitals teaching/*statistics & numerical data
Hospitals teaching/economics/manpower/organization & administration
Hospitals teaching/manpower
Hospitals teaching/manpower/*organization & administration/standards
Hospitals teaching/manpower/*standards
Hospitals university
Hospitals university/*economics/utilization
Hospitals university/*manpower
Hospitals university/*standards
Hospitals university/economics
Hospitals university/economics/organization & administration
Hospitals university/manpower
Hospitals university/manpower/organization & administration/statistics &
Hospitals university/manpower/statistics & numerical data
Hospitals urban
Hospitals urban/*manpower
Hospitals urban/manpower/*standards
Hospitals veterans/*standards/statistics & numerical data
Hospitals veterans/manpower
Hospitals veterans/manpower/*standards
Hospitals/*manpower
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Infection/epidemiology/etiology/inpatients

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Inpatients/*education
Inpatients/*legislation & jurisprudence/*psychology
Inpatients/*psychology
Inpatients/*psychology/statistics & numerical data
Inpatients/*statistics & numerical data
Inpatients/classification
Inpatients/education/*psychology/inpatients/history/psychology
Intensive care units neonatal/economics/*manpower
Intensive care units neonatal/economics/manpower/utilization
Intensive care units neonatal/manpower
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Intensive care units neonatal/manpower/*statistics & numerical data
Intensive care units pediatric
Intensive care units pediatric/*economics/manpower
Intensive care units pediatric/economics/manpower/utilization
Intensive care units pediatric/manpower/*organization & administration
Intensive care units pediatric/organization & administration/*standards
Intensive care units/*economics
Intensive care units/*legislation & jurisprudence/*manpower
Intensive care units/*manpower/*utilization
Intensive care units/*manpower/organization & administration
Intensive care units/*manpower/organization & administration/statistics &
Intensive care units/*manpower/standards
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Intensive care units/economics/manpower
Intensive care/manpower/*organization & administration
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Internal medicine/manpower/*standards
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Labor unions/*organization & administration
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Legislation nursing
Length of stay/*economics
Length of stay/economics/*statistics & numerical data
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Licensure nursing
Licensure nursing/*legislation & jurisprudence
Licensure nursing/legislation & jurisprudence
Licensure nursing/statistics & numerical data
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Malpractice/*economics/*legislation & jurisprudence
 Malpractice/*legislation & jurisprudence
 Malpractice/legislation & jurisprudence
 Malpractice/legislation & jurisprudence/*statistics & numerical data
 Managed care programs
 Managed care programs/*economics
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 Maternal-child nursing/*manpower
 Maternal-child nursing/*organization & administration
 Maternal-child nursing/*standards
 Maternal-child nursing/*trends
 Maternal-child nursing/education/*methods
 Maternal-child nursing/education/*organization & administration
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 Maternal-child nursing/manpower/*standards
 Maternal-child nursing/methods/*standards
 Medical errors/*adverse effects/*prevention & control
 Medical errors/*nursing/prevention & control/*statistics & numerical data
 Medical errors/*nursing/statistics & numerical data
 Medical errors/nursing/prevention & control/*statistics & numerical data
 Medical staff hospital/*economics/supply & distribution
 Medication errors/*nursing/standards/statistics & numerical data
 Medication errors/methods/nursing/*prevention & control
 Neonatal nursing/*manpower/*methods
 Neonatal nursing/*organization & administration
 Neonatal nursing/*standards
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 Night care/*organization & administration
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 Nurse administrators/*education/*organization & administration/psychology
 Nurse administrators/*legislation & jurisprudence
 Nurse administrators/*organization & administration
 Nurse administrators/*organization & administration/*psychology
 Nurse administrators/*organization & administration/psychology
 Nurse administrators/economics/supply & distribution
 Nurse administrators/education
 Nurse administrators/education/*organization & administration
 Nurse administrators/education/*psychology
 Nurse administrators/education/organization & administration/*psychology
 Nurse administrators/education/organization & administration/psychology
 Nurse administrators/legislation & jurisprudence/psychology
 Nurse administrators/statistics & numerical data

Nurse clinicians
 Nurse clinicians/*organization & administration
 Nurse clinicians/*organization & administration/*psychology
 Nurse clinicians/*organization & administration/psychology
 Nurse clinicians/*organization & administration/standards
 Nurse clinicians/*standards
 Nurse clinicians/*supply & distribution
 Nurse clinicians/education
 Nurse clinicians/education/*organization & administration
 Nurse clinicians/education/*organization & administration/psychology
 Nurse clinicians/education/standards/supply & distribution
 Nurse clinicians/legislation & jurisprudence
 Nurse clinicians/organization & administration
 Nurse clinicians/psychology/*supply & distribution
 Nurse's role*
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 Nurses' aides
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 Nurses' aides/*education
 Nurses' aides/*organization & administration/psychology
 Nurses' aides/*psychology
 Nurses' aides/*standards
 Nurses' aides/distribution
 Nurses' aides/education/*organization & administration
 Nurses' aides/education/*organization & administration/psychology
 Nurses' aides/education/*psychology
 Nurses' aides/education/*supply & distribution
 Nurses' aides/education/*utilization
 Nurses' aides/education/organization & administration
 Nurses' aides/education/organization & administration/psychology
 Nurses' aides/education/psychology
 Nurses' aides/education/supply & distribution
 Nurses' aides/legislation & jurisprudence
 Nurses' aides/legislation & jurisprudence/utilization
 Nurses' aides/organization & administration
 Nurses' aides/organization & administration/psychology
 Nurses' aides/psychology/*supply & distribution
 Nurses' aides/standards
 Nurses' aides/statistics & numerical data/*utilization
 Nurses/*organization & administration
 Nurses/*psychology
 Nurses/economics/organization & administration/utilization
 Nurses/economics/statistics & numerical data/*supply & distribution
 Nurses/psychology
 Nurses/psychology/*statistics & numerical data

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Nursing administration research/*education
Nursing administration research/*methods
Nursing administration research/*methods/standards
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Nursing administration research/*organization & administration
Nursing administration research/methods
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Nursing assessment
Nursing assessment/*ethics/methods
Nursing assessment/*legislation & jurisprudence
Nursing assessment/*methods
Nursing assessment/*methods/*statistics & numerical data
Nursing assessment/*methods/standards
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Nursing assessment/methods/standards/statistics & numerical data
Nursing audit/*methods
Nursing audit/*organization & administration
Nursing audit/organization & administration
Nursing care
Nursing care/*classification
Nursing care/*classification/methods
Nursing care/*methods
Nursing care/*methods/*psychology
Nursing care/*psychology
Nursing care/*psychology/*standards
Nursing care/*standards/statistics & numerical data
Nursing care/*utilization
Nursing care/classification
Nursing care/classification/*methods/standards/*statistics & numerical
Nursing care/classification/*psychology/*standards
Nursing care/manpower/methods/*statistics & numerical data
Nursing care/methods/*psychology
Nursing care/methods/organization & administration
Nursing care/organization & administration
Nursing care/psychology/standards
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Nursing diagnosis
Nursing diagnosis/*standards
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Nursing education research
Nursing evaluation research/*methods
Nursing evaluation research/*methods/standards
Nursing evaluation research/*organization & administration
Nursing evaluation research/methods

Nursing methodology research
Nursing methodology research/*methods
Nursing methodology research/*methods/*standards
Nursing methodology research/*methods/standards
Nursing methodology research/education/*methods
Nursing methodology research/methods/standards
Nursing process
Nursing process/*organization & administration
Nursing process/*statistics & numerical data
Nursing process/classification/standards/*statistics & numerical data
Nursing records
Nursing records*legislation & jurisprudence
Nursing records/*standards
Nursing records/*standards/statistics & numerical data
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Nursing records/standards
Nursing records/standards/statistics & numerical data
Nursing records/statistics & numerical data
Nursing research/*methods/standards
Nursing research/*methods/statistics & numerical data
Nursing research/*organization & administration
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Nursing service hospital/*classification
Nursing service hospital/*economics
Nursing service hospital/*history/manpower/organization & administration
Nursing service hospital/*manpower
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Nursing service hospital/*organization & administration
Nursing service hospital/*organization & administration/trends
Nursing service hospital/classification/*utilization
Nursing service hospital/classification/manpower/*organization
Nursing service hospital/economics
Nursing service hospital/economics/*organization & administration
Nursing service hospital/economics/*standards
Nursing service hospital/economics/*trends
Nursing service hospital/economics/manpower/*organization &
Nursing service hospital/manpower/*organization &
Nursing service hospital/manpower/*organization & administration
Nursing service hospital/manpower/*organization & administration/trends
Nursing service
Nursing staff
Nursing staff hospital
Nursing staff hospital/*economics
Nursing staff hospital/*economics/*legislation & jurisprudence

Nursing staff hospital/*economics/*supply & distribution
Nursing staff hospital/*economics/legislation & jurisprudence
Nursing staff hospital/*economics/legislation & jurisprudence/statistics
Nursing staff hospital/*economics/organization & administration/trends
Nursing staff hospital/*economics/psychology
Nursing staff hospital/*economics/standards
Nursing staff hospital/*economics/standards/supply & distribution
Nursing staff hospital/*economics/supply & distribution
Nursing staff hospital/*education
Nursing staff hospital/*education/*legislation & jurisprudence
Nursing staff hospital/*education/*organization &
Nursing staff hospital/*education/*organization administration
Nursing staff hospital/*education/*psychology
Nursing staff hospital/*education/*psychology/supply & distribution
Nursing staff hospital/*education/*supply & distribution
Nursing staff hospital/*education/*supply & distribution/trends
Nursing staff hospital/*education/organization
Nursing staff hospital/organization & administration
Nursing staff hospital/*ethics/organization & administration/*psychology
Nursing staff hospital/*ethics/psychology
Nursing staff hospital/*legislation & jurisprudence
Nursing staff hospital/*legislation & jurisprudence/*standards
Nursing staff hospital/*legislation & jurisprudence/statistics
Nursing staff hospital/*legislation & jurisprudence/supply & distribution
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Nursing staff hospital/*organization & administration/*psychology
Nursing staff hospital/*organization & administration/*statistics &
Nursing staff hospital/*organization & administration/*supply &
Nursing staff hospital/*organization & administration/psychology
Nursing staff hospital/economics/*legislation & jurisprudence
Nursing staff hospital/economics/*statistics & numerical data
Nursing staff hospital/economics/*supply & distribution/utilization
Nursing staff hospital/economics/*utilization
Nursing staff hospital/economics/education
Nursing staff hospital/legislation & jurisprudence
Nursing staff hospital/legislation & jurisprudence/*organization &
Nursing staff hospital/legislation & jurisprudence/psychology/*supply &
Nursing staff hospital/organization & administration/*standards
Nursing staff hospital/organization & administration/*utilization
Nursing staff hospital/standards/*utilization
Nursing staff hospital/standards/supply & distribution
Nursing staff hospital/statistics & numerical data
Nursing staff hospital/statistics & numerical data/*supply & distribution
Nursing staff hospital/supply & distribution
Nursing staff hospital/supply & distribution/*trends
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Nursing practical
Nursing practical
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Nursing practical/*legislation & jurisprudence
Nursing practical/*manpower
Nursing practical/*statistics & numerical data
Nursing practical/economics/*manpower
Nursing practical/education
Nursing practical/education/*manpower
Nursing practical/education/organization & administration
Nursing practical/education/standards
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Nursing supervisory/*economics
Nursing supervisory/*legislation & jurisprudence
Nursing supervisory/*methods
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Nursing supervisory/*standards
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Nursing supervisory/methods
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Nursing team/*organization & administration
Nursing team/organization & administration
Nursing team/statistics & numerical data
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Oncologic nursing/*manpower
Oncologic nursing/*methods/standards
Oncologic nursing/*organization & administration
Oncologic nursing/*standards
Oncologic nursing/economics/education/*manpower
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Oncologic nursing/legislation & jurisprudence
Oncologic nursing/manpower
Oncologic nursing/manpower/*standards
Oncologic nursing/methods/*standards
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Outcome assessment (health care)/economics/*statistics & numerical data
Outcome assessment (health care) /methods
Outcome assessment (health care)/organization & administration
Outcome assessment (health care)/standards
Outcome and process assessment (health care)/*statistics & numerical data
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Process assessment (health care)/methods
Outcome and process assessment (health care)/organization & administration
Pain postoperative/*nursing
Pain postoperative/diagnosis/etiology/*nursing/*prevention & control
Pain postoperative/diagnosis/etiology/*nursing/psychology
Pain/*nursing
Pain/*nursing/*therapy
Pain/diagnosis/nursing
Patient care
Patient care planning
Patient care planning/*classification
Patient care planning/*economics/standards
Patient care planning/*methods
Patient care planning/*organization & administration
Patient care planning/economics/statistics & numerical data
Patient care planning/organization & administration
Patient care planning/organization & administration/*standards
Patient care team/*organization & administration
Patient care team/*standards
Patient care team/*statistics & numerical data
Patient care team/economics
Patient care team/economics/*organization & administration
Patient care team/economics /statistics & numerical data/*utilization
Patient care team/organization & administration
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Patient care/*economics
Patient care/economics
Patient readmission
Patient readmission/*statistics & numerical data
Patient readmission/economics
Patient readmission/statistics & numerical data
Patient transfer/manpower/*organization & administration/standards
Patient transfer/methods/*organization & administration
Patient transfer/methods/*standards
Patient transfer/methods/organization & administration/*standard
Patient-centered care
Patient-centered care/*economics
Patient-centered care/*ethics/organization & administration
Patient-centered care/*manpower
Patient-centered care/*manpower/*organization & administration

Patient-centered care/*methods
Patient-centered care/*organization & administration
Patient-centered care/*organization & administration/*statistics
Patient-centered care/*standards
Patient-centered care/*trends
Patient-centered care/economics/*manpower/standards
Patient-centered care/history
Patient-centered care/methods
Patient-centered care/methods/*organization & administration
Patient-centered care/methods/*standards
Patient-centered care/organization & administration
Care/standards
Pediatric nursing
Pediatric nursing/*education
Pediatric nursing/*education/*organization & administration
Pediatric nursing/*history
Pediatric nursing/*legislation & jurisprudence
Pediatric nursing/*manpower
Pediatric nursing/*methods
Pediatric nursing/*methods/standards
Pediatric nursing/*organization & administration
Pediatric nursing/*organization & administration/*standards
Pediatric nursing/*standards
Pediatric nursing/*statistics & numerical data
Pediatric nursing/education
Pediatric nursing/education/*manpower
Pediatric nursing/education/*methods
Pediatric nursing/education/*methods/standards
Pediatric nursing/education/*organization & administration
Pediatric nursing/education/*standards
Pediatric nursing/history
Pediatric nursing/manpower
Pediatric nursing/manpower/standards
Pediatric nursing/methods
Pediatric nursing/organization & administration
Pediatric nursing/statistics & numerical data
Perioperative care/manpower
Perioperative care/nursing/organization & administration
Perioperative nursing
Perioperative nursing/*education
Perioperative nursing/*manpower
Perioperative nursing/*manpower/standards
Perioperative nursing/*manpower/statistics & numerical data
Perioperative nursing/*methods
Perioperative nursing/*organization & administration
Perioperative nursing/*organization & administration/standards

Perioperative nursing/*standards
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Perioperative nursing/education/*methods
Perioperative nursing/education/*methods/*standards
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Personal satisfaction
Personal space
Personality
Personality inventory
Personnel administration hospital
Personnel administration hospital/*legislation & jurisprudence
Personnel administration hospital/*methods
Personnel administration hospital/*methods/statistics & numerical data
Personnel administration hospital/*standards
Personnel administration hospital/*statistics & numerical data
Personnel administration hospital/economics
Personnel administration hospital/economics/*methods/trends
Personnel administration hospital/legislation & jurisprudence/*standards
Personnel administration hospital/methods
Personnel administration hospital/standards
Personnel administration hospital/standards/statistics & numerical data
Personnel management/*legislation & jurisprudence
Personnel management/*methods
Personnel management/*organization & administration
Personnel management/*standards
Personnel management/*trends
Personnel management/economics/*methods
Personnel management/methods
Personnel management/standards
Personnel staffing and scheduling information
Personnel staffing and scheduling information systems
Personnel staffing and scheduling information systems/*organization &
Personnel staffing and scheduling/*classification
Personnel staffing and scheduling/*classification/organization &
Personnel staffing and scheduling/*economics/organization & administration
Personnel staffing and scheduling/*legislation &
Personnel staffing and scheduling/*legislation & jurisprudence/standards
Personnel staffing and scheduling/*organization
Personnel staffing and scheduling/*organization & administration/standards
Personnel staffing and scheduling/*statistics & numerical data/*trends
Personnel staffing and scheduling/*statistics & numerical data/trends
Personnel staffing and scheduling/economics/*legislation & jurisprudence
Personnel staffing and scheduling/legislation & jurisprudence/standards
Personnel staffing and scheduling/organization & administration/*standards

Personnel staffing and scheduling/organization & administration/standards
Personnel staffing and scheduling/organization & administration/statistics
Personnel turnover/*statistics & numerical data
Personnel turnover/*trends
Personnel turnover/economics
Personnel turnover/economics/*statistics & numerical data
Personnel turnover/statistics & numerical data/*trends
Personnel hospital/*statistics & numerical data
Personnel hospital/classification/economics/*supply & distribution
Personnel hospital/economics
Personnel hospital/education/*standards
Personnel hospital/education/psychology
Personnel hospital/legislation & jurisprudence
Personnel hospital/standards/*supply & distribution
Personnel hospital/statistics & numerical data/*utilization
Personnel hospital/statistics & numerical data/supply & distribution
Philosophy nursing
Pneumonia/classification/nursing
Postnatal care/economics/manpower/*organization & postoperative care/*nursing/*standards
Postoperative care/methods/nursing
Postoperative care/nursing/*standards
Postoperative care/nursing/psychology/statistics & numerical data
Preoperative care/*preoperative care/economics/*
Primary health care
Primary health care/*manpower
Primary health care/*organization & administration
Primary health care/organization & administration
Primary nursing care
Primary nursing care/*manpower
Primary nursing care/*methods
Primary nursing care/*organization & administration
Primary nursing care/manpower
Primary nursing care/methods/*standard
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Primary nursing care/organization & administration/*standards
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Process assessment (health care)
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Process assessment (health care)/methods
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Professional competence/*standards
Progressive patient care
Progressive patient care/*manpower
Progressive patient care/*organization & administration
Progressive patient care/classification/*standards
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Quality assurance health care/*legislation & jurisprudence
Quality assurance health care/*methods
Quality assurance health care/*organization & administration
Quality assurance health care/*statistics & numerical data
Quality assurance health care/economics/trends
Quality assurance health care/legislation & jurisprudence
Quality assurance health care/methods
Quality assurance health care/organization & administration
Quality assurance health care/standards
Quality assurance health care/statistics & numerical data
Quality control
Quality indicators health care
Quality indicators health care/organization & administration
Quality indicators health care/*statistics & numerical data
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Quality of health care/*legislation &
Quality of health care/*statistics & numerical data
Quality of health care/*trends
Quality of health care/legislation & jurisprudence
Quality of health care/organization & administration
Quality of health care/organization & administration/standards
Quality of health care/standards
Rehabilitation nursing/*legislation & jurisprudence
Rehabilitation nursing/*manpower/*methods
Restraint physical
Resuscitation
Resuscitation orders
Resuscitation/*education/standards
Resuscitation/*standards/statistics & numerical data
Risk management/*organization & administration
Risk management/*organization & administration/statistics & numerical data
Risk management/*standards
Risk management/*statistics & numerical data
Safety management/*
Safety management/*methods
Safety management/*organization & administration
Safety management/*standards
Safety management/legislation & jurisprudence
Safety management/methods
Safety management/methods/standards
Safety management/organization & administration
Safety/*legislation & jurisprudence
Safety/standards
Total quality management/*organization & administration

Total quality management/organization & administration
Unnecessary procedures/nursing/statistics & numerical data
Urinary catheterization/*adverse effects/*nursing
Urinary catheterization/adverse effects/*nursing
Urinary catheterization/nursing/*standards
Work schedule tolerance
Workload/*classification/economics
Workload/*legislation & jurisprudence
Workload/*legislation & jurisprudence/*standards
Workload/*legislation & jurisprudence/standards
Workload/*psychology
Workload/*psychology/statistics & numerical data
Workload/*standards
Workload/economics/statistics & numerical data
Workload/legislation & jurisprudence
Workload/legislation & jurisprudence/*standards/statistics & numerical data
Workload/legislation & jurisprudence/standards
Workload/legislation & jurisprudence/statistics & numerical data
Workload/psychology/*statistics & numerical data
Workload/statistics & numerical data
Workplace
Workplace/*organization & administration

Appendix B: List of Excluded Studies

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Appendix C: Technical Expert Panel Members and Affiliation

Peer reviewer comments on a preliminary draft of this report were considered by the EPC in preparation of this final report. Synthesis of the scientific literature presented here does not necessarily represent the views of individual reviewers.

TEP Member	Affiliation
Sandra Edwardson, Ph.D., R.N.	School of Nursing University of Minnesota
Colleen Goode, R.N., Ph.D., F.A.A.N.	Patient Care Services University of Colorado Hospital
Christine Kovner, Ph.D., R.N.	College of Nursing New York University
Barbara Mark, R.N., Ph.D., F.A.A.N.	School of Nursing University of North Carolina at Chapel Hill
Jack Needleman, Ph.D.	School of Public Health UCLA
Pamela Thompson, M.S., R.N., F.A.A.N.	Chief Executive Officer American Organization of Nurse Executives

Appendix D: Sample Abstraction Forms

Nurse Staffing in North American Hospitals Staffing Ratios/Patient Outcomes Abstraction Form

(Complete for each study)

Number of the study _____
First author _____
Year of the publication _____
Journal of the publication _____
Database to identify the study _____
Person to score the study _____

Publication type (check one)

- Published article
- Administrative report
- Dissertation
- Abstract/Presentation
- Book/book chapter

Purpose/aim of study _____

Design of the study (check one)

- prospective cohort
- retrospective cohort
- cross-sectional
- descriptive study
- case-control
- case-series
- randomized controlled clinical trial
- not randomized clinical interventions
- ecologic

Nurse staffing variables (independent variables)

1. Mark Yes/No by assessment in the study.
2. Provide the definition of each variable used in the article.

Data source for nurse staffing variables (define) _____

Nurse to patient ratios:

Registered nurse/patient ratio

- Yes No

If Yes, define _____

Licensed nurse practitioner/patient ratio

- Yes No

If Yes, define _____

Aid/patient ratio, number of patients/aid

- Yes No

If Yes, define _____

Proportion of RN among nursing personnel

Yes No

If Yes, define _____

Licensed nurses/patient ratio

Yes No

If Yes, define _____

Proportion of licensed nurses among nursing personnel

Yes No

If Yes, define _____

Measures of nurse work hours

Total hours of care/patient day

Yes No

If Yes, define _____

Registered nurse hours/patient day

Yes No

If Yes, define _____

Licensed nurse hours/patient day

Yes No

If Yes, define _____

Aid hours /patient day

Yes No

If Yes, define _____

Patient outcomes variables

1. Mark Yes/No by assessment in the study.
2. Provide the definition of the variable used in the article.

Mortality

Yes No

If Yes, define _____

Data source to measure mortality : _____

Time of follow up from the day of surgery to death, in days _____

Time of follow up from hospitalization to death , in days _____

Mortality rate in groups with different staffing levels

Yes No

If yes, how reported (mark all applicable):

Number of events

Proportion in %

Relative risk

Adverse drug events

1. Mark Yes/No by assessment in the study.
2. Provide the definition of each variable used in the article.
3. Provide the data source to measure the outcome.
4. Mark how the outcome was reported

Variable	Assessment in the study		Definition	Source to measure	Reporting number of events	Proportion in %	Relative risk
	Yes	No					
Adverse events							
Other							

Length of stay.

Length of stay in the unit, days

Yes No

Length of stay in the hospital, days

Yes No

Data source to measure LOS _____

Data extraction table: Complete cells with values of LOS reported in the article

Exposure variable	Categories of independent staffing variable	LOS					
		Mean	STD	Median	RR	Lower 95%CL	Upper 95%CL
LOS in hospital in days							
LOS in units in days							

Nurse quality outcomes

1. Mark Yes/No by assessment in the study.
2. Provide the definition of each variable used in the article.
3. Provide the data source to measure the outcome.
4. Mark how the outcome was reported

Variable	Assessment in the study		Definition	Source to measure	Reporting number of events	Proportion in %	Relative risk
	Yes	No					
Falls							
Injury							
Pressure ulcers							
Failure to rescue							

Patient satisfaction.

1. Mark Yes/No by assessment in the study.
2. Mark how the outcome was reported

Variable	Assessment in the study		Reporting scores	% of favorable responses	Relative risk
	Yes	No			
Satisfaction with nurse care					
Satisfaction with education					
Satisfaction with pain management					

Time from the hospitalization to the measurement of the patient satisfaction, in days _____ days

Patient satisfaction scale (define) _____

Quality Measures:

Patient related:

1. Mark Yes/No by assessment in the study.
2. Provide the definition of each variable used in the article.
3. Provide the data source to measure the outcome.
4. Mark how the outcome was reported

Variable	Assessment in the study		Definition	Source to measure	Reporting number of events	Proportion in %	Relative risk
	Yes	No					
Urinary tract infection							
Postoperative complications							
Gastrointestinal bleeding							
Hospital-acquired pneumonia							
Shock							
Atelectasis or pulmonal failure							
Accidental extubation							
Nosocomial infection							
Surgical wound infection							
Post surgical thrombosis							
Cardio-pulmonary arrest							
Any complication							
Any Medical complication							
Any surgical complication							
Sepsis							
Post surgical bleeding							
Other							

Nurses related:

1. Mark Yes/No by assessment in the study.
2. Provide the definition of each variable used in the article.
3. Provide the data source to measure the outcome.
4. Mark how the outcome was reported

Variable	Assessment in the study		Definition	Source to measure	Reporting number of events	Proportion in %	Relative risk
	Yes	No					
Turnover rate							
Burnout							
Vacancy							

Nurse self-reported.

1. Mark Yes/No by assessment in the study.
2. Provide the definition of each variable used in the article.
3. Provide scale to measure the outcome.
4. Mark how the outcome was reported

Variable	Assessment in the study		Definition	Scale to measure	Reporting scores	% favorable responses	Relative risk
	Yes	No					
Satisfaction with job							
Perception of adequacy of staffing							
Perception of quality care							
Autonomy of nurses							
Nurses Governance							
Stress							

Patient characteristics.

Patient Eligibility criteria

Complete the table with definitions used in the article:

	Inclusion criteria	Exclusion criteria
Age		
Sex		
Race		
Insurance		
Residency		
Hospitalization		
Availability of records		
Diagnosis (ICD code)		
Comorbidities		
Severity		
Acuity		
Other		

Patients

- Medical % of the sample _____
- Surgical % of the sample _____
- Adults % of the sample _____
- Pediatric % of the sample _____
- combined _____

Sample characteristics:

Complete with values reported in the article and with page number in the article where the data was extracted:

	Page in the article	Exposure categories	
Exposure :			
# Subjects			
Mean age			
Sex			
% of males			
Not reported			
Race (%)			
White			
Black			
Asian			
Other			
Not reported			
Ethnicity(%)			
Hispanic			
Not Hispanic			
Other			

Not reported			
Socioeconomic status (Scores)			
Not reported			
Primary diagnosis			
% ICD codes			
Co morbidities (case-mix index)			
Severity			
Acuity			
DRG			

Nurse characteristics.

Nurse eligibility criteria

Complete the table with definitions used in the article:

	Inclusion criteria	Exclusion criteria
Age		
License		
Experience		
Gender		
Working status		
Self-selection		
Other		

Nurses sample characteristics:

Complete with values reported in the article and with page number in the article where the data was extracted:

	Page in the article	Exposure categories	
Exposure :			
Mean age			
Gender			
% of males			
Not reported			
Race (%)			
White			
Black			
Asian			
Other			
Not reported			

Ethnicity (%)			
Hispanic			
Not Hispanic			
Other			
Not reported			
Foreign graduates %			
Not reported			

Other nurse characteristics which may impact patients outcomes:

1. Mark Yes/No by assessment in the study.
2. Provide the data source to measure the outcome.

Nurse education

Yes No

Data Source _____

Nurse degree

Yes No

Data Source _____

	Nursing degree	Non nursing degree
Associated degree		
Diploma		
BSN		
MS		
Doctorate		

Nurse experience in years (in nursing)

Yes No

Data Source _____

Proportion of nurses with temporary positions (pool nurses)

Yes No

Data Source _____

Nursing unions

Yes No

Data Source _____

Organization characteristics which may impact patient outcomes.

Hospital eligibility criteria

Complete the table with definitions used in the article:

	Inclusion criteria	Exclusion criteria
Data source		
Location		
Size		
Care		
Teaching status		
Ownership		
Availability of information		
Self-selection		
Other		

Status of selected hospital(s)

- Number of eligible hospitals
- Number of enrolled hospitals
- Number of analyzed hospitals

if more than 1:

- Teaching, % of the sample _____
- Not teaching, % of the sample _____
- Combined sample

Location _____

Size (number of beds) _____

Ownership

- profit, % of the sample _____
- non profit, % of the sample _____
- public, % of the sample _____
- private, % of the sample _____

Technology index _____

not reported

Computerization of communication and records _____

not reported

Central hospital support adequacy _____

not reported

HMO penetrating _____

not reported

Clinical units

- Intensive care unit
- Labor and delivery
- Pre-natal
- Post-natal
- Nursery
- Emergency
- Trauma
- Critical care
- Visits
- Hospital general
- Medical
- Surgical
- Operating room
- Pediatric

- Post-anesthesia
- Psychiatry
- Specialty
- Step down units
- Telemetry
- Combined
- Unknown

Data extraction tables.

/*Complete with values reported in the article with the page number in the articles the data was extracted for a quality control*/

/*Add as many lines for categories as necessary*/

/*Median is calculated when ranges only reported assuming normal distribution*/

/*Increment is analyzed when regression coefficients only reported*/

Staffing variables:

Variable	Categories defined by authors	Mean	STD	95%CL	Median	Page number
<u>Ratios</u>						
Registered nurse/patient ratio						
Licensed nurse/patient ratio						
Aid/patient ratio, number of patients/aid						
Number of Patients/Licensed nurses						
Proportion of RN among total nursing personnel in %						
Proportion of licensed nurses /total nursing staff in %						
<u>Hours</u>						
Total hours of care/patient day						
Registered nurse hours/patient day						
Licensed nurse hours/patient day						
Aid hours /patient day						

Patient outcomes.

/*Add lines for interactions Exposure*Interaction factor*/

Outcomes	Exposure categories (treatment groups)	Rate in %			Events	Subjects	Page
		Mean	STD	95%CL			
Mortality							
Nurse quality outcomes							
Urinary tract infection							
Falls							
Injury							
Pressure ulcers							
Any complication							
Any Medical complication							
Any surgical complication							
Nosocomial infections							
Sepsis							
Surgical wound infection							
Postoperative complications							
Gastrointestinal bleeding							
Post surgical bleeding							
Hospital-acquired pneumonia							
Atelectasis or pulmonal failure							
Accidental extubation							
Post surgical Thrombosis							
Cardio-pulmonary arrest							
Failure to rescue							
Shock							

Continuation of the previous table:

Outcomes	Exposure categories	Relative Risk (RR)	Lower 95%CL of RR	Upper 95%CL of RR		Page
Mortality						
Nurse quality outcomes						
Falls						
Injury						
Pressure ulcers						
Urinary tract infection						
Any complication						
Any Medical complication						
Any surgical complication						

Nosocomial infections							
Sepsis							
Surgical wound infection							
Postoperative complications							
Gastrointestinal bleeding							
Post surgical bleeding							
Hospital-acquired pneumonia							
Atelectasis or pulmonary failure							
Accidental extubation							
Post surgical Thrombosis							
Cardio-pulmonary arrest							
Failure to rescue							
Shock							

Patient Satisfaction

Outcomes	Exposure	Exposure categories (treatment groups)	Mean	STD	95%CL	Median	Page
Satisfaction with nurse care							

Continuation of the previous table:

Outcomes	Exposure categories	Relative Risk (RR)	Lower 95%CL of RR	Upper 95%CL of RR	Page
Satisfaction with nurse care					
Satisfaction with pain management					

Nurse characteristics:

Variable	Categories defined by authors	Mean	STD	95%CL	Median	Page
Nurses characteristics						
Nurse experience in years						
Nurses education (%)						
Associate degree						
BSN						
MS						
PhD						
Proportion of nurses with temporary positions (pool nurses) in %						
Organization characteristics						
Duration of shift in hours						
Proportion of nurses working full time						

Variable	Categories defined by authors	Mean	STD	95%CL	Median	Page
Turnover rate						
Burnout, %						
Vacancy, %						
<i>Nurses self-reported variables</i>						
Satisfaction with job, % satisfied						
Perception of adequacy of staffing, % perceived as adequate						
Perception of quality care, % of satisfied						
Autonomy of nurses, % perceived as adequate						
Nurses Governance, % perceived as adequate						
Stress, % of perceived as significant						

ASSESSMENT OF STUDY QUALITY

OBSERVATIONAL STUDIES (based on "Systems to Rate the Strength Of Scientific Evidence, AHRQ Publication No. 02-E016, April 2002)

Score each domain on a scale of 0 (poor, not defined) to 5 (excellent, clearly defined)

Observational Studies Quality Domains/Elements	Score
Study question clearly focused and appropriate Notes:	
Sampling of Study Population Random Convenient Self-selected Notes:	
Clear definition of exposure Notes:	
Primary/secondary outcomes defined Notes:	
Statistical Analysis: Assessment of confounding attempted Did the analysis adjust for or examine the effects of various factors Patient characteristics Hospital characteristics Cluster of patients and hospitals Notes:	
Statistical methods used to take into account the effect of more than one variable on the outcome such as multiple regression, multivariate analysis, regression modeling -see <i>methods in paper</i> Notes:	
Measure of effect for outcomes and appropriate measure of precision (SE, 95%CL) Notes:	
Conclusions supported by results with possible bias and limitations taken into consideration Notes:	
Single versus Multi-site study (<i>note one of the other</i>) Notes:	
Co morbidities mentioned Notes:	
Co morbidities incorporated in the analyses Notes:	
Total score	

INTERVENTIONAL STUDIES.

<i>Intervention Studies Quality Domains/Elements</i>	Score
Study question clearly focused and appropriate Notes:	
Sampling of Study Population Random Convenient Self-selected Notes:	
Clear definition of exposure Notes:	
Randomization used to allocate patients (units) into treatment groups Notes:	
Randomization allocation concealment method Clearly adequate: Centralized randomization by telephone, randomization scheme controlled by pharmacy, numbered or coded identical containers administered sequentially, on site computer system which can only be accessed after entering the characteristics of an enrolled participant, sequentially numbered sealed opaque envelopes. Clearly inadequate: Alternation (consequent, odd-even, etc.), date of birth, date of week	
Sample size Justification of the sample size for each tested hypothesis	
Statistical Analysis: Assessment of adequacy of randomization - distribution of confounding factors at baseline in treatment groups: Patient characteristics Hospital characteristics Cluster of patients and hospitals Notes:	
Intention to treat analysis. All eligible patients (units) included into analysis. Notes:	
For each primary and secondary outcome, a summary of results for each group, and the estimated effect size and its precision (SE, 95% confidence interval). Notes:	
Conclusions supported by results with clinical significance of effect size Notes:	
Single versus Multi-site study (<i>note one of the other</i>) Notes:	
Total score	

Study design characteristics

Adequacy of the sampling (random selection or not) (*check one*)

- random sampling
- convenience sampling
- non-random sampling
- single hospital study
- self-selected
- not specified
- all sampled subjects were analyzed
- sampled subjects were excluded from the analysis _____%

95% CL as reported estimates of the association between exposure and outcomes

- Yes
- No

P value as reported estimates of the association between exposure and outcomes

- Yes
- No

Correlation coefficient reported between exposure and outcomes

- Yes
- No

Propensity scores used for nonrandom unequal distribution of confounding factors among treatment groups

- Yes
- No

Adjustment for confounding factors:

Adjustment for age of the patients

- Yes
- No

Adjustment for race of the patients

- Yes
- No

Adjustment for patient sex

- Yes
- No

Adjustment for patient Diagnoses/comorbidities

- Yes
- No

Adjustment for socioeconomic status of the patients

- Yes
- No

Adjustment for hospital (provider) characteristics

- Yes
- No

Country

- Canada
- State or province abbreviation
- Combined

Sampling units (can be more than one)

- patients †
- hospitals
- hospital units
- nurses
- other (define) _____

Analytic unit (can be more than one)

- patients
- hospitals †-
- hospital units †-
- nurses

Level of evidence of the individual study (check one)

Interventions:

- I – Well-designed randomized controlled trial
- II-1A - Well-designed controlled trial with pseudo-randomization
- I-1B - Well-designed controlled trial without randomization

Observational studies

- I-2A - Well-designed cohort (prospective) study with concurrent controls
- I-2B - Well-designed cohort (prospective) study with historical controls
- II-2C - Well-designed cohort (retrospective) study with concurrent controls
- II-3 – Well-designed case-controlled (retrospective) study
- III – Large differences from comparisons between times and/or places
- IY – Opinion of respected authorities based in clinical experience

**Nurse Staffing in North American Hospitals
Nursing Staffing Strategies /Patient Outcomes Abstraction Form**

(Complete for each study)

Number of the study _____

First author _____

Year of the publication _____

Journal of the publication _____

Database to identify the study _____

Person to score the study _____

Publication type (check one)

- Published article
- Administrative report
- Dissertation
- Abstract/Presentation
- Book/book chapter

Purpose/aim of study _____

Design of the study (check one)

- prospective cohort
- retrospective cohort
- cross-sectional
- descriptive study
- case-control
- case-series
- randomized controlled clinical trial
- not randomized clinical interventions
- ecologic

Nurse staffing strategies (independent variables).

1. Mark Yes/No by assessment in the study.
2. Provide the definition of each variable used in the article.

Data source for variables (define) _____

Use of temporary nursing agencies

Yes No

If Yes, define _____

Use of part time nurses

Yes No

If Yes, define _____

Proportion of registered nurses

Yes No

If Yes, define _____

Experience mix of the nursing staffs

Yes No

If Yes, define _____

Continuing nurse education

Yes No

If Yes, define _____

Nurse staffing models

1. Mark Yes/No by assessment in the study.
2. Provide the definition of staffing strategies (changes in staffing) used in the article

Patient Focused Care

Yes No

If Yes, define _____

Primary or Total Nursing Care

Yes No

If Yes, define _____

Team or Functional Nursing Care

Yes No

If Yes, define _____

Magnet Hospital Environment/Shared governance

Yes No

If Yes, define _____

Evidence Based Clinical Pathway

Yes No

If Yes, define _____

Staff scheduling strategies:

Shift

Yes No

If Yes, define _____

Duration of shift in hours

Yes No

If Yes, define _____

Over time work

Yes No

If Yes, define _____

Decentralized scheduling – nurse manager

Yes No

If Yes, define _____

Patient outcomes variables

- 1. Mark Yes/No by assessment in the study.
- 2. Provide the definition of the variable used in the article.

Mortality

Yes No

If Yes, define _____

Data source to measure mortality : _____

Time of follow up from the day of surgery to death, in days _____

Time of follow up from hospitalization to death , in days _____

Mortality rate in groups with different staffing levels

Yes No

If yes, how reported (mark all applicable):

- Number of events
- Proportion in %
- Relative risk

Adverse Drug Events.

- 1. Mark Yes/No by assessment in the study.
- 2. Provide the definition of each variable used in the article.
- 3. Provide the data source to measure the outcome.
- 4. Mark how the outcome was reported

Variable	Assessment in the study		Definition	Source to measure	Reporting number of events	Proportion in %	Relative risk
	Yes	No					
Adverse events							
Other							

Length of stay.

Length of stay in the unit, days

Yes No

Length of stay in the hospital, days

Yes No

Data source to measure LOS _____

Data extraction table: Complete cells with values of LOS reported in the article

Exposure variable	Categories of independent staffing variable	LOS					
		Mean	STD	Median	RR	Lower 95%CL	Upper 95%CL
LOS in hospital in days							
LOS in units in days							

Nurse quality outcomes

1. Mark Yes/No by assessment in the study.
2. Provide the definition of each variable used in the article.
3. Provide the data source to measure the outcome.
4. Mark how the outcome was reported

Variable	Assessment in the study		Definition	Source to measure	Reporting number of events	Proportion in %	Relative risk
	Yes	No					
Falls							
Injury							
Pressure ulcers							
Failure to rescue							

Patient satisfaction.

1. Mark Yes/No by assessment in the study.
2. Mark how the outcome was reported

Variable	Assessment in the study		Reporting scores	% of favorable responses	Relative risk
	Yes	No			
Satisfaction with nurse care					
Satisfaction with education					
Satisfaction with pain management					

Time from the hospitalization to the measurement of the patient satisfaction, in days _____ days

Patient satisfaction scale (define) _____

Other Quality Measures:

Patient related:

1. Mark Yes/No by assessment in the study.
2. Provide the definition of each variable used in the article.
3. Provide the data source to measure the outcome.
4. Mark how the outcome was reported

Variable	Assessment in the study		Definition	Source to measure	Reporting number of events	Proportion in %	Relative risk
	Yes	No					
Urinary tract infection							
Postoperative complications							
Gastrointestinal bleeding							
Hospital-acquired pneumonia							
Shock							
Atelectasis or pulmonal failure							
Accidental extubation							
Nosocomial infection							

Surgical wound infection							
Post surgical thrombosis							
Cardio-pulmonary arrest							
Any complication							
Any Medical complication							
Any surgical complication							
Sepsis							
Post surgical bleeding							
Other							

Nurses related:

1. Mark Yes/No by assessment in the study.
2. Provide the definition of each variable used in the article.
3. Provide the data source to measure the outcome.
4. Mark how the outcome was reported

Variable	Assessment in the study		Definition	Source to measure	Reporting number of events	Proportion in %	Relative risk
	Yes	No					
Turnover rate							
Burnout							
Vacancy							

Nurse self-reported.

1. Mark Yes/No by assessment in the study.
2. Provide the definition of each variable used in the article.
3. Provide scale to measure the outcome.
4. Mark how the outcome was reported

Variable	Assessment in the study		Definition	Scale to measure	Reporting scores	% favorable responses	Relative risk
	Yes	No					
Satisfaction with job							
Perception of adequacy of staffing							
Perception of quality care							

Patient characteristics.

Patient Eligibility criteria

Complete the table with definitions used in the article:

	Inclusion criteria	Exclusion criteria
Age		
Sex		
Race		
Insurance		
Residency		
Hospitalization		
Availability of records		
Diagnosis (ICD code)		
Comorbidities		
Severity		
Acuity		
Other		

Patients

- Medical % of the sample _____
- Surgical % of the sample _____
- Adults % of the sample _____
- Pediatric % of the sample _____
- combined _____

Sample characteristics:

Complete with values reported in the article and with page number in the article where the data was extracted:

	Page in the article	Exposure categories	
Exposure :			
# Subjects			
Mean age			
Sex			
% of males			
Not reported			
Race (%)			
White			
Black			
Asian			
Other			
Not reported			
Ethnicity(%)			
Hispanic			
Not Hispanic			
Other			
Not reported			
Socioeconomic status (Scores)			
Not reported			
Primary diagnosis			
% ICD codes			
Co morbidities (case-mix index)			
Severity			
Acuity			
DRG			

Nurse characteristics.

Nurse eligibility criteria

Complete the table with definitions used in the article:

	Inclusion criteria	Exclusion criteria
Age		
License		
Experience		
Gender		
Working status		
Self-selection		
Other		

Nurses sample characteristics:

Complete with values reported in the article and with page number in the article where the data was extracted:

	Page in the article	Exposure categories	
Exposure :			
Mean age			
Gender			
% of males			
Not reported			
Race (%)			
White			
Black			
Asian			
Other			
Not reported			
Ethnicity (%)			
Hispanic			
Not Hispanic			
Other			
Not reported			
Foreign graduates %			
Not reported			

Organization characteristics which may impact patient outcomes.

Hospital eligibility criteria

Complete the table with definitions used in the article:

	Inclusion criteria	Exclusion criteria
Data source		
Location		
Size		
Care		
Teaching status		
Ownership		
Availability of information		
Self-selection		
Other		

Status of selected hospital(s)

- Number of eligible hospitals
- Number of enrolled hospitals
- Number of analyzed hospitals

if more than 1:

- Teaching, % of the sample _____
- Not teaching, % of the sample _____
- Combined sample

Location _____

Size (number of beds) _____

Ownership

- profit, % of the sample _____
- non profit, % of the sample _____
- public, % of the sample _____
- private, % of the sample _____

Technology index _____

not reported

Computerization of communication and records _____

not reported

Central hospital support adequacy _____

not reported

HMO penetrating _____

not reported

Clinical units

- Intensive care unit
- Labor and delivery
- Pre-natal
- Post-natal
- Nursery
- Emergency
- Trauma
- Critical care
- Visits
- Hospital general
- Medical
- Surgical
- Operating room
- Pediatric

- Post-anesthesia
- Psychiatry
- Specialty
- Step down units
- Telemetry
- Combined
- Unknown

Data extraction tables.

/*Complete with values reported in the article with the page number in the articles the data was extracted for a quality control*/

/*Add as many lines for categories as necessary*/

/*Median is calculated when ranges only reported assuming normal distribution*/

/* Increment is analyzed when regression coefficients only reported*/

Staffing variables:

Variable	Categories defined by authors	Mean	STD	95%CL	Median	Page number
Proportion of part time nurses, in%						
Proportion of registered nurses, in %						
Proportion of nurses with BS, in %						
Proportion of nurses with MS, in %						
Duration of shift in hours						

Patient outcomes.

/*Add lines for interactions Exposure*Interaction factor*/

Outcomes	Exposure categories (treatment groups)	Rate in %			Rate in %	Events	Subjects	Page
		Mean	STD	95%CL	Median			
Mortality								
Adverse events								
Adverse events								
Nurse quality outcomes								
Urinary tract infection								
Falls								
Injury								
Pressure ulcers								
Any complication								
Any Medical complication								

Any surgical complication								
Nosocomial infections								
Sepsis								
Surgical wound infection								
Postoperative complications								
Gastrointestinal bleeding								
Post surgical bleeding								
Hospital-acquired pneumonia								
Atelectasis or pulmonal failure								
Accidental extubation								
Post surgical Thrombosis								
Cardio-pulmonary arrest								
Failure to rescue								
Shock								

Outcomes	Exposure categories	Relative Risk (RR)	Lower 95%CL of RR	Upper 95%CL of RR		Page
<i>Mortality</i>						
Adverse events						
<i>Nurse quality outcomes</i>						
Falls						
Injury						
Pressure ulcers						
Urinary tract infection						
Any complication						
Any Medical complication						
Any surgical complication						
Nosocomial infections						
Sepsis						
Surgical wound infection						
Postoperative complications						
Gastrointestinal bleeding						
Post surgical bleeding						
Hospital-acquired pneumonia						
Atelectasis or pulmonal failure						
Accidental extubation						
Post surgical Thrombosis						
Cardio-pulmonary arrest						
Failure to rescue						
Shock						

Patient Satisfaction

Outcomes	Exposure	Exposure categories (treatment groups)	Mean	STD	95%CL	Median	Page
Satisfaction with nurse care							
Satisfaction with pain management							

ASSESSMENT OF STUDY QUALITY

OBSERVATIONAL STUDIES (based on "Systems to Rate the Strength of Scientific Evidence, AHRQ Publication No. 02-E016, April 2002)

Score each domain on a scale of 0 (poor, not defined) to 5 (excellent, clearly defined)

Observational Studies Quality Domains/Elements	Score
Study question clearly focused and appropriate Notes:	
Sampling of Study Population Random Convenient Self-selected Notes:	
Clear definition of exposure Notes:	
Primary/secondary outcomes defined Notes:	
Statistical Analysis: Assessment of confounding attempted Did the analysis adjust for or examine the effects of various factors Patient characteristics Hospital characteristics Cluster of patients and hospitals Notes:	
Statistical methods used to take into account the effect of more than one variable on the outcome such as multiple regression, multivariate analysis, regression modeling -see <i>methods in paper</i> Notes:	
Measure of effect for outcomes and appropriate measure of precision (SE, 95%CL) Notes:	
Conclusions supported by results with possible bias and limitations taken into consideration Notes:	
Single versus Multi-site study (<i>note one of the other</i>) Notes:	
Co morbidities mentioned Notes:	
Co morbidities incorporated in the analyses Notes:	
Total score	

INTERVENTIONAL STUDIES.

<i>Intervention Studies Quality Domains/Elements</i>	Score
Study question clearly focused and appropriate Notes:	
Sampling of Study Population Random Convenient Self-selected Notes:	
Clear definition of exposure Notes:	
Randomization used to allocate patients (units) into treatment groups Notes:	
Randomization allocation concealment method Clearly adequate: Centralized randomization by telephone, randomization scheme controlled by pharmacy, numbered or coded identical containers administered sequentially, on site computer system which can only be accessed after entering the characteristics of an enrolled participant, sequentially numbered sealed opaque envelopes. Clearly Inadequate: Alternation (consequent, odd-even, etc.), date of birth, date of week	
Sample size Justification of the sample size for each tested hypothesis	
Statistical Analysis: Assessment of adequacy of randomization - distribution of confounding factors at baseline in treatment groups: Patient characteristics Hospital characteristics Cluster of patients and hospitals Notes:	
Intention to treat analysis. All eligible patients (units) included into analysis. Notes:	
For each primary and secondary outcome, a summary of results for each group, and the estimated effect size and its precision (SE, 95% confidence interval). Notes:	
Conclusions supported by results with clinical significance of effect size Notes:	
Single versus Multi-site study (<i>note one of the other</i>) Notes:	
Total score	

Study design characteristics

Adequacy of the sampling (random selection or not) (*check one*)

- random sampling
- convenience sampling
- non-random sampling
- single hospital study
- self-selected
- not specified
- all sampled subjects were analyzed
- sampled subjects were excluded from the analysis _____%

95% CL as reported estimates of the association between exposure and outcomes

- Yes
- No

P value as reported estimates of the association between exposure and outcomes

- Yes
- No

Correlation coefficient reported between exposure and outcomes

- Yes
- No

Propensity scores used for nonrandom unequal distribution of confounding factors among treatment groups

- Yes
- No

Adjustment for confounding factors:

Adjustment for age of the patients

- Yes
- No

Adjustment for race of the patients

- Yes
- No

Adjustment for patient sex

- Yes
- No

Adjustment for patient Diagnoses/comorbidities

- Yes
- No

Adjustment for socioeconomic status of the patients

- Yes
- No

Adjustment for hospital (provider) characteristics

- Yes
- No

Country

- Canada
- State or province abbreviation
- Combined

Sampling units (can be more than one)

- patients †
- hospitals
- hospital units
- nurses
- other (define) _____

Analytic unit (can be more than one)

- patients
- hospitals †-
- hospital units †-
- nurses

Level of evidence of the individual study (check one)

Interventions:

- I – Well-designed randomized controlled trial
- II-1A - Well-designed controlled trial with pseudo-randomization
- I-1B - Well-designed controlled trial without randomization

Observational studies

- I-2A - Well-designed cohort (prospective) study with concurrent controls
- I-2B - Well-designed cohort (prospective) study with historical controls
- II-2C - Well-designed cohort (retrospective) study with concurrent controls
- II-3 – Well-designed case-controlled (retrospective) study
- III – Large differences from comparisons between times and/or places
- IY – Opinion of respected authorities based in clinical experience

Appendix E: Quality of the Studies

Table E1 shows the quality of the studies, using a 5 score scale from 0 (poorest) to 5 (highest):

- A. Study question clearly focused and appropriate
- B. Clear definition of exposure
- C. Clear definition of the primary and secondary outcomes
- D. Validation of exposure (yes or no, the responses do not count for the total scores)
- E. Validation of outcomes (yes or no, the responses do not count for the total scores)
- F. Sampling of study population:
 - 5 = Random population based sampling
 - 4 = Random clinic based sampling
 - 3 = Convenient
 - 2 = Self-selected
 - 1 = Single hospital study
 - 0 = Not specified
- G. Statistical Analysis: Assessment of confounding attempted
- H. Adjustment to examine the effects of various factors
 - 1) Patient characteristics: age; race; sex; comorbidities; SES - 1-3 scores
 - 2) Hospital characteristics – 1+2 - 4 scores
 - 3) Cluster of patients and hospitals - 1+2+3 - 5 scores
- I. Statistical methods used to take into account the effect of more than one variable on the outcome such as multiple regression, multivariate analysis, regression modeling
- J. Measure of effect for outcomes and appropriate measure of precision (SE, 95% CI)
- K. External validity: single hospital study; multi-site study; nationally representative sample
- L. Conclusions supported by results with possible bias and limitations taken into consideration; clinical significance of effect size provided
- M. Total score as a percentage of the maximum possible (50)

Each item was graded with 0 to 5 scores. We summarized scores (maximum possible 50) to have the overall quality score and to compare with the maximum.

Definitions

External validity – applicability of the results from the studies on different clinical settings.

Internal validity – the extent to which the findings of a study accurately represent the causal relationship between nurse staffing and patient outcomes. The truth why patients had different outcomes may be related to patient characteristics or quality of the treatments (surgical quality) more than nurse care. To examine how nurse ratios and hours may affect patient outcomes independent of all known factors they measured, the authors adjusted the results for confounding factors.

Table E1. Quality of the studies

Year	Author	Class	A	B	C	D	E	F	G	H	I	J	K	L	Total Score	M %
1982	Arnow ¹	II-2C	5	4	5	Yes	Yes	5	3	0	3	2	2	4	33	66
1987	Wan ²	II-2C	5	4	4			3	4	2	4	4	4	4	38	76
1988	Flood ³	III	4	4	4			1	3	1	3	3	2	3	28	56
1989	Hartz ⁴	III	5	3	4			3	3	3	3	3	4	3	34	68
1992	McDaniel ⁵	III	4	4	5			4	3	0	2	2	2	3	29	58
1992	Krakauer ⁶	III	5	3	4			5	5	5	4	5	5	4	45	90
1993	Halpine ⁷	III	5	4	5			3	3	2	3	3	3	4	35	70
1994	Aiken ⁸	II-2B	5	4	5			4	5	5	4	5	4	4	45	90
1994	Shamian ⁹	III	4	3	3			3	3	2	3	3	4	4	32	64
1994	Taunton ¹⁰	III	5	4	4			2	3	0	2	3	3	4	30	60
1988	Shortell ¹¹	II-2C	5	3	4			5	4	4	4	4	5	4	42	84
1994	Shortell ¹²	II-2C	5	4	4			4	3	3	3	4	4	4	38	76
1995	Grillo-Peck ¹³	III	5	5	4			3	2	1	3	2	3	3	31	62
1995	Thorson ¹⁴	II-2C	5	5	4			4	4	4	4	4	4	5	43	86
1996	Fridkin ¹⁵	II-2C	5	4	5		Yes	4	5	4	5	4	3	4	43	86
1996	Dugan ¹⁶	III	3	3	4			2	0	0	3	2	2	3	22	44
1997	Bloom ¹⁷	III	4	4	5			4	3	3	4	4	5	4	40	80
1997	Archibald ¹⁸	II-2C	5	4	5		Yes	3	3	2	3	3	2	4	34	68
1997	Minnick ¹⁹	III	3	3	3			4	3	2	4	4	4	4	34	68
1997	Melberg ²⁰	III	0	4	5			3	0	0	2	2	3	3	22	44
1997	ANA ²¹	II-2C	5	4	4			3	3	4	3	4	4	4	38	76
1998	Blegen ²²	II-2C	5	4	4			3	3	3	4	2	4	4	36	72
1998	Blegen ²³	II-2C	5	4	5			3	4	3	4	4	3	4	39	78
1998	Kovner ²⁴	III	5	4	4			4	4	4	4	4	4	4	41	82
1998	Leiter ²⁵	III	4	4	4			2	3	0	3	3	3	4	30	60
1998	Aiken ²⁶	II-2C	5	3	5		Yes	3	5	4	4	5	4	4	42	84
1999	Pronovost ²⁷	II-2C	5	3	5			2	5	5	5	5	4	5	44	88
1999	Aiken ²⁸	II-2C	5	3	5		Yes	3	5	4	4	5	4	4	42	84
1999	Robertson ²⁹	II-2C	5	4	5			3	4	4	4	4	4	4	41	82
1999	Lichtig ³⁰	II-2C	5	4	4			3	4	4	3	4	3	4	38	76
1999	Seago ³¹	III	4	4	3			3	0	0	3	3	3	4	27	54
1999	Bond ³²	II-2C	5	4	4			5	4	4	5	5	5	4	45	90
2000	Amaravadi ³³	II-2C	5	4	5		Yes	2	5	5	5	5	4	5	45	90
2000	Gandjour ³⁴	III	3	3	5			3	4	3	3	4	3	4	35	70
2000	Robert ³⁵	II-2C	5	5	5	Yes	Yes	4	4	2	5	4	3	5	42	84
2000	Silber ³⁶	II-2C	5	4	5			5	4	5	5	5	5	4	47	94
2000	ANA ³⁷	II-2C	5	3	4			5	3	3	4	3	5	4	39	78
2000	Hoover ³⁸	III	5	4	5			3	4	4	3	3	3	4	38	76
2000	Unruh ³⁹	II-2C	5	4	4			3	4	4	3	4	4	4	39	78
2001	Pronovost ⁴⁰	II-2C	5	4	5			3	5	4	5	5	4	5	45	90
2001	Dimick ⁴¹	II-2C	5	4	5			2	5	4	4	5	4	5	43	86

Table E1. Quality of the studies (continued)

Year	Author	Class	A	B	C	D	E	F	G	H	I	J	K	L	Total Score	M %
2001	Blegen ⁴²	II-2C	4	3	3			3	4	3	4	4	4	4	36	72
2001	Needleman ⁴³	III	5	5	5			4	5	4	4	5	5	5	47	94
2001	Bolton ⁴⁴	III	5	4	4			3	3	2	2	2	4	4	33	66
2001	Aiken ⁴⁵	III	4	3	3			3	3	0	2	2	3	4	27	54
2001	Whitman ⁴⁶	II-2A	4	4	5			3	2	2	3	3	3	4	33	66
2001	Sovie ⁴⁷	II-2C	5	4	4			3	3	2	3	3	3	4	34	68
2001	Ridge ⁴⁸	III	5	5	4			4	3	3	3	3	2	4	36	72
2001	Ritter-Teitel ⁴⁹	II-2C	5	4	4			5	4	4	4	4	5	5	44	88
2002	Dang ⁵⁰	II-2C	5	4	5			3	4	4	5	5	4	5	44	88
2002	Aiken ⁵¹	II-2C	5	3	5		Yes	3	5	5	5	4	4	4	43	86
2002	Seago ⁵²	III	5	4	5		Yes	3	4	4	4	4	3	4	40	80
2002	Tourangeau ⁵³	II-2C	5	4	5	Yes	Yes	3	5	4	4	4	5	5	44	88
2002	Kovner ⁵⁴	III	5	4	4			5	4	4	4	5	4	5	44	88
2002	Langemo ⁵⁵	III	5	3	4			3	3	0	2	0	3	3	26	52
2002	Needleman ⁵⁶	III	5	4	4			3	5	4	5	5	5	5	45	90
2002	Barkell ⁵⁷	III	5	4	5		Yes	3	2	0	2	2	1	3	27	54
2002	Stegenga ⁵⁸	II-2C	5	5	5	Yes	Yes	3	4	0	5	4	2	4	37	74
2002	Whitman ⁵⁹	III	5	4	4			3	3	0	3	2	3	3	30	60
2002	Cheung ⁶⁰	III	3	5	5	Yes	Yes	3	3	2	2	3	2	3	31	62
2002	Oster ⁶¹	III	5	5	5			3	4	3	4	3	3	3	38	76
2003	Aiken ⁶²	III	5	4	5		Yes	4	5	5	5	5	4	5	47	94
2003	Beckman ⁶³	III	5	5	5	Yes	Yes	4	4	4	3	3	2	3	38	76
2003	Berney ⁶⁴	II-2C	5	5	5		Yes	3	5	5	4	5	4	5	46	92
2003	Unruh ⁶⁵	II-2C	5	5	5			3	4	4	4	4	4	5	43	86
2003	Cho ^{66,67}	II-2C	4	4	4		Yes	3	5	4	5	5	4	5	43	86
2003	Langemo ⁶⁸	III	4	3	3			3	2	0	2	2	2	3	24	48
2003	Needleman ⁶⁹	III	5	4	4			4	4	4	4	4	5	4	42	84
2003	Mark ⁷⁰	II-1B	5	3	4			3	2	1	3	2	3	4	30	60
2003	Alonso-Echanove ⁷¹	II-2A	5	5	5	Yes	Yes	4	4	4	5	4	4	5	45	90
2003	Bolton ⁷²	III	5	4	4			3	2	1	2	3	4	3	31	62
2003	Potter ⁷³	III	4	4	5			3	3	2	3	3	2	4	33	66
2003	Hope ⁷⁴	II-2C	5	5	5	Yes	Yes	3	5	4	5	5	3	5	45	90
2003	Simmonds ⁷⁵	II-2C	5	4	5			3	4	3	4	4	2	3	37	74
2003	Zidek ⁷⁶	II-2C	5	4	4			3	3	3	3	3	3	3	34	68
2003	Tallier ⁷⁷	II-2C	4	4	4			3	2	0	3	1	2	3	26	52
2004	Person ⁷⁸	II-2C	5	4	5			5	5	5	5	5	5	5	49	98
2004	Sochalski ⁷⁹	III	5	3	3			5	3	2	4	3	4	3	35	70
2004	Mark ⁸⁰	II-2C	5	4	4			4	4	4	5	5	4	5	44	88
2004	Van Doren ⁸¹	III	4	5	5			4	2	0	3	2	3	4	32	64
2004	Vahey ⁸²	III	5	3	4			3	4	4	5	5	3	4	40	80
2004	Boyle ⁸³	III	3	3	4			3	3	2	3	3	2	3	29	58
2004	Cimiotti ⁸⁴	II-2C	5	4	4			3	4	4	4	4	3	4	39	78
2005	Estabrooks ⁸⁵	III	5	3	5	Yes	Yes	3	4	4	5	5	4	4	42	84

Table E1. Quality of the studies (continued)

Year	Author	Class	A	B	C	D	E	F	G	H	I	J	K	L	Total Score	M %
2005	Marcin ⁸⁶	II-2C	5	5	5	Yes	Yes	3	4	4	5	5	3	4	43	86
2005	Elting ⁸⁷	II-2C	5	3	5			3	5	5	5	5	4	4	44	88
2005	Mark ⁸⁸	II-2C	5	4	4			4	4	4	4	4	4	5	42	84
2004	Donaldson ⁸⁹	III	5	4	3			3	3	2	4	3	4	4	35	70
2005	Tschannen ⁹⁰	III	5	5	5	Yes	Yes	3	5	4	4	4	2	3	40	80
2005	Houser ⁹¹	III	5	4	5			5	4	4	4	4	5	5	45	90
2005	Halm ⁹²	III	5	5	5			3	3	3	4	4	2	4	38	76
2005	Donaldson ⁹³	III	5	5	4			3	4	5	4	5	4	4	43	86
2005	Stratton ⁹⁴	II-2C	5	4	4			3	4	4	3	3	4	4	38	76
2006	Seago ⁹⁵	II-2C	5	4	5			3	3	2	3	3	3	3	34	68

Figure E1 plots the quality scores (expressed as the percent of maximum possible scores) over time to look for changes in ratings. Although there is a modestly positive overall trend, it is not significant.

Figure E1. Association between quality of studies and time of publication

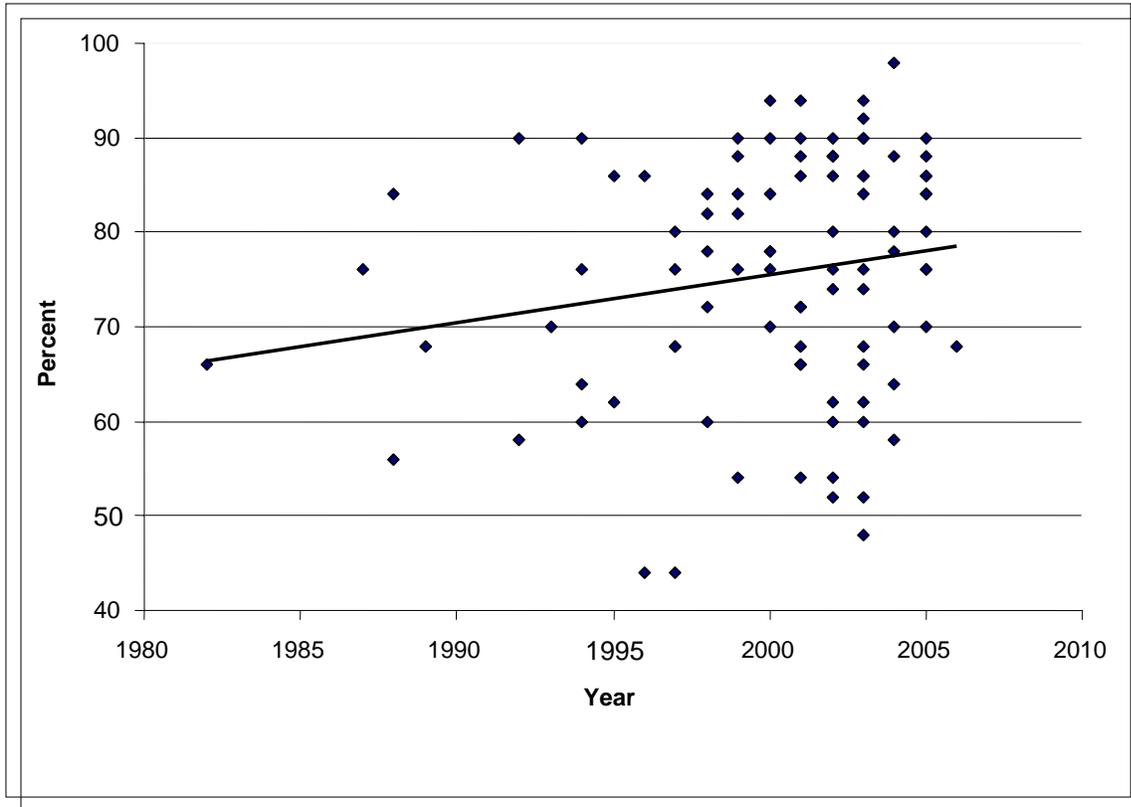


Table E2. Studies published in peer reviewed journals indexed in Medline

Source*	Number of Publications	Quality (% from maximum)
Am J Crit Care	1	86
Anesthesiology	1	94
book	2	77
Can J Nurs Res	1	88
Cancer	1	88
Clin Nurse Spec	1	76
Dissertation	15	77
Eff Clin Pract	1	90
Health Econ	1	84
Health Serv Manage Res	1	82
Health Serv Res	4	88
Heart Lung	1	88
Image J Nurs Sch	1	82
Infect Control Hosp Epidemiol	4	84
Intensive Care Med	1	90
J Health Hum Serv Adm	1	54
J Nurs Adm	12	65
J Nurs Care Qual	1	44
J Nurs Scholarsh	1	66
J Trauma	1	66
JAMA	3	89
Lippincotts Case Manag	1	64
Manag Care Interface	1	70
Med Care	8	82
N Engl J Med	3	81
Nurs Adm Q	1	
Nurs Econ	4	65
Nurs Manage	3	49
Nurs Res	4	79
Outcomes Manag	1	54
Pediatr Crit Care Med	1	86
Pediatr Infect Dis J	1	68
Pharmacotherapy	1	90
Phys Rev B Condens Matter	1	76
Phys Rev C Nucl Phys	1	78
Policy Polit Nurs Pract	1	70
QRB Qual Rev Bull	1	76
Qual Health C	1	84
Report	1	94
Report	1	86
Soc Sci Med	2	64

*Title abbreviations from the National Library of Medicine

Table E3. Assessment of patient comorbidities in included studies

Author	Source to Measure Patient Outcomes	Assessment of Comorbid Conditions Analytic Unit
Aiken	Medical charts of consecutively admitted patients	Severity classification for AIDS hospitalization, clinical AIDS Prognostic Staging Analytic unit: Patient
Aiken	Hospitals discharge database	ICD codes for pre-existing comorbid conditions Analytic unit: Patient
Aiken	Health Care Cost Containment Council	ICD codes for pre-existing co morbid conditions Analytic unit :Patient
Aiken	HCFA database	Medicare Case Mix Index Analytic unit: Hospital
Aiken	Patients survey	HIV risk categories, illness severity Analytic unit: Patient
Alonso-Echanove	Medical charts	Secondary diagnoses and individual medical history present at the time of the admission Analytic unit: Patient
Amaravadi	Uniform Hospital Health Discharge Data Set	ICD codes for comorbid conditions (secondary diagnoses and procedures) Analytic unit: Patient
ANA	HCFA discharges database	Patients' case mix index and severity of illness index Analytic unit: Hospital
ANA	Uniform Hospital Discharge Data Set	Patient case mix index and severity of illness index Analytic unit: Hospital
Berney	New York Statewide Planning and Research Cooperative System	DRG codes for comorbid conditions Analytic unit: Hospital
Blegen	Comparative occurrence reporting service (CORS)	Hospital Medicare Case Mix Scores Analytic unit: Hospital Unit
Blegen	Hospitals discharge database	Hospital Medicare Case Mix Index Analytic unit: Hospital Unit
Blegen	Hospital discharge records	Patient's acuity data from the monthly acuity system reports Analytic unit: Hospital Unit
Bloom	Transaction Cost Analysis; Area Resource File	Medicare Case Mix Index Analytic unit: Hospital
Bond	Hospital Medicare mortality rates from the Health Care Financing Administration	Medicare case mix, APACHE scores, Severity of illness scores Analytic unit: Hospital
Boyle	Hospital discharge data	Patients case mix index Analytic unit: Patient
Cho	State inpatient databases	DRG codes to calculate the number of diagnoses at admission Analytic unit: Patient and hospitals
Cimiotti	Patient discharges and medical records reviewed by study's nurse epidemiologist	DRG for comorbid conditions and procedures Analytic unit: Patient
Dang	Uniform Hospital Health Discharge Data Set	ICD codes for comorbid conditions (secondary diagnoses and procedures) Analytic unit: Patient
Dimick	Uniform Health Discharge Data Set	ICD codes for comorbid conditions (secondary diagnoses and procedures) Analytic unit: Patient
Elting	Center for Medicare and Medicaid Services and the American Hospital Association	Comorbid conditions were coded using the Dartmouth Manitoba Adaptation of Charlson comorbidity score Analytic unit: Hospital
Estabrooks	Hospital inpatient database	Charlson index modified by Devo Analytic unit: Patient

Table E3. Assessment of patient comorbidities in included studies (continued)

Author	Source to Measure Patient Outcomes	Assessment of Comorbid Conditions Analytic Unit
Fridkin	Medical records	Severity of illness with APACHE II scores Analytic unit: Patient
Gandjour	Health Care Financing Administration	Medicare case-mix Analytic unit: Hospital
Halm	Hospital's data warehouse with patient discharges	DRGs codes for comorbid conditions Analytic unit: Patient
Halpine	Hospital Medical Records Institute database	Case Mix Groups Analytic unit: Patient
Hartz	Hospital discharges data from The Health Care Financing Administration (HCFA)	ICD codes for 4 secondary diagnoses, Severity of Illness index Analytic unit: Hospital
Hoover	Health Care Financing Administration, HealthCareReportCards.com; MEDPAR database	Medicare Case Mix Index Analytic unit: Hospital
Hope	Medical Microbiology Laboratory and Infection Control Services; Discharge Abstract Database	Patient severity of Illness index Analytic unit: Patient
Houser	Nationwide inpatient sample of 2001 with hospital discharge records	ICD codes for comorbid conditions Analytic unit: Patient
Kovner	National Inpatient Sample (NIS)	Medicare Case Mix Index Analytic unit: Hospital
Kovner	Nationwide inpatient sample of hospital discharges	Medicare Case Mix Index Analytic unit: Hospital
Krakauer	Medical records for all Medicare discharges	ICD codes for 4 comorbid conditions and additional clinical data with MediQual system Analytic unit: Hospital
Marcin	Medical charts, Pediatric Intensive Care Unit Evaluations Database	Pediatric Risk of Mortality (PRISM) III index Analytic unit: Patient
Mark	Centers for Medicare Services Minimum Cost and Capital File, CMS Provider of Services File, CMS Case Mix Index File, CMS Online Survey Certification and Reporting system (OSCAR) files, and HCUP files	CMS Case Mix Index Analytic unit: Hospital
Mark	Hospital's incident reporting system	CMS Case Mix Index File Analytic unit: Patient (survey)
Mark	Healthcare Cost and Utilization Project (HCUP) National Inpatient Sample (NIS)	CMS case mix index file, Medstat's Disease Staging methodology Analytic unit: Hospital
Needleman	Hospital discharge data from 11 states (all patients and Medicare sample) and MedPAR national database (all Medicare patients)	DRGs codes for comorbid conditions Analytic unit: Hospital and units
Person	Medicare database	Patients severity of illness index Analytic unit :Patient
Pronovost	Uniform Hospital Health Discharge Data Set	ICD codes for comorbid conditions Analytic unit: Patient
Pronovost	Uniform Hospital Health Discharge Data Set	ICD codes for comorbid conditions (secondary diagnoses and procedures) Analytic unit: Patient
Ridge	Patient survey 2 weeks after discharge with computerized phone interview system	Medicare case mix Analytic unit: Patient
Ritter-Teitel	Hospitals Incidence reports and patient surveys	Patients case mix index Analytic unit: Unit
Robert	Medical charts	Severity of illness with APACHE II scores Analytic unit: Patient
Robertson	HCFA database and Hospitals Information Reports	Medicare Case Mix Index Analytic unit: Hospital
Seago	California Office of Statewide Health Planning and Development (OSHPD) Hospital Disclosure Report database	Patients severity of illness index Analytic unit: Hospital

Table E3. Assessment of patient comorbidities in included studies (continued)

Author	Source to Measure Patient Outcomes	Assessment of Comorbid Conditions Analytic Unit
Seago	Incident reporting system, patient survey	Case-mix index Analytic unit: Patient
Shamian	National Comparative Database for Nursing Resource Consumption	ICD codes for secondary diagnoses present at admission Analytic unit: Unit
Shortell	MedPAR dataset of hospital discharges	Medicare case mix Analytic unit: Hospital
Shortell	Hospitals discharge data	DRG codes for comorbid conditions, APACHE III scores Analytic unit: Unit
Silber	Pennsylvania Medicare claims records; Medicare Standard Analytic Files; random sample of 50% of Medicare patients who underwent general surgical or orthopedic procedures	ICD codes for comorbid conditions present at admission and physician's current procedural terminology for outpatient visits within 3 months before index hospital stay Analytic unit: Hospital
Tourangeau	Ontario Acute Care Hospitals Dataset	DCID codes for pre-existing comorbid conditions (Manitoba adaptation of the Charlson index) Analytic unit: Hospital
Tschannen	Patient medical records	Patient Acuity Index, ICD codes for comorbid conditions Analytic unit: Patient
Unruh	Pennsylvania Health Care Cost Containment Council	MediQual severity measure to calculate scores Analytic unit: Hospital
Unruh	State Health Care Cost Containment Council	MediQual severity scores Analytic unit: Patient
Wan	Hospital records	Patient Acuity Index Analytic unit: Hospital
Zidek	Hospital discharge data, patient records, and chart audits	Patients severity of illness index Analytic unit: Patient

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Appendix F. Analytic Framework

Appendix F contains details on analytical framework of the meta-analysis: definitions, hypotheses, and statistical models.

Differences in definitions of nurse staffing. The variation in the ways nurse staffing rates are calculated and expressed makes it difficult to summarize data across studies. The nurse to patient or patients to nurse ratio reflects the number of patients cared for by one nurse typically specified by job category (RN, LPN, or LVN); this ratio may be calculated by shift or by nursing unit; some researchers use this term to mean nurse hours per inpatient day.

Various authors used different operational definitions for the nurse to patient ratio, including:

- number of patients cared for by one nurse per shift
- FTE/1,000 patient-days
- nurse/patient-day or FTE/occupied bed

Total nursing staff or hours per patient day represent all staff or all hours of care including RN, LPN, LVN, and aides counted per patient day (a patient day is the number of days any one patient stays in the hospital, i.e. one patient staying 10 days would be 10 patient days).

RN, LPN, or LVN full-time equivalents per patient day: (an FTE is 2,080 hours per year and can be composed of multiple part-time or one full-time individual.¹ FTE/occupied bed ratios were calculated based on FTE/mean annual number of occupied bed-days (patient-days).

We reported nursing rates as they were used by individual authors, but we have also created two standardized rates for purposes of comparison.

1. The number of patients cared by one nurse per shift. This ratio can be expressed as FTE/patient or patients/FTE per shift.
2. RN FTE/patient day ratio

We conducted separate analysis and report the results in these ways:

- with definitions the authors used
- corresponding to increase by 1 RN FTE/patient day
- in categories of patients/RN per shift in ICUs, and with surgical and medical patients.

Different methods have been used to estimate nurse hours per patient day from FTEs. Some investigators assume a 40 hour week and 52 working weeks per year (2,080 hours/year). Others use more conservative estimates (e.g. 37.5 hours per week for 48 weeks = 1,800 hours/year). In our conversions, we used the latter estimate.²

Nurse hours per patient day = (FTE*40)/patient days³

One nurse/patient day = 8 working hours per patient day²

Then the patient/nurse ratio = 24 hours/nurse hours per patient day.³

We made the following assumptions:

37.5 hour work week on average;

48 working weeks/year (4 weeks vacation, holidays, sick time);

All FTE are full-time nurses with the same shift distribution (assume 3 8-hour shifts);
Length of shift does not modify the association between nurse staffing and patient outcomes;
Patient density is the same over the year.

The same estimation was used for the each nurse job category- RN, LPN, and UAP.

The following examples of calculations may help clarify the approach to conversions.

1. The authors reported RN FTE/1,000 patient-days.

We calculated:

RN hours/patient days: $[(\text{RN FTE}/1,000 * 1,800\text{hours})]/1,000$

Nurse to patient per shift ratio:

Patient/nurse ratio = $24 \text{ hours}/\text{nurse hours per patient day}^3$

Numeric example: The authors reported 3 RN FTE/1,000 patient days

RN hours/patient day = $(3*1,800)/1,000=5.4 \text{ RN hours/patient day}$

Patients/RN per shift ratio = $24 \text{ hours}/5.4 = 4.4 \text{ patients}$

2. The authors reported RN/patient day

We calculated

RN hours/patient days: $(\text{FTE}*40)/5 \text{ patient days per week}^3$

RN hours/patient day = $\text{FTE}*8$

Patients/RN per shift ratio = $24 \text{ hours}/\text{RN hours per patient day}^3$

Numeric example: The authors reported 0.5 FTE/patient day

RN hours/patient day: $0.5 \text{ FTE}*8 \text{ hours} = 4 \text{ hours/patient day}$

Patients/RN per shift ratio = $24 \text{ hours}/4 = 6 \text{ patients}$

3. The authors reported patients/RN per shift ratio.

We calculated

RN hours/patient day = $24 \text{ hours}/\text{reported ratio of patients}/\text{RN}^3$

RN FTE/patient day = $\text{RN hours per patient day}/8 \text{ hours}$

Numeric example: The authors reported 2 patients/RN/shift

RN hours/patient day = $24 \text{ hours}/2 = 12 \text{ hours/patient day}$

RN FTE/patient day = $12 \text{ hours per patient day}/8 \text{ hours} = 1.5 \text{ RN FTE}$

When the authors reported outcome rates among different categories of nurse staffing; we extracted the reported means or calculated medians of nurse staffing ranges. When the authors reported changes in outcomes corresponding to 1 unit increase in nurse staffing ratio. We defined a reference nurse staffing level equal to the published means^{4,5} in different clinical settings assuming that the same linear association would be observed corresponding to an increase by 1 unit from the mean. This assumption ignores nonlinearity but provides more realistic staffing estimation. When the authors reported regression coefficients from several statistical models, we used maximum likelihood criteria to extract one regression coefficient for the pooled analysis—models with significant regression coefficient for the association:

- the smallest number of nonsignificant regression coefficients for confounding factors in the model
- main effects models without interaction and nonlinear associations.

Independent staffing variables for questions 1, 2, and 4 extracted from the studies:
 RN FTE/patient day as a continuous variable
 Patients/RN/shift ratio as a continuous variable
 Quartiles of patients/RN/shift ratio as a categorical variable
 Patients/LPN/shift ratio as a continuous variable
 Patients/UAP/shift ratio as a continuous variable
 Total nursing hours as a continuous variable equal nursing hours/patient or patient day
 RN hours/patient day as a continuous variable equal RN hours/patient day
 LPN hours/patient day as a continuous variable equal LPN hours/patient day
 UAP hours/patient day as a continuous variable equal UAP hours/patient day
 Licensed hours/patient day as a continuous variable equal RN and LPN hours/patient day

We calculated means, standard deviations, and quartiles of nurse staffing variables in different clinical settings to compare with published articles.^{4,5}

Nurse Variables	Needleman et al
Number of hours of nursing care per patient-day	Mean ± STD
Registered nurse-hours	7.8 ± 1.9
Licensed-practical nurse-hours	1.2 ± 1.0
Aide hours	2.4 ± 1.2
Total	11.4 ± 2.3
Proportion of total hours of nursing care (%)	
Registered nurse hours	68 ± 10

The present report:

Nurse Staffing	Number of Studies	Mean	Standard Deviation
ICUs			
RN FTE/patient day	15	1.31	0.70
Patients/RN per shift	15	3.11	1.82
Total nursing hours/patient day	15	11.00	5.23
RN hours/patient day	10	12.61	5.28
LPN hours/patient day	3	0.34	0.57
UAP hours/patient day	4	2.26	1.20
Licensed nurse hours/patient day	1	7.29	0.43
Surgical patients			
RN FTE/patient day	13	1.14	0.84
Patients/RN per shift	13	4.04	2.32
Patients/LPN per shift	2	3.07	2.21
Total nursing hours/patient day	12	7.73	4.31
RN hours/patient day	11	7.81	5.28
LPN hours/patient day	7	1.49	1.58
UAP hours/patient day	5	2.07	0.62
Medical patients			
RN FTE/patient day	20	1.10	0.99
Patients/RN per shift	20	4.42	2.94
Patients/LPN per shift	6	13.25	8.52
Patients/UAP per shift	4	11.95	8.87
Patients/licensed nurse per shift	2	4.12	1.09
Total nursing hours/patient day	27	8.23	4.36
RN hours/patient day	23	6.06	3.60
LPN hours/patient day	13	2.84	3.33
UAP hours/patient day	12	2.97	3.22
Licensed nurse hours/patient day	4	3.32	2.92

Independent staffing strategies variables:

Skill mix % of RN nurses/total nursing personnel as a continuous variable
% of nurses with BSN degrees/total nursing personnel as a continuous variable
% of licensed nurses (RNs + LPNs)/total nursing personnel as a continuous variable

Experience mix: nurse experience in years as a continuous variable

% of overtime nursing hours as a continuous variable
% of temporary nurses as a continuous variable
% of full-time nurses as a continuous variable

The authors used different operational definitions of the outcomes rates: the percentage of the patients with outcomes among all hospitalized patients and the rates of the outcomes per 1,000 patient days. We reported these rates as they were used by the individual authors, but we have also standardized rates as the percentage of patients with outcomes among all hospitalized patients for purposes of comparison. We estimated that

Percentage of patients with outcomes = (rate per 1,000 patient days/10) * an average length of stay. We use published averages of length of stay in ICUs, in medical, and surgical patients.⁴

Weighting variable:

Sample size as patient or analytic unit number (when patient number was not reported); hospital number per every level of exposure.

Tested sources of heterogeneity:

1. Analytic unit
2. Patient population
3. Hospital unit
2. Study design
3. Adjustment for comorbidities
4. Definition of nurse to patient ratio
5. Quality scores
6. Adjustment for provider characteristics and patient socio-economic status
7. Adjustment for clustering between providers and patients
8. Source of the data (administrative vs. medical record)
9. Definition of outcomes

We tested the possible sources of heterogeneity as interaction variables which could modify the effect of nurse staffing on patient outcomes and conducted sensitivity analysis within each category of effect modifiers.

Hypotheses tested in pooled analysis:

1. The outcome is associated with nurse staffing as a continuous variable, weighted by the study sample size * number of hospitals, in a random effects model—random intercept for each study
2. The outcome is associated with nurse staffing as a continuous variable, weighted by the study sample size * number of hospitals, in a fixed effects model

3. The outcome is associated with nurse staffing as a continuous variable with nonlinear association, weighted by the study sample size * number of hospitals in a random effects model
4. The outcome is associated with nurse staffing as a continuous variable with nonlinear association, weighted by the study sample size * number of hospitals, in a fixed effects model
5. The association with nurse staffing as a continuous variable can be modified by analytic unit (hospital, unit, and patient levels), when the model is weighted by the study sample size * number of hospitals in a random effects model—random intercept for each study
6. The association with nurse staffing as a continuous variable can be modified by analytic unit when the model is weighted by the study sample size * number of hospitals in a fixed effects model
7. The association with nurse staffing as a continuous variable can be modified by hospital unit (ICU, medical, surgical) when the model is weighted by the study sample size * number of hospitals in a random effects model—random intercept for each study
8. The association with nurse staffing as a continuous variable can be modified by hospital unit when the model is weighted by the study sample size * number of hospitals in a fixed effects model
9. The association with nurse staffing as a continuous variable can be modified by patient type (medical vs. surgical) when the model is weighted by the study sample size * number of hospitals in a random effects model with a random intercept for each study.
10. The association with nurse staffing as continuous variables can be modified by patient type (medical vs. surgical) when the model is weighted by the study sample size * number of hospitals in a fixed effects model
11. The outcome was associated with nurse staffing as a categorical variables, weighted by the study sample size * number of hospitals, in a random effects model—random intercept for each study
12. The outcome is associated with nurse staffing as continuous variable weighted by the study sample size * number of hospitals in a fixed effects model
13. A sensitivity analysis by analytic units, hospital units, and patient population tested all previous hypotheses with random and fixed effects models weighted by the sample size in subgroups where the analytic units are hospitals, hospital units, and patients and the hospital units are ICU, medical, and surgical and the patients are medical and surgical
14. Individual studies were analyzed with simple linear regression in STATA to find slopes for each study when possible. Meta-analysis was used to estimate pooled regression coefficients: changes in outcomes corresponding to incremental changes by one unit in nurse staffing
15. Interaction models and sensitivity analysis examined the effects of the year of outcomes occurrence and adjustment for patient and provider characteristics and clustering of patients and providers.

Algorithms of meta-analysis⁶

Pooled estimate as a weighted average:

$$\theta_{IV} = \frac{\sum_i w_i \theta_i}{\sum_i w_i}$$

Weights are inverse of variance (standard error):²

$$w_i = \frac{1}{SE(\theta_i)^2}$$

Standard error of pooled estimate:

$$SE(\theta_{IV}) = \frac{1}{\sqrt{\sum_i w_i}}$$

Heterogeneity (between-study variability) measured by:

$$Q = \sum_i w_i (\theta_i - \theta_{IV})^2$$

Assumptions for random effects model: true effect sizes q_i have a normal distribution with mean q and variance t_2 ; t_2 is the between-study variance

Between study variance:

$$\tau^2 = \frac{Q - (k - 1)}{\sum_i w_i - \left(\frac{\sum_i w_i^2}{\sum_i w_i} \right)}$$

Where:

w_i are the weights from the fixed effect inverse-variance method

Q is the heterogeneity test statistic from before (either from inverse-variance method or Mantel-Haenszel method)

k is the number of studies, and

t_2 is set to zero if $Q < k - 1$

Random effect pooled estimate is weighted average:

$$\theta_{DL} = \frac{\sum_i w'_i \theta_i}{\sum_i w'_i}$$

Weights used for the pooled estimate are similar to the inverse-variance, but now incorporate a component for between-study variation:

$$w'_i = \frac{1}{SE(\theta_i)^2 + \tau^2}$$

Standard error of pooled estimate

$$SE(\theta_{DL}) = \frac{1}{\sqrt{\sum_i w'_i}}$$

The likelihood-based approach to general linear mixed models was used to analyze the association between independent variable and outcomes with the basic assumption that the data are linearly related to unobserved multivariate normal random variables.

General linear model $Y = X\beta + \varepsilon$

(Y - the vector of observed y_i 's, X - known matrix of x_{ij} 's, β - the unknown *fixed-effects* parameter vector, and ε - the unobserved vector of independent and identically distributed Gaussian random errors) is written in the mixed model:

$Y = X\beta + Z\lambda + \varepsilon$

where Z - known design matrix, and λ the vector of unknown *random-effects parameters*.

The model assumes that λ and ε are normally distributed.

Attributable risk was calculated as the outcome events rate in patients exposed to different nurse staffing levels.⁷⁻⁹

Attributable risk of the outcome = rate of events in patients with below of the recommended nurse/patient ratio x (relative risk = 1)

Number needed to treat to prevent one adverse event was calculated as reciprocal to absolute risk differences in rates of outcomes events in the groups of the patients with different nurse staffing levels.¹⁰

Administrative data was obtained to estimate nurse shortage and distribution in a state level in the USA.^{11,12} Correlation between nurse distribution and fatal adverse events related to health care were computed with 95% confidence level to determine a strength and directions of the correlations.¹³

Definitions of fatal injuries related to health care:

Misadventures to patients during surgical and medical care (E870-E876):

E870 Accidental cut, puncture, perforation, or hemorrhage during medical care-

E870.0 Surgical operation

E870.1 Infusion or transfusion

E870.2 Kidney dialysis or other perfusion

E870.3 Injection or vaccination

E870.4 Endoscopic examination

E870.5 Aspiration of fluid or tissue, puncture, and catheterization

Abdominal paracentesis

Aspirating needle biopsy

Blood sampling

Lumbar puncture

Thoracentesis

E871 Foreign object left in body during procedure

E872 Failure of sterile precautions during procedure

E873 Failure in dosage

E873.0 Excessive amount of blood or other fluid during transfusion or infusion

E873.1 Incorrect dilution of fluid during infusion

E873.2 Overdose of radiation in therapy

E873.3 Inadvertent exposure of patient to radiation during medical care

E873.4 Failure in dosage in electroshock or insulin-shock therapy

E873.5 Inappropriate [too hot or too cold] temperature in local application and packing

E873.6 Nonadministration of necessary drug or medicinal substance

E873.8 Other specified failure in dosage

E873.9 Unspecified failure in dosage

E874 Mechanical failure of instrument or apparatus during procedure

E875 Contaminated or infected blood, other fluid, drug, or biological substance

Includes:

presence of:

bacterial pyrogens

endotoxin-producing bacteria

serum hepatitis-producing agent

E876 Other and unspecified misadventures during medical care

E876.0 Mismatched blood in transfusion

E876.1 Wrong fluid in infusion

E876.2 Failure in suture and ligature during surgical operation

E876.3 Endotracheal tube wrongly placed during anesthetic procedure

E876.4 Failure to introduce or to remove other tube or instrument

E876.5 Performance of inappropriate operation

E876.8 Other specified misadventures during medical care

Performance of inappropriate treatment NEC

E876.9 Unspecified misadventure during medical care

Surgical and medical procedures as the cause of abnormal reaction of patient or later complication, without mention of misadventure at the time of procedure (E878-E879)

Includes:

procedures as the cause of abnormal reaction, such as:

displacement or malfunction of prosthetic device

hepatorenal failure, postoperative

malfunction of external stoma

postoperative intestinal obstruction

rejection of transplanted organ

E878 Surgical operation and other surgical procedures as the cause of abnormal reaction of patient, or of later complication, without mention of misadventure at the time of operation

E879 Other procedures, without mention of misadventure at the time of procedure, as the cause of abnormal reaction of patient, or of later complication

Drugs, medicinal and biological substances causing adverse effects in therapeutic use (E930-E949)

Includes:

correct drug properly administered in therapeutic or prophylactic dosage, as the cause of any adverse effect including allergic or hypersensitivity reactions

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Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes

Case control studies

Author, Year, Publication Type	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis, Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Fridkin, 1966 ¹ Article	Examine the associations between nurse staffing and central venous catheter-associated bloodstream infections	Single hospital study: university-affiliated Veterans Affairs medical center	1992-1993, Patient, Random sample of 1,760 patients	Medical records, Adults, Catheter-associated bloodstream infections, Veterans Affairs	Patient age, gender, length of stay, primary diagnosis, severity of illness	Bloodstream infections
Arnow, 1982 ² Article	Examine association between staffing by overtime or temporary nurses and nosocomial infection in a burn unit	Single unit study, Medical records	1975, Patient, 147 patients, 27.21%	Medical records, Adults	Not reported	Nosocomial infection
Marcin, 2005 ³ Article	Examine the association between unplanned extubation and years of nurse experience and nurse-to-patient ratio in the pediatric intensive care unit	Single hospital study	1999-2002, Patient, 220 patients	Medical records, Children	Matching: a) weaning status and duration of intubation; b) patient age; and c) severity of illness as defined by PRISM III. Adjustment: patient age, physical restraints, sedation, patient agitation	Unplanned extubation

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis, Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Aiken, 1998 ⁴ Article	Examine association between hospital organization, nurse burnout, and patient satisfaction	American Hospital Association Annual Hospital Survey	1990-1991, Patient, 1,393 patients, 13.50%	Medical records, Adults, AIDS	Patient sex, age, race, type of insurance, HIV risk categories, illness severity; admitting physician as a part of an AIDS specialty service; the extent of nurse control over practice environment	Patient satisfaction
Aiken, 1999 ⁵ Article	Compare differences in AIDS patients' 30-day mortality and satisfaction with care in dedicated AIDS units, scattered-bed units in hospitals with and without dedicated AIDS units, and in magnet hospitals known to provide good nursing care	American Hospital Association Annual Hospital Survey	1990-1991, Patient, 1,393 patients, 13.50%	Medical records, Adults, AIDS	Patient sex, age, race, type of insurance, HIV risk categories, illness severity; admitting physician as a part of an AIDS specialty service; the extent of nurse control over practice environment	Mortality, patient satisfaction
Robert, 2000 ⁶ Article	Examine the association between nosocomial primary bloodstream infections (BSIs) and nursing-staff levels in surgical intensive care unit (SICU) patients	Single hospital study - 20-bed SICU in a 1,000-bed inner-city public hospital, 100, South	1994-1995, Patient, Random sample of 127 patients	Medical records, Adults, Nosocomial primary bloodstream infections	Patient age, diagnosis, comorbidity, length of stay	Bloodstream infection

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis, Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Aiken, 1994 ⁷ Article	Examine the association between Medicare mortality and hospitals with different nursing care	39 magnet hospitals and 195 control hospitals, selected using a multivariate matched sampling procedure that controls for hospital characteristics, 28.2%, 7.7%	1988, Hospital, Random sample of 234 hospitals	Administrative, Adults, 65, Medicare	Patient age, sex, comorbidities, type and source of admission, propensity scores for 12 hospital characteristics census, size occupancy rate, location, technology index)	Mortality

G-5

Case-series

Author, Year, Publication Type	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Seago, 1999 ⁸ Article	Examine the association of patient-focused care at one tertiary care university teaching hospital on patient outcomes	Single tertiary care hospital study before and after implementation of patient-focused care	1996-1997, Patient, 89,256 patients	Medical records, Adults	Not reported	Patient satisfaction, pressure ulcers, falls
Donaldson, 2005 ⁹ Article	Examine patients' outcomes before and after legislations for mandatory nurse/patient ratios in California hospitals	Convenience sample of 68 acute hospitals participating in the California Nursing Outcomes Coalition project	2004-2005, Unit, 268, 39.55%	Administrative, Adults	Not reported; before-after comparison were conducted in the same units	Pressure ulcers. falls

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Grillo-Peck, 1995 ¹⁰ Article	Examine the impact of implementation of a new nursing partnership model with a reduction of RN from 80% to 60% on patient outcomes in neuroscience unit	Single hospital study	1995-1993, Patient, 156 patients	Medical records, Adults, Cerebrovascular diseases	Not reported. The authors reported that patients had similar demographic characteristics	Length of stay, nosocomial infection, falls

Cross-sectional studies

Author, Year, Publication Type	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis, Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Hartz, 1989 ¹¹ Article	Examine the association between nurse staffing and mortality in Medicare population	3,100 hospitals from the 1986 HCFA mortality study and the American Hospital Association's 1986 annual survey of hospitals, 8.1%, 11.9%	1986, Hospital, 5,781 patients 46.38%	Administrative, Adults >65years, Medicare	Severity of illness	Mortality

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis, Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Krakauer, 1992 ¹² Article	Examine the association of nurse staffing on mortality in Medicare population	84 statistically selected hospitals from 1986 American Hospital Association (AHA) survey, Single hospital study	1986, Hospital, 42,773 patients, Random sampling, bias assessed	Medical records Adults, >65 years, Medicare	Patient one principal discharge diagnosis, up to four secondary diagnoses, age, sex, race, comorbidities, transfer status; hospital size, location, finances, technical capability of the hospital, cluster patients and hospitals	Mortality
McDaniel, 1992 ¹³ Article	Examine relationship between nurse turnover and patient and nurse satisfaction	Single hospital study	Patient, 300 patients	Medical records, Adults	Not reported	Patient satisfaction
Halpine, 1993 ¹⁴ Article	Examine the association between nurse staffing and length of stay in Ontario hospitals	The Hospital Medical Records Institute, 75%	1989-1990, Hospital, 40,000 patients, 22.36%	Administrative	Nursing intensity index	Length of stay
Shamian, 1994 ¹⁵ Article	Examine relationship between length of stay and hours per patient day in 11 clinical specialty areas	58 hospitals in the U.S., 33%	Unit, 1,733 patients	Administrative	Patient age, primary and secondary diagnosis; hospital unionization, unit computerization, hospital ownership	Length of stay
Taunton, 1994 ¹⁶ Article	Examine associations between patient outcomes and staff registered nurse absenteeism	Taunton, 25%	1989-1990, Unit, 65 units	Administrative, Adults	Not reported	Urinary tract infection, falls, bloodstream infection

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis, Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Dugan, 1996 ¹⁷ Article	Examine the association between nurses' perceived stress and patient incidents, including falls	Single hospital study	1996, Nurse, 600 nurses, 51.17%	Survey	Not reported	Falls
Bloom, 1997 ¹⁸ Article	Examine association between registered nurses (RNs) from temporary agencies; part-time career RNs; RN rich skill mix; and organizationally experienced RNs on operational and total hospital cost	1981 AHA annual survey of hospitals; A 20% random sample (1,222 hospitals)	Hospital, 732 hospitals, 20.36%, Random sampling, sample bias assessed	Administrative, Adults	Hospital size, ownership/control, teaching status, operating capacity, geographic region, urban/rural status, local economic climate, hospital wage rates, supply of nursing labor within the community	Length of stay
Minnick, 1997 ¹⁹ Article	Examine association between nurse staffing and patient satisfaction	117 no intensive medical-surgical inpatient units in 17 hospitals selected from a pool of 69 institutions within a metropolitan area by a stratified random sample	1991-1992, Unit, 2,595 patients, 20.96%	Survey, Adults	Patient age, gender, marital status, race, education, diagnosis	Patient satisfaction
Melberg, 1997 ²⁰ Book	Examine the association between nurse staffing and length of stay	Single system in California, 100%, Pacific	1994-1995, Hospital, 5%	Administrative, Adults	Not reported	Length of stay

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis, Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Leiter, 1998 ²¹ Article	Examine the relationships of nurse burnout, intention to quit, and meaningfulness of work as assessed on a staff survey with patient satisfaction with nursing care	Single hospital study	1998, Patient Random sample of 605 patients	Survey	Not reported	Patient satisfaction
Kovner, 1998 ²² Article	Examine the relationship between nurse staffing and adverse events controlling for related hospital characteristics	Stratified probability sample of U.S. community hospitals - 589 acute-care hospitals in 10 states, 21%, 11.8%	1993, Hospital, 900 hospitals, 34.56%	Administrative, Adults, >18years	Case mix (patient age, sex, and comorbidity); hospital teaching status, ownership, bed size, region	Urinary tract infection, gastrointestinal bleeding, pneumonia, pulmonary failure. thrombosis, acute myocardial infarction as a secondary diagnosis after surgery
Hoover, 2000 ²³ Dissertation	Examine the association between managed care penetration, nurse staffing, and hospital outcomes in three southern states	American Hospital Association Annual Survey, Health Care Financing Administration, Mississippi State Department of Public Health, U.S. Census Bureau	1995-1997, Hospital, 271 hospitals, 35.06%	Administrative, Adults, >65 years, Chronic obstructive pulmonary disease, viral pneumonia, heart attack, shock, stroke, and hip procedures, Medicare	Patient age, sex, race, procedure, comorbidity; hospital size, location, and teaching status	Mortality, length of stay

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis, Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Gandjour, 2000 ²⁴ Article	Determine the effect of managed health care plans on hospital staffing	Tennessee Department of Health, 17%, 25.97%, 29-60%	1995, Hospital, 151 hospitals, 49.01%	Administrative, Adults	Medicare case-mix, number of patient days, hospital beds, average salary, hospital status, occupancy rate	Length of stay
Ridge, 2001 ²⁵ Dissertation	Examine the association between nurse staffing and patient satisfaction	Single hospital study-JCAHO-accredited tertiary care hospital, 100%	1997-1999, Patient, 5,509 patients, 80.47%	Survey, Adults	Patient age, gender, race, and acuity, Medicare case mix, primary and secondary diagnoses	Length of stay, patient satisfaction
Bolton, 2001 ²⁶ Article	Examine association between nurse staffing and patient safety outcomes	Voluntary sample of California acute care hospitals; 257 medical, surgical, medical-surgical combined, step-down, 24-hour observation units, and critical care patient care units, 9% of all general acute care hospitals in California	1998-1999, Unit, 257 units, Sampling bias, Assessed	Administrative, Adults, >16 years	Not reported	Pressure ulcers, falls
Aiken, 2001 ²⁷ Article	Examine the association between nurse staffing and mortality	Hospital Association Annual Survey	1997-1998, Hospital, 22 hospitals	Administrative, Adults, Medicare	Not reported	Mortality

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis, Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Needleman, 2001 ^{28,29} Report	Examine the relationship between patient outcomes potentially sensitive to nursing and nurse staffing in inpatient units in acute care hospitals	American Hospital Association Annual Survey of hospitals; hospital patient discharge data and state hospital financial reports or hospital staffing surveys; 11 states across the U.S.	1997, Hospital, 3,173,705 patients	Administrative	Patient diagnosis, age, sex, comorbidities, health care, emergency admission, hospital location, number of beds, occupancy rate, teaching status, patient acuity in each hospital's mix of patients	Gastrointestinal bleeding, pneumonia, shock, failure to rescue, pressure ulcers, pulmonary failure. surgical wound infection, thrombosis, cardiac arrest and CPR, CNS complications (coma and stupor, acute delirium, reactive confusion, reactive depression), physiologic/ metabolic complications bloodstream infection

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis, Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Cho, 2002 ³⁰ Dissertation	Examine the association between nurse staffing and adverse patient outcomes	Hospital Financial Data and HCUP State Inpatient Database, 5.6%, 29.7%	1997, Hospital, 124,204 patients	Administrative, Adults, >18 years	Patient age, sex, race, primary payer, DRG, number of diagnoses at admission, and type of admission (scheduled or unscheduled); hospital location, size, teaching status, ownership; clustering patients in hospitals (two levels model)	Urinary tract infection, pressure ulcers, falls, surgical wound infection, bloodstream infection
Oster, 2002 ³¹ Dissertation	Examine the association between nurse staffing and patient outcomes in patient with acute myocardial infarction in urban emergency department	Single hospital study in an academic medical center	2000-2001, Patient, 543 patients	Medical records, Adults, Acute myocardial infarction	Patient age, sex, ethnicity, payer type	Length of stay
Cheung, 2002 ³² Dissertation	Examine the association between nurse staffing, time spent on direct and indirect care, and adverse events in five inpatient units in acute care hospital	Single hospital study	Nurse, 1,007 nurses	Medical records, Adults, >17 years	Unit acuity, skill mix, total number of nursing personnel, events, and nursing characteristics	Pressure ulcers, falls, nosocomial infection, unexpected injury not due to underlying condition of the patients that occurs during the care: falls, decubitus ulcers, medication errors, and blood stream infections

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis, Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Langemo, 2002 ³³ Article	Examine nursing quality outcome indicators (falls and pressure ulcers) after implementation of ANA Nursing Care Report Card	North Dakota Nurses Association (NDNA) Research Council	2003, Patient, 942 patients	Administrative, Adults	Not reported	Patient satisfaction, pressure ulcers, falls
Seago, 2002 ³⁴ Article	Examine the relationship between the presence of a bargaining unit for registered nurses and the acute myocardial infarction mortality rate for acute care hospitals in California	California Office of Statewide Health Planning and Development (OSHPD) Hospital Disclosure Report database	1991-1993, Hospital, 385 hospitals, 10.91%, Sampling bias assessed	Medical records, Adults, Acute myocardial infarction	Patient age, sex, severity of illness; hospital services, patient volume, teaching status, number of MDs per acute myocardial infarction-related discharges, the cardiac technology index, rural status and the Hospital Service Area (HSA) wage index	Mortality
Needleman, 2002 ²⁹ Article based on the report	Examine the relationship between the amount of care provided by nurses at the hospital and patients' outcomes	American Hospital Association's Annual Survey of Hospitals	1997, Hospital, 6,180,628 patients	Administrative, Adults	Rate of the outcome in the patient's diagnosis-related group, state of residence, age, sex, primary health insurer, emergency admission, and comorbidities, hospital number of beds, teaching status, state, and metropolitan or non metropolitan location	Mortality, urinary tract infection, gastrointestinal bleeding, pneumonia, shock, failure to rescue

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis, Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Kovner, 2002 ³⁵ Article	Examine the association between nurse staffing and patient adverse events after controlling for hospital characteristics	National Inpatient Sample, 80.5%	1990-1996, Hospital, Random sample of 570 hospitals	Administrative, Adults, >18 years	Medicare Case Mix Index, hospital bed size, location, region, ownership, teaching status, HMO penetration	Urinary tract infection, pneumonia, pulmonary failure, thrombosis
Whitman, 2002 ³⁶ Article	Determine the relationships between nursing staffing and specific nurse-sensitive outcomes (central line blood-associated infection, pressure ulcer, fall, medication error, and restraint application duration rates) across specialty units	Secondary analysis of prospective, observational data from 10 adult acute care hospitals	1999, Unit, 95 units	Administrative, Adults	Not reported	Pressure ulcers, falls, bloodstream infection
Beckman, 2003 ³⁷ Dissertation	Examine association between nurse management and patient outcomes	Single hospital study, 100%, 17%	1999-2000, Patient, 429 patients, 74.36%	Survey, Adults	Patient age, sex, race	Random, length of stay

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis, Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Cho, 2003 ³⁸ Article	Examine the effects of nurse staffing on adverse events, morbidity, mortality, and medical costs	Hospital financial data, state Inpatient databases, 5%, 20%	1996-1999, Patient, 124,204 patients	Administrative, Adults, >18 years	Patient age, sex, race, primary payer, DRG, number of diagnoses at admission, and type of admission (scheduled or unscheduled); hospital location, size, teaching status, ownership; clustering patients in hospitals (two levels model)	Urinary tract infection, pressure ulcers, falls, surgical wound infection, bloodstream infection, ICD-9-CM for adverse drug event
Aiken, 2003 ³⁹ Article	Examine whether the proportion of hospital RNs educated at the baccalaureate level or higher is associated with risk-adjusted mortality and failure to rescue (deaths in surgical patients with serious complications)	Pennsylvania Health Care Cost Containment Council, 36%	1998-1999, Patient, 232,342 patients	Administrative, Adults, >20 years, general surgical, orthopedic, vascular operation	Patient age, sex, referral from another hospital, comorbidities; hospital size, teaching status, and technology; having a board-certified surgeon	Mortality, failure to rescue
Potter, 2003 ⁴⁰ Article	Examine the association between nurse staffing and patient outcomes at the unit level in the acute care adjusting for patient acuity and proportion of floating nurses	Single hospital study, 100%	1999-2001, Unit, 32 units	Medical records, Adults	Not reported	Patient satisfaction, falls

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis, Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Langemo, 2003 ⁴¹ Article	Examine the association between pressure ulcer incidence, staff mix, and nursing care hours	Midwest Research Institute/National Database of Nursing Quality Indicators	2003, Hospital, 942 hospitals	Administrative	Not reported	Pressure ulcers
Bolton, 2003 ⁴² Article	Examine the relationship between nurse staffing and patient perceptions of nursing care in a convenience sample of 40 California hospitals	Hospitals participating in both the ongoing California Nursing Outcomes Coalition statewide database project and the statewide Patients' Evaluation of Performance in California project	1998-2000, Hospital, 113 hospitals	Administrative, Adults	Not reported	Patient satisfaction
Needleman, 2003 ⁴³ Article	Assess whether adverse outcomes in Medicare patients can be used as a surrogate for measures from all patients in quality of care research using administrative datasets	National MedPAR discharge data for Medicare patients from 3,357 hospitals, state hospital staffing surveys or financial reports, American Hospital Association Annual Survey, present sample is 26% of all discharges in the U.S. in 1997	1997-1998, Hospital, 6,180,628 patients	Administrative, Adults	Patient age, sex, primary DRG, health insurance, emergency admission, and comorbidities, hospital teaching, metropolitan status, and bed size	Length of stay, urinary tract infection, gastrointestinal bleeding, pneumonia, shock, failure to rescue, pressure ulcers, surgical wound infection, cardiac arrest and CPR, bloodstream infection

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis, Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Vahey, 2004 ⁴⁴ Article	Examine the effects of the nurse work environment and nurse burnout on patients' satisfaction with their nursing care	40 units in 20 urban hospitals across the U.S. (sample from the study of quality of care in AIDS patients)	1991, Patient, 722 patients, 13.99%	Survey, Adults, AIDS	Patient age, sex, and race, severity of illness, nurse sex, race, age, experience in nursing and in the unit; clustering nurses and patients within hospitals	Patient satisfaction
Sochalski, 2004 ⁴⁵ Article	Examine the effects of nurse staffing and process of nursing care indicators on assessments of the quality of nursing care	Hospitals where responding licensed RNs in Pennsylvania worked in 1999	1999, Nurse, 8,500 nurses, 7.70%, Random sample, Bias assessed	Survey	Nurses clustered within hospitals, nurses perceived quality of care and patient safety	Falls
Van Doren, 2004 ⁴⁶ Article	Examine the relationships between congestive heart failure patient outcomes and RN hours	Single hospital study, 75%	1998, 0.57%, Random of 175 patients	Medical records, Adults, Heart failure	Not reported	Length of stay
Boyle, 2004 ⁴⁷ Article	Examine the association between nurse autonomy and collaboration and patient outcomes	Single hospital study, 100%	2001, Unit, 11,496 patients	Survey, Adults	Case mix index	Mortality, length of stay, urinary tract infection, pneumonia, failure to rescue, pressure ulcers, falls, cardiac arrest, and CPR

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis, Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Donaldson, 2005 ⁹ Report	Test associations between daily nurse staffing in adult medical-surgical units and hospital acquired pressure ulcers, patient falls	25 acute care, not-for-profit California hospitals, the part of the California Nursing Outcomes Coalition (CalNOC)	2002-2003, Unit, 77 units	Administrative, Adults	Hospital rural/urban designation; ownership; no. licensed acute care beds; average daily census	Pressure ulcers, falls, adverse events, unexpected clinical events not related to the patient's illness or underlying condition resulting in unanticipated death or major permanent loss of function, or adversely affects the patient care quality or outcomes
Tschannen, 2005 ⁴⁸ Dissertation	Examine association between patient length of stay and nurse staffing and nurse-physician collaboration	Single hospital study	2005, Patient, 406 patients, 23.65%	Medical records	Patient DRG, age, gender, acuity scores, unit of admission, admission type and source, and comorbidities; nursing characteristics	Length of stay
Houser, 2005 ⁴⁹ Dissertation	Examine the association between nurse staffing and nurse-sensitive patient outcomes	American Hospital Association Annual Survey (685 hospitals); 20% random sample of U.S. hospitals	2001, Patient, 7,452,727 patients, 24.37%, Random sample	Administrative, Adults	Patient age, race, sex, health insurance, comorbidity; hospital size, teaching status, location, ownership	Length of stay, failure to rescue, pressure ulcers, pulmonary failure, thrombosis

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis, Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Estabrooks, 2005 ⁵⁰ Article	Examine the association between nurse education and skill mix, and 30-day mortality after adjusting for institutional factors and individual patients characteristic	International Hospital Outcome Study, 8.2%	1998-1999, Patient, 18,142 patients	Administrative, Adults, >18 years, acute myocardial infarction, stroke, congestive heart failure, chronic obstructive pulmonary disease, pneumonia	Comorbidity scores, patient age, and gender	Mortality
Halm, 2005 ⁵¹ Article	Examine the association between nurse-to-patient ratio and patient mortality, failure to rescue, emotional exhaustion and job satisfaction of nurse	Single hospital study, 100%, 0%	2002, Patient, 6,216 patients, 56.42%	Administrative, Adults, General, orthopedic, and vascular surgery	Patients demographics, emergency department admission, comorbidity and complications	Mortality, failure to rescue

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Studies that assessed temporality in association between patient outcomes and nurse staffing patterns

Author, Year, Publication Type, Data Collection	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Wan, 1987 ⁵² Article, Retrospective	Examine association between nurse staffing and patient adverse events in 45 community acute care hospitals across the U.S.	Health area resources file, hospital survey	1985, Hospital, 60 hospitals, 25.0%	Administrative, Adults	Severity of adverse event	Falls

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type, Data Collection	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Flood, 1988 ⁵³ Article, Prospective	Examine association between nurse shortage and length of stay	Single hospital study	1986, Patient, 497 patients	Medical records, Adults	Not reported, subgroup analysis by patient acuity	Length of stay, adverse events, infections including urinary tract infection and gangrene; congestive heart failure, and arrhythmias, gastrointestinal bleeding
Shortell, 1994 ¹⁵ Article, Retrospective	Examine staffing factors associated with risk-adjusted mortality, risk-adjusted average length of stay, and nurse turnover	1,691 non federal U.S. hospitals with >200 beds, 53%, 12%	1988-1990, Unit, 17,440 patients, Random sample, bias assessed	Administrative, Adults, >16 years	Patient demographic characteristics, primary DRG and comorbidity (APACHE III scores)	Mortality
Shortell, 1988 ⁵⁴ Article, Retrospective	Examine the association between the proportion of RNs on mortality rates in Medicare patients for 16 selected clinical conditions	981 hospitals in 45 states, 46%	1983-1984, Hospital, 214,839 patients, Sample bias Assessed	Administrative, Adults, >65 years, >16 years, Selected clinical conditions, Medicare	Patient age, sex, comorbidity, length of stay, Medicare case mix; hospital's size, location, ownership	Mortality, length of stay
Thorson, 1995 ⁵⁵ Dissertation, Retrospective	Relationship between the available hours of RN care and patient outcomes, defined as discharge disposition and death	Acute care short term hospitals in North Carolina, 19%	1988-1993, Patient, 146,000 patients	Medical records, Adults	Patient age, gender, length of stay, major diagnostic category; hospital ownership, occupancy, size, location, teaching status, and technology	Mortality, length of stay

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type, Data Collection	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
ANA, 1997 ⁵⁶ Report, Retrospective	Examine association between nurse staffing and patient outcomes	502 hospitals from California, Massachusetts, and New York	1992-1994, Hospital, 502 hospitals, Sample bias assessed	Administrative	Nursing Intensity weights, hospital teaching status, location	Length of stay, urinary tract infection, pneumonia, pressure ulcers, nosocomial infection
Archibald, 1997 ⁵⁷ Article, Retrospective	Examine the effect of fluctuations in cardiac intensive care unit nurse staffing levels and patient census on cardiac care unit nosocomial infection rate	Single hospital study	1994-1995, Patient, 782 patients	Medical records, Children	Not reported	Nosocomial infection
Blegen, 1998 ⁵⁸ Article, Retrospective	Describe, at the level of the nursing care unit, the relationships among total hours of nursing care, registered nurse skill mix, and adverse patient outcomes	Consortium of hospitals members of Information and Quality Healthcare	1993, Unit, 42 units	Administrative, Adults	Patient severity, nursing acuity system	Mortality, patient satisfaction, pressure ulcers, falls, nosocomial infection
Blegen, 1998 ⁵⁹ Article, Retrospective	Determine the relationship between different levels of nurse staffing (total hours/patient day and proportion of RNs) and patient falls and cardiovascular arrests	Consortium of hospitals members of Information and Quality Healthcare	1993-1995, Unit, 39	Administrative, Adults	Medicare case mix scores	Falls, cardiac arrest, and CPR
Bond, 1999 ⁶⁰ Article, Retrospective	Examine associations between nurse staffing levels and mortality rates in 3,763 U.S. hospitals	American Hospital Association's Abridged Guide to the Health Care Field, 8.3%, 14.2%	1992, Hospital, 4,822 hospitals, 21.96%	Administrative, Adults, Medicare	Severity of illness: % of ICU days, annual number of emergency room visits/average daily census, and % of Medicaid patients	Mortality

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type, Data Collection	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Pronovost, 1999 ⁶¹ Article, Retrospective	Determine whether nurse to patient ratio in ICUs is associated with length of stay in abdominal aortic surgery patients who typically receive care in an ICU	Maryland Health Services Cost Review Commission	1994-1996, Patient, 2,996 patients, 0.30%, Sample bias assessed	Medical records, Adults, >30 years, Abdominal aortic surgery	Patients' age, sex, race, nature of admission, type of aneurism, comorbidity, surgeon and hospital volumes	Mortality, length of stay
Robertson, 1999 ⁶² Article, Retrospective	Examine the association between staffing intensity, skill mix, and mortality in patients with chronic obstructive lung disease	American Hospital Association	1989-1991, Hospital, 5,708 patients, Sample bias assessed	Administrative, Adults, chronic obstructive pulmonary disease, Medicare	Severity of illness and comorbidity (Medicare case mix index); hospital's financial status, ownership, technology index, size, staffing variables (nursing, physicians, technologists)	Mortality
Lichtig, 1999 ⁶³ Article, Retrospective	Examine the relationships between patient outcome indicators and nurse staffing	Hospital cost reports from New York and California	1992,1994, Hospital, 691, 33.00%	Administrative, Adults	Nursing intensity weights based on patients' characteristics, teaching status, and location	Length of stay, urinary tract infection, pneumonia, pressure ulcers, surgical wound infection

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type, Data Collection	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Amaravadi, 2000 ⁶⁴ Article, Retrospective	Determine if a night-time nurse-to-patient ratio in the intensive care unit is associated with clinical and economic outcomes following esophageal resection	Maryland Health Service Cost Review Commission	1994-1996, Patient, 366 patients in 32 hospitals	Adults, >18 years, Esophageal resection	Patient age, sex, nature of admission, type of operation, comorbid disease and hospital and surgeon volume; clustering of outcomes within a hospital	Mortality, length of stay, pneumonia, pulmonary failure, unplanned extubation, cardiac arrest and CPR, septicemia postoperative infection, myocardial infarction, surgical complications, acute renal failure

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type, Data Collection	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
ANA, 2000 ⁶⁵ Report, Retrospective	Examine the association between nurse staffing and patient outcomes in the inpatient hospital settings	HCFA	1992-1996, Hospital, 14,251,921 patients, 9.32%	Administrative, Adults, >75 years, Medicare	Large urban location (Y/N); rural location (Y/N); teaching status; nursing intensity weights	Length of stay, urinary tract infection, pneumonia, pressure ulcers, surgical wound infection, thrombosis, anoxic brain damage; communicable conditions; complications in post-partum period; diabetic complications, joint effusion, metabolic imbalances, personal care complications, psychiatric secondary diagnosis, transfusion reactions, trauma in non-trauma patients, adverse drug reactions

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type, Data Collection	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Unruh, 2000 ⁶⁶ Dissertation, Retrospective	Examine the association between nurse staffing and quality of patient care	211 hospitals yearly, 1,477 during 7 years acute care hospitals in Pennsylvania, State Department of health with unique information on nurse staffing and patients discharge, 0.4%	1991-1997, Patient, 83,924 patients	Administrative	Patient age, gender, race, acuity (Mediqual, hospital location, size, ratio of board certified physicians/ adjusted patients days of care; hospital restructuring including capacity utilization, merger status, ownership, number of administrators/ adjusted patients days of care	Mortality, length of stay, urinary tract infection, pneumonia, pressure ulcers, falls, pulmonary failure, surgical wound infection, cardiac arrest and CPR, complications: secondary diagnosis of misadventures to patients during surgical and medical care

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type, Data Collection	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Silber, 2000 ⁶⁷ Article, Retrospective	Examine the association between nurse staffing and patient outcomes in surgical Medicare patients	Medicare patients in 245 hospitals	1991-1994, Hospital, 217,440 patients	Administrative, Adults, >65 years, Medicare	27 patient characteristics including age, sex, race, diagnosis and comorbidities, hospital size, location, technology, % of certified physicians and anesthesiologists	Mortality, failure to rescue, in-hospital complication rate, cardiac event, congestive heart failure, shock, deep vein thrombosis and pulmonary embolus, stroke, transient ischemic attack, coma, nosocomial infections, pneumonia, pulmonary failure, pressure ulcers, wound infections, sepsis, bleeding
Whitman, 2001 ⁶⁸ Article, Prospective	Examine the relationship between restraint use and staffing	A secondary analysis of prospective, observational data from 10 adult acute care hospitals with bed capacity ranging from 59–861 beds, in an integrated healthcare system in the east, 50%	1999, Unit, 370,574 patients	Medical records, Adults	Not reported; however, the authors obtained hierarchical longitudinal linear models (random coefficient regression models)	Restraint use

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type, Data Collection	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Ritter-Teitel, 2001 ⁶⁹ Dissertation, Retrospective	Examine the association between nurse staffing and patient outcomes	Sample from HRIO study ("Hospital Restructuring's Impact on Outcomes") of 42 teaching hospitals, 100%	1997-1998, Unit, 56, Sample bias assessed	Administrative	Age, primary diagnosis and case-mix index, random effects of hospitals	Patient satisfaction, transient ischemic attack, pressure ulcers, falls
Dimick, 2001 ⁷⁰ Article, Retrospective	Determine if nurse-to-patient ratio in the intensive care unit at night is associated with differences in clinical and economic outcomes after hepatectomy	Maryland Health Services Cost Review Commission	1994-1998, Patient, 569 patients, 2.28%	Administrative, Adults, >18 years, hepatic resection	Patient age, sex, nature of admission, type of operation, comorbidity; hospital and surgeon volumes	Mortality, length of stay, pneumonia, pulmonary failure, unplanned extubation, cardiac arrest and CPR, postoperative myocardial infarction, acute renal failure, bloodstream infection
Sovie, 2001 ⁷¹ Article, Retrospective	Examine the association between nurse staffing and patient outcomes	29 university teaching hospitals based on the MECON-PEERx Operations Benchmarking Database Reports, 100%	Hospital, 29 hospitals	Administrative, Adults	Year of submission and type of unit	Patient satisfaction, urinary tract infection, pressure ulcers, falls

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type, Data Collection	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Pronovost, 2001 ⁷² Article, Retrospective	Evaluate the association between nurse-to-patient ratio in the ICU and risk for medical and surgical complications after abdominal aortic surgery	Health Services Cost Review Commission	1994-1996, Patient, 2,615 patients, 0.34%, Sampling bias assessed	Administrative, Adults, >30 years, Abdominal aortic surgery	Number of hospital beds and the volume of aortic surgery performed during the study period by each hospital and each surgeon in the database; patient age (in years), sex, race, and comorbidities	Mortality, length of stay, pulmonary failure, unplanned extubation, cardiac arrest and CPR, medical complications acute renal failure, septicemia, acute myocardial infarction, surgical complications, reoperation for bleeding, bloodstream infection
Blegen, 2001 ⁷³ Article, Retrospective	Describe the relationships between the quality of patient care and the education and experience of the nurses providing that care		1993-1995, Unit, 81 units	Administrative, Adults	Hospital Medicare case mix index	Falls
Aiken, 2002 ⁷⁴ Article, Retrospective	Determine the association between the patient-to-nurse ratio and patient mortality, failure to rescue (deaths following complications) among surgical patients, and factors related to nurse retention	American Hospital Association (AHA) annual survey and 1999 Pennsylvania Department of Health Hospital Survey, 36.2%	1998-1999, Patient, 232,342 patients	Administrative, Adults, >20 years, General surgical, orthopedic, or vascular operation	Patient age, sex, surgery types, comorbidity; hospital size, teaching status, and technology; nurse's sex, years of experience in nursing, education	Mortality, failure to rescue

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type, Data Collection	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Dang, 2002 ⁷⁵ Article, Retrospective	Examine the association between ICU nurse staffing and the likelihood of complications for patients undergoing abdominal aortic surgery	Maryland Health Services Cost Review Commission	1994-1996, Patient, 2,987 patients, 12.76%	Administrative, Adults, 30, Abdominal aortic surgery	Patient age, sex, race, comorbidity, severity of illness, nature of admission, hospital and ICU bed size; hospital and surgeon volume, type of unit, full-time medical director and nurse manager, RN attendance at daily rounds, use of clinical pathways	Pulmonary failure, unplanned extubation, cardiac arrest and CPR, complications: acute myocardial infarction, cardiac complications after a procedure, acute renal failure, platelet transfusion, bloodstream infection
Tourangeau, 2002 ⁷⁶ Article, Retrospective	Examine the association between nursing-related hospital variables and 30-day mortality rates for hospitalized patients	Ontario Hospital Reporting system, 13.3%	1998-1999, Hospital, 46,941 hospitals	Administrative, Adults, >21 years, Acute myocardial infarction, stroke, pneumonia, or septicemia	Patient age, sex, comorbidities, socio-economic status; hospital teaching status, and location	Mortality
Barkell, 2002 ⁷⁷ Article, Retrospective	Examine the effects of a change in the staffing model on length of stay, variable cost, patient satisfaction, incidence of urinary tract infection and pneumonia, and pain management in bowel resection patients	Single hospital study: 508-bed full service community-based teaching hospital	1999-2000, Patient, 96 patients	Medical records, Adults, >18 years, Postoperative bowel procedure	Not reported	Length of stay, patient satisfaction, urinary tract infection, pneumonia

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type, Data Collection	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Stegenga, 2002 ⁷⁸ Article, Retrospective	Examine the relationship between nurse staffing levels and the rate of nosocomial viral gastrointestinal infections (NVGIs) in a general pediatrics population	Single hospital study, general pediatrics ward at The Hospital for Sick Children in Toronto, Ontario, Canada, a 320-bed, tertiary-care pediatric institution	1997-1999, Patient, 2,929 patients	Medical records, Children	Not reported	Nosocomial infection
Alonso-Echanove, 2003 ⁷⁹ Article, Prospective	Examine the association between nurse staffing and bloodstream infections in intensive care units	Part of Detailed ICU Surveillance Component (DISC) Study (prospective, multi center cohort study). 6 hospitals, 8 ICU units	1997-1999, Patient, 8,593 patients	Medical records, Adults, Central venous catheter	Patient age, gender, weight, height, diagnosis, comorbidity	Bloodstream infection
Mark, 2003 ⁸⁰ Article, Prospective	Examine the association between nurse practice and patient outcomes (patient satisfaction, rate of reported medication errors, and falls)	68 randomly selected non-federal, no psychiatric, not-for-profit, accredited acute care hospitals with more than 150 beds in 10 southeastern states, 34%	1995-2000, Patient, 1,326 patients, Random sampling	Survey, Adults	Case mix index, hospital size, technology	Length of stay, patient satisfaction, falls
Unruh, 2003 ⁸¹ Article, Retrospective	Examine the changes in licensed nursing staff in Pennsylvania hospitals from 1991 to 1997, and to assess the relationship of licensed nursing staff with patient adverse events in hospitals	Pennsylvania Department of Health	1991-1997, Hospital, 83,924 patients, Sampling bias assessed	Administrative, Adults	Patient age, gender, race, ethnic status, and level of severity, ownership status, hospital mergers, number of board-certified physicians, and capacity utilization	Urinary tract infection, pneumonia, pressure ulcers, falls, pulmonary failure, nosocomial infection

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type, Data Collection	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Simmonds, 2003 ⁸² Dissertation, Retrospective	Examine the association between nurse staffing and colonization vancomycin-resistant enterococci colonization in chronic dialysis patients	Single hospital study	2000-2002, Patient, 1,084 patients, 26.11%	Medical records, Chronic renal diseases that requires hemodialysis	Nursing workload index, patient age, and acuity	Nosocomial infection
Tallier, 2003 ⁸³ Dissertation, Retrospective	Examine the relationship between nurse staffing and patient outcomes	Single hospital study including 7 nursing units with patients at high risk of acquiring events	2000-2001, Patient, 2,897 patients	Medical records, Adults, >18 years	Not reported	Patient satisfaction, urinary tract infection, pressure ulcers, nosocomial infection
Berney, 2003 ⁸⁴ Dissertation, Retrospective	Examine association between nurse overtime and patient mortality and 6 nurse-sensitive patient outcomes	Hospitals in New York state completed Institutional Cost Reports, 41.2%	1995-2000, Hospital, 10,210,556 patients	Administrative, Adults	Patient age's, race, primary payer, emergency admission, primary diagnosis and comorbidities (DRGs), hospital variables (location, teaching status, unionization, size, margins), clustering patient within hospitals	Mortality, urinary tract infection, gastrointestinal bleeding, pneumonia, shock, failure to rescue, cardiac arrest and CPR, bloodstream infection
Zidek, 2003 ⁸⁵ Dissertation, Retrospective	Examine the association between changes in nurse staffing determined based on a new patient classification system and patient outcomes	Single hospital study: rural acute tertiary care facility	1999-2001, Patient, 5,067 patients	Medical records	Patient age, sex, primary diagnosis, acuity; unit size, organizational leadership	Length of stay, pressure ulcers, falls

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type, Data Collection	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Hope, 2003 ⁸⁶ Dissertation, Retrospective	Examine the relationship between nursing workload and nosocomial infections in acute care hospital	Single hospital study	1998-2000, Patient, 39,481 patients, 37.23%	Administrative	Patient age, gender, and primary diagnosis, severity of illness; ward type, national risk of infection; resource intensity weight	Urinary tract infections, pneumonia, nosocomial infection, surgical wound infection, bloodstream infection
Cimiotti, 2004 ⁸⁷ Dissertation, Prospective	Examined the association between nurse staffing, healthcare-associated infection, and length of stay among infants in the neonatal ICU	Two Level III-IV neonatal ICU units in New York City participated in a clinical trial to test hygiene regimens	2001-2003, Patient, 2,675 patients	Medical records, Children	Patient acuity based on DRG and nursing Intensity weight; use of surgery and invasive medical devices, birth weight, differences in practices in study's sites	Length of stay, nosocomial infection
Person, 2004 ⁸⁸ Article, Retrospective	Assess the association of nurse staffing with in-hospital mortality for patients with acute myocardial infarction	Cooperative Cardiovascular Project (CCP) dataset, 39.2%	1994-1995, Patient, 234,754 patients, 49.33%, Random	Administrative, Adults, >65 years, Acute myocardial infarction, Medicare	Patient age, gender, ethnicity, and severity of illness, hospital volume, rural/urban location, and teaching status	Mortality
Mark, 2004 ⁸⁹ Article, Retrospective	Examine the effects of change in registered nurse staffing on change in quality of care	American Hospital Association	1990-1995, Hospital, 422 patients, Random	Administrative	Patient's age, gender, admission type, admission source, and type of treatment (medical vs. surgical); hospital size, case mix, and the availability of high technology services	Mortality, urinary tract infection, pneumonia, pressure ulcers

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type, Data Collection	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Mark, 2005 ⁹⁰ Article, Retrospective	Examine structural differences in the relationship between nurse staffing and quality of care in different levels of managed care penetration	Longitudinal cohort of the Healthcare Cost and Utilization Project (HCUP) National Inpatient Sample (NIS); a 20% probability sample of U.S. community hospitals from 11 states, 0.122%, 3.26%	1990-1995, Hospital, 422 hospitals, Random sampling, Sampling bias assessed	Administrative	Patient's age, gender, admission type, admission source, and type of treatment (medical vs. surgical), hospital size, case mix, and the availability of high technology services	Mortality, length of stay
Stratton, 2005 ⁹¹ Dissertation, Retrospective	Relationships between pediatric nurse staffing and 5 indicators of quality care (measured as adverse occurrence rates) in 17 medical/surgical, 5 oncology, and 12 intensive care units	Seven, academic, not-for-profit children's hospitals from the National Association of Children's Hospitals and Related Institutions (NACHRI), 100%, 0%, Different % HMO penetration	2002, Unit, 6,011 patients	Administrative, Children, >1year	Patient age, sex, race, socio economic status, unit/hospital type, size, and occupancy, transfers, technological complexity, organizational factors including care model, length of shift, flexible staffing, self-governance, paid continuing nursing education, relationships with physicians	Length of stay, patient satisfaction, nosocomial infection

Table G1. Design, external, and internal validity of the studies that examined the associations between nurse staffing and strategies and patient outcomes (continued)

Author, Year, Publication Type, Data Collection	Aim of the Study	Hospital Eligibility Criteria, Database, % of Teaching Hospitals, % of Hospitals for Profit, % of HMO	Time, Analytic Units, Sample Size, % Excluded from Analysis Sampling, Assessment of Sampling Bias	Patient Eligibility Criteria: Database, Population, Age, Diagnosis, Medical Care	Adjustment for Confounding Factors	Outcomes
Elting, 2005 ⁹² Article, Retrospective	Examine the association between nurse staffing (RN/patient ratio) and patient mortality and complication after cystectomy	Texas Hospital Discharge Public Use Data	1999-2001, Hospital, 1,302 hospitals	Administrative, Adults, Bladder carcinoma (ICD-9 codes 188.0-188.9 and 236.7) after total cystectomy	Age, gender, race, ethnicity, comorbidities, and distance from the closest high-volume hospital	Mortality, bacteremia, wound infections, pulmonary compromise, pneumonia, deep venous thrombosis, pulmonary embolus, reoperation, postoperative coma or shock, acute myocardial infarction, arrhythmia, and cardiac arrest or shock
Seago, 2006 ⁹³ Article, Retrospective	Examine the association between nurse staffing and patient outcomes for 3 adult medical-surgical nursing units in one university teaching hospital across 4 years (16 fiscal quarters)	Single hospital study, 100%	1999-2002, Patient, 1,012 patients	Administrative, Adults	Case-mix	Patient satisfaction, failure to rescue, pressure ulcers, falls

CNS = Central Nervous System; CPR = Cardio-pulmonary Resuscitation; DRG = Diagnosis Related Group; HMO = Health Maintenance Organization; ICU = Intensive Care Unit; MedPAR = Medicare Provider Analysis Review; RN = Registered Nurse

Table G2. Calculated change in hospital-related mortality corresponding to an increase by one patient/RN, LPN/shift (results from individual studies)

Definition of Nurse to Patient Ratio	Source to Measure Ratio	Author	Increase by One Patient/RN/Shift				Increase by One Patient/LPN/Shift			
			Death Rate	p Value	RR	p Value	Death Rate	p Value	RR	p Value
RN/patient day	Survey of RNs	Aiken ⁵			1.83	NS				
Patients/RN/shift	Survey of RNs	Aiken ³⁹	0.11	<0.05	1.06	<0.05				
Patients/RN/shift	Survey of RNs	Aiken ⁷⁴			1.08	<0.05				
Patients/RN/shift	Survey of ICU directors	Amaravadi ⁶⁴	4.7	NS	1.2	NS				
Nurse/patient day	AHA and HCFA data bases	Bond ⁶⁰						NS		
Patients/RN/shift	Survey of ICU directors	Dimick ⁷⁰				NS				
RN, LPN FTE/ number of occupied beds	Hospital Cost Report Information System, Provider of Services files, and the American Hospital Association Survey	Elting ⁹²	0.42	NS	1.18	<0.05	1.12	<0.05		
Patients/RN/shift	Survey of staff nurses; daily staffing plans and unit census records	Halm ⁵¹			0.99	NS				
RN, LPN FTE/1,000 patient days	Area Resource Files, American Hospital Association Annual Survey, CMS Wage Rate File, CMS Online Survey	Mark ⁹⁰			1.001	NS				NS
RN, LPN FTE/1,000 patient days	Area Resource Files, American Hospital Association Annual Survey, CMS Wage Rate File, CMS Online Survey	Mark ⁸⁹			1	NS				NS
RN, LPN FTE/ patient day	CCP and AHA datasets	Person ⁸⁸	1.41	NS	1.1	<0.05		NS		NS
Patients/RN/shift	Survey of ICU directors	Pronovost ⁷²	0.5	NS						
Patients/RN/shift	Survey of ICU directors	Pronovost ⁶¹			1.9	<0.05				
RN FTE/patient day	AHA database	Robertson ⁶²			1.02	<0.05				
Patients/RN/shift	Hospital administrative databases; survey of nursing directors in each unit	Shortell ⁹⁴				NS				
Patients/RN/shift	AHA Annual Surveys for 1991–1993, and the Pennsylvania Health Care Cost Containment Council Data Base for years 1991–1994	Silber ⁶⁷			1.05	<0.05				
RN, LPN FTE/ 1,000 patient days	State Department of Health, AHA database	Unruh ⁶⁶	-1.4	<0.05			0.14	<0.05		

LPN = Licensed Practical Nurse; NS = Not Significant; RN = Registered Nurse; RR = Relative Risk

Table G3. Evidence of the association between nurse staffing and mortality

Author, Source to Measure Mortality, Definition of Mortality	Source to Measure Nurse Staffing, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Mortality
Pronovost, 2001 ⁷² The Uniform Health Discharge Data Set In-hospital mortality from all causes	Survey to the ICU directors, An average ICU nurse-to-patient ratio during the day and evening	Mean age 68 years, 89% whites, 66% males, 11-13% emergency admissions, Units: ICU Patients: surgical	More nurses: RN/patient 1:1 or 1:2 (7 hospitals) Fewer nurses: RN/patient 1:3 or 1:4 (31 hospitals)	Crude rate % ± SD 7 ± 26 8 ± 36
Pronovost, 1999 ⁶¹ The Uniform Hospital Health Discharge Data Set In-hospital mortality	Survey of intensive care unit directors, An average nurse to patient ratio in day and in evening; decreased nurse to patient ratio in evening	Mean age 68 years, 89% whites, 66% males, 11-13% emergency admissions, Units: ICU Patients: surgical	Decreased nurse to patient ratio in evening (7 hospitals) Nurse to patient ratio >1:2 in evening (31 hospitals)	Relative risk (95% CI) 1.9 (1.2; 3) Reference
Amaravadi, 2000 ⁶⁴ The Uniform Health Discharge Data Set In-hospital mortality	Survey of ICU directors, An average nurse-to-patient ratio during the day and at night	32 hospitals Units: ICU Patients: surgical Age % Whites Males 63 77 70 60 83 79 60 83 79 63 77 70	Night time nurse to patient ratio >1:2 Night time nurse to patient ratio <1:2 Night time nurse to patient ratio >1:2 Night time nurse to patient ratio <1:2	Relative Risk (95% CI) 0.7 (0.3;2) Reference Crude rate % 5.6 15
Dimick, 2001 ⁷⁰ The Uniform Health Discharge Data Set In-hospital mortality	Survey of ICU directors, An average nurse-to-patient ratio in the ICU during the day and evening and at night	Units: ICU Patients: surgical Age % Whites Males 56 82 51 57 67 55	More nurses: RN/patient 1:1-1:2 (8 hospitals) Fewer nurses: RN/patient 1:3-1:4 (25 hospitals)	Relative risk (95% CI) Reference 0.49 (0.18;1.29)

Table G3. Evidence of the association between nurse staffing and mortality (continued)

Author, Source to Measure Mortality, Definition of Mortality	Source to Measure Nurse Staffing, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Mortality																																																																											
Blegen, 1998 ⁵⁹ Hospital records Death rates per 1,000 patient days. All deaths, whether expected, unexpected, procedure-related, or do not resuscitate, were included	A record of hours worked for each individual employee was completed by the staffing clerk and approved by the employee and nurse manager before being entered into the computerized payroll database. The hours of care per patient day from all nursing personnel: Hours of direct patient care by RNs, LPNs, and nursing assistants each month divided by the patient days of care on the unit for the month. The hours of direct patient care from RNs divided by patient days excluding hours for non patient care (meetings, vacation, sick leave, and holidays)	Single hospital study, 42 units	Increase by 1% in proportion of RN nurses Proportion of RN >87.5% Increase by 1 hour in total nursing hours Mean nurse staffing Total nursing hours 10.7, RN hours 7.7	Changes in death rate/100 patient days -0.36 ± 1.64 0.14 ± 0.53 0.02 ± 0.07 Death Rate 0.06																																																																											
Aiken, 1999 ⁵ Medical charts of consecutively admitted patients Mortality within 30 days from admission	Survey of all registered and licensed practical nurses who worked at least 16 hours per week The average number of nurses per patient day (self-reported) Nurse autonomy: nurse control over the practice environment across hospital units (Clinical Environment Index)	<table border="0"> <tr> <td>Hospitals</td> <td>Units</td> <td></td> </tr> <tr> <td>20</td> <td>40</td> <td></td> </tr> <tr> <td>5</td> <td>8</td> <td></td> </tr> <tr> <td>5</td> <td>8</td> <td></td> </tr> <tr> <td>5</td> <td>8</td> <td></td> </tr> <tr> <td>20</td> <td>40</td> <td></td> </tr> <tr> <td>Age</td> <td>% Whites</td> <td>Males</td> </tr> <tr> <td>37</td> <td>47</td> <td>88</td> </tr> <tr> <td>39</td> <td>29</td> <td>77</td> </tr> <tr> <td>37</td> <td>45</td> <td>87</td> </tr> </table>	Hospitals	Units		20	40		5	8		5	8		5	8		20	40		Age	% Whites	Males	37	47	88	39	29	77	37	45	87	<table border="0"> <tr> <td>Increase by 1 RN/patient</td> <td></td> <td></td> </tr> <tr> <td>Dedicated AIDS units</td> <td></td> <td></td> </tr> <tr> <td>AIDS hospital-scattered bed units</td> <td></td> <td></td> </tr> <tr> <td>Conventional scattered bed units</td> <td></td> <td></td> </tr> <tr> <td>Nurse control over practice setting</td> <td></td> <td></td> </tr> <tr> <td colspan="3"> </td> </tr> <tr> <td>Increase by 1 RN/patient</td> <td></td> <td></td> </tr> <tr> <td>Dedicated AIDS units</td> <td></td> <td></td> </tr> <tr> <td>AIDS hospital-scattered bed units</td> <td></td> <td></td> </tr> </table>	Increase by 1 RN/patient			Dedicated AIDS units			AIDS hospital-scattered bed units			Conventional scattered bed units			Nurse control over practice setting						Increase by 1 RN/patient			Dedicated AIDS units			AIDS hospital-scattered bed units			<table border="0"> <tr> <td colspan="3">Relative risk (95% CI)</td> </tr> <tr> <td>0.43</td> <td>0.24</td> <td>0.78</td> </tr> <tr> <td>1.06</td> <td>0.59</td> <td>1.9</td> </tr> <tr> <td>0.69</td> <td>0.34</td> <td>1.41</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> </tr> <tr> <td>1.03</td> <td>0.94</td> <td>1.13</td> </tr> </table>	Relative risk (95% CI)			0.43	0.24	0.78	1.06	0.59	1.9	0.69	0.34	1.41	1	1	1	1.03	0.94	1.13
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Table G3. Evidence of the association between nurse staffing and mortality (continued)

Author, Source to Measure Mortality, Definition of Mortality	Source to Measure Nurse Staffing, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Mortality
Aiken, 2003 ³⁹ Discharge abstracts Deaths within 30 days of hospital admission	Surveys of hospital nurses (the Pennsylvania Board of Nursing) The mean number of patients assigned to all staff nurses who reported caring for at least 1 but fewer than 20 patients on the last shift they worked; highest credential in nursing: a hospital school diploma, an associate degree, a bachelor's degree, a master's degree, or another degree; the mean number of years of experience working as an RN for nurses from each hospital	Units: ICU Patients: surgical	Increase by 1 year in nurse experience Increase in workload of 1 patient 10% increase in nurses with BSN degree	Relative risk (95% CI) 1 0.98 1.02 1.06 1.01 1.1 0.95 0.91 0.99
		Hospitals 53	40% of hospital workforce with BSN or higher, 4 patients/nurse	Mortality rate/100 patients 1.8
		34	20% of hospital workforce with BSN or higher, 4 patients/nurse	1.97
		168	60% of hospital workforce with BSN or higher, 6 patients/nurse	1.8
		19	40% of hospital workforce with BSN or higher, 6 patients/nurse	1.98
		26	20% of hospital workforce with BSN or higher, 6 patients/nurse	2.16
		36	60% of hospital workforce with BSN or higher, 4 patients/nurse	1.64
			20-29% of hospital workforce with BSN or higher	2.2
			<20% of hospital workforce with BSN or higher	2.3
			20% of hospital workforce with BSN or higher, 8 patients/nurse	2.38
			>50% of hospital workforce with BSN or higher	1.7
			40-49% of hospital workforce with BSN or higher	1.9
			30-39% of hospital workforce with BSN or higher	1.8
	40% of hospital workforce with BSN or higher	2.17		
	60% of hospital workforce with BSN or higher, 8 patients/day	1.98		

Table G3. Evidence of the association between nurse staffing and mortality (continued)

Author, Source to Measure Mortality, Definition of Mortality	Source to Measure Nurse Staffing, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Mortality
Aiken, 2002 ⁷⁴ Hospital data (Health Care Cost Containment Council) Death within 30 days of hospital admission	Survey of 50% random sample of registered nurses who were on the Pennsylvania Board of Nursing rolls; Burnout: the Emotional Exhaustion scale of the Maslach Burnout Inventory Scale Nurse' job satisfaction: 4-point scale from very dissatisfied to very satisfied	Patients Surgical Hospitals 168 % males 44 Mean age 44 years	Increase by 6 patients/nurse Increase by 1 patient/nurse Increase by 8 patients/nurse Increase by 4 patients/nurse	Relative risk (95% CI) 1.5 1.19 1.97 1.07 1.03 1.12 1.72 1.27 2.48 1.31 1.13 1.57
Person, 2004 ⁸⁸ Medicare database In-hospital mortality and within 30 days of hospital admission	AHA Survey The ratio of full-time equivalent RNs to average daily census (ADC) categorized by their respective quartiles of nurse to ADC ratio; the ratio of full-time equivalent licensed practical nurses (LPNs) to ADC categorized by their respective quartiles of nurse to ADC ratio; ratio of RNs to LPNs	Hospitals 4,401 Age % Whites Males 77 90 50	Skill Mix: % of RN 1 quartile of LPN staffing 1 quartile of LPN staffing 1 quartile of RN staffing 1 quartile of RN staffing 2 quartiles of LPN staffing 2 quartiles of LPN staffing 2 quartiles of RN staffing 2 quartiles of RN staffing 3 quartiles of LPN staffing 3 quartiles of LPN staffing 3 quartiles of RN staffing 3 quartiles of RN staffing 4 quartiles of LPN staffing 4 quartiles of LPN staffing 4 quartiles of RN staffing 4 quartiles of RN staffing 1 quartile of LPN staffing 1 quartile of RN staffing 2 quartiles of LPN staffing 2 quartiles of RN staffing 3 quartiles of LPN staffing 3 quartiles of RN staffing 4 quartiles of LPN staffing 4 quartiles of RN staffing	Mortality Rate 23.9 20 20.1 23.3 17.9 20.9 21.6 18.6 20.1 22.1 17.4 20.5 17.2 18.7 21.5 17.8 Relative Risk (95% CI) 1 1 1 1 1 1 1 0.94 1.07 0.96 0.9 1 1.02 0.96 1.09 0.94 0.88 1 1.07 1 1.15 0.91 0.86 0.97

Table G3. Evidence of the association between nurse staffing and mortality (continued)

Author, Source to Measure Mortality, Definition of Mortality	Source to Measure Nurse Staffing, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Mortality
Berney, 2003 ⁸⁴ The New York Statewide Planning and Research Cooperative System In-hospital mortality	The New York State Institutional Cost Reports RN total hours in inpatient cost units/patient-days in units adjusted for nursing acuity, RN acute hours/ (RN+LPN acute hours); % of total RN hours paid as overtime hours; Union: RN are represented by unions as reported in ICR	Hospitals: 161 Surgical Medical Surgical Medical Medical Medical Surgical Surgical	1% increase in RN overtime work 1 hour increase in RN hours/acute patient day 1% increase in RN hours/total licensed hours 1st (low overtime) quartile 4th (high overtime) quartile 1% increase in RN overtime work 1st (low overtime) quartile 4th (high overtime) quartile	Relative risk (95% CI) 0.99 0.98 1.01 0.98 0.97 0.99 0.97 0.95 0.98 0.99 0.98 1.00 1.00 1.00 1.00 1.00 0.99 1.00 0.99 0.98 1.00 1.00 1.00 1.00
Needleman, 2001 ²⁸ 799 hospitals (11 states, all-patients + Medicare patients) – hospital level analysis; 256 California hospitals (part of the 11 state sample) – unit level analysis; National sample of 3,357 hospitals (Medicare patients) –hospital level analysis; in-hospital mortality	State hospital financial reports or hospital staffing surveys; the American Hospital Association Annual Survey of hospitals (2,080 hours * each FTE category) + (1,040 hours * number of part-time employees). Total nursing hours/patient-day NIW adjusted; RNs, clinical nurse specialists, general duty nurses, nurse practitioner excluding nursing directors, managers, administrators, supervisors, instructors, anesthetists, and midwives. RN hours/patient day NIW adjusted. Licensed hours/patient-day NIW adjusted LPN/LVN, excluding the director of nursing. LPN/LVN hours/patient-day NIW adjusted Nursing aides, orderlies and attendants, excluding	4,156 hospitals	Increase by 1 hour of RN hours in medical patients Increase by 1 hour in RN hours in surgical patients Increase by 1 hour in LPN hours in medical patients Increase by 1 hour in LPN hours in surgical patients Increase by 1 hour in aide hours in medical patients Increase by 1 hour in aide hours in surgical patients Increase by 1 hour in total nursing hours in medical patients Increase by 1 hour in total nursing hours in surgical patients Increase by 1% in RN/total nursing hours in medical patients Increase by 1% in RN/total nursing hours in surgical patients Increase by 1 hour in licensed hours/patient-day in medical patients Increase by 1% of RN hours/total licensed hours per patient day in medical patients Increase by 1 hour in licensed hours/patient-day in surgical patients Increase by 1% in RN hours/total	Relative risk (95% CI) 1.00 0.99 1.01 1.00 0.99 1.01 1.01 0.99 1.03 1.00 0.96 1.04 1.01 1.00 1.02 1.07 1.04 1.09 1.00 1.00 1.01 1.00 0.99 1.01 0.87 0.71 1.05 0.96 0.68 1.35 1.00 0.99 1.01 0.90 0.74 1.09 1.00 0.99 1.01 0.99 0.67 1.47

Table G3. Evidence of the association between nurse staffing and mortality (continued)

Author, Source to Measure Mortality, Definition of Mortality	Source to Measure Nurse Staffing, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Mortality		
	ward clerks. Total aide hours/patient day NIW adjusted RN hours per day/total hours per day; RN hours/licensed hours = RN hours per day/licensed hours per day (RN + LPN)		licensed hours per patient-day in surgical patients	1.00	1.00	1.01
			Increase by 1 hour in RN hours in medical patients	1.00	0.99	1.01
			Increase by 1 hour in LPN hours in medical patients	1.00	1.00	1.00
			Increase by 1 hour in licensed hours in medical patients	0.98	0.89	1.08
			Increase by 1% in RN hours/total licensed hours in medical patients	1.00	1.00	1.01
			Increase in total nurse hours in medical patients	0.84	0.71	1.01
			Increase by 1% in RN hours/total nurse hours in medical patients	1.01	1.00	1.02
			Increase by 1 hour in aide hours in medical patients	0.98	0.95	1.00
			Increase by 1 hour in RN hours in surgical patients	1.01	1.00	1.02
			Increase by 1 hour in LPN in surgical patients	1.00	0.99	1.00
			Increase by 1 hour in licensed hours in surgical patients	0.88	0.75	1.03
			Increase by 1% in RN hours/licensed hours in surgical patients	1.00	0.98	1.03
			Increase by 1 hour in aide hours in surgical patients	1.00	0.99	1.01
			Increase by 1 hour in total nursing hours	1.02	0.70	1.48
			Increase by 1% in RN hours/total nursing hours	0.98	0.97	0.99
			Increase by 1 hour in RN hours in medical patients, hospital level analysis, California hospitals	0.98	0.94	1.02
			Increase by 1 hour in LPN hours in medical patients, hospital level analysis, California hospitals	1.02	1.00	1.04
			Increase by 1 hour in aide hours in medical patients, hospital level analysis, California hospitals	0.87	0.81	0.94
			Increase by 1 hour in total nursing			

Table G3. Evidence of the association between nurse staffing and mortality (continued)

Author, Source to Measure Mortality, Definition of Mortality	Source to Measure Nurse Staffing, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Mortality		
			hours in medical patients, hospital level analysis, California hospitals	0.59	0.45	0.78
			Increase by 1% in RN hours/total nursing hours in medical patients, hospital level analysis, California hospitals	0.98	0.97	1.00
			Increase by 1 hour of licensed nursing hours in medical patients, hospital level analysis, California hospitals	0.91	0.65	1.27
			Increase by 1% of RN hours/total licensed hours in medical patients, hospital level analysis, California hospitals	0.98	0.96	1.00
			Increase by 1 hour of RN hours in medical patients, unit level analysis, California hospitals	0.98	0.94	1.02
			Increase by 1 hour in LPN hours in medical patients, unit level analysis, California hospitals	1.28	1.06	1.54
			Increase by 1 hour in aide hours/patient day in medical patients, unit level analysis, California hospitals	0.81	0.72	0.90
			Increase by 1 hour in total nursing hours in medical patients, unit level analysis, California hospitals.	0.60	0.46	0.78
			Increase by 1% in RN hours/total nursing hours in medical patients, unit level analysis, California hospitals	0.98	0.96	1.00
			Increase by 1 hour of total licensed hours in medical patients, unit level analysis, California hospitals	0.89	0.68	1.16
			Increase by 1% of RN hours/licensed hours in medical patients, unit level analysis, California hospitals	1.02	1.00	1.04
			Increase by 1 hour of RN hours in surgical patients, hospital level analysis, California hospitals	1.07	0.97	1.17
			Increase by 1 hour in LPN hours in			

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Table G3. Evidence of the association between nurse staffing and mortality (continued)

Author, Source to Measure Mortality, Definition of Mortality	Source to Measure Nurse Staffing, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Mortality		
			surgical patients, hospital level analysis, California hospitals	1.01	0.96	1.06
			Increase by 1 hour in aide hours in surgical patients, hospital level analysis, California hospitals	1.02	1.00	1.04
			Increase by 1 hour in total nursing hours in surgical patients, hospital level analysis, California hospitals	1.29	0.74	2.26
			Increase by 1% in RN hours/total nursing hours in surgical patients, hospital level analysis, California hospitals	1.03	1.00	1.05
			Increase by 1 hour in licensed hours in surgical patients, hospital level analysis, California hospitals	0.76	0.34	1.69
			Increase by 1% in RN hours/licensed hours in surgical patients, hospital level analysis, California hospitals	1.04	1.01	1.07
			Increase by 1 hour of RN hours in surgical patients, unit level analysis, California hospitals	1.06	0.96	1.16
			Increase by 1 hour in LPN hours in surgical patients, unit level analysis, California hospitals	0.98	0.92	1.03
			Increase by 1 hour in aide hours in surgical patients, unit level analysis, California hospitals	1.02	1.00	1.05
			Increase by 1 hour in total nursing hours in surgical patients, unit level analysis, California hospitals	1.69	1.02	2.81
			Increase by 1% in RN hours/total nursing hours in surgical patients, unit level analysis, California hospitals	1.04	1.01	1.07
			Increase by 1 hour in licensed hours in surgical patients, unit level analysis, California hospitals	0.86	0.46	1.61
			Increase by 1% in RN hours/ licensed hours in surgical patients, unit level analysis, California hospitals			

Table G3. Evidence of the association between nurse staffing and mortality (continued)

Author, Source to Measure Mortality, Definition of Mortality	Source to Measure Nurse Staffing, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Mortality
Seago, 2002 ³⁴ The California Office of Statewide Health Planning and Development (OSHPD) Hospital Disclosure Report database; the California Vital Statistics data set from the California Department of Human Services (DHS), mortality within 30 days of hospital admission	The California Office of Statewide Health Planning and Development (OSHPD) Hospital Disclosure Report database; the National Labor Relations Board, number of RN hours/acute myocardial infarction (AMI) related discharge; the presence of a bargaining unit for registered nurses	Hospitals 106 238 343 343 343 343	Union hospitals Not union hospitals Union vs. not union 5 RN hour/AMI discharge 1 RN hour/AMI discharge 8 RN hour/AMI discharge	Mortality Rate ± SD 14.4 ± 3 15.2 ± 3.5 Relative risk 0.43 0.89 0.97 0.834
Estabrooks, 2005 ⁵⁰ Hospital Inpatient Database; Alberta Health Care Insurance Plan Registry (AHCIPR) was linked to identify persons who died within 30 days of admission Mortality within 30 days of hospital admission	Survey of RN (Alberta Association of Registered Nurses registry) working in acute care hospitals Self-reported % of RNs to total nursing staff, Self reported highest RN credential: Diploma; Baccalaureate; Masters; Otherwise; % of BSN in hospital level derived from the question regarding the highest degree; Nurse job satisfaction: responses for the question: "On the whole, how satisfied are you with your job?" 1. Very dissatisfied 2. A little dissatisfied 3. Moderately satisfied 4. Very satisfied) Nurse autonomy: freedom to make important patient care and work decisions	49 hospitals	Hospitals with lower proportion of temporary nurses Hospitals with higher proportion of nurses with BSN Hospitals with lower proportion of nurses with BSN Hospitals with higher proportion of temporary nurses Hospitals with lower proportion of RN Hospitals with lower proportion of RN Hospitals with higher proportion of RN Hospitals with lower proportion of temporary nurses Hospitals with higher proportion of temporary nurses Hospitals with higher proportion of RN Hospitals with lower proportion of nurses with BSN Hospitals with higher proportion of nurses with BSN	Relative risk (95% CI) 1 1 1 0.81 0.68 0.96 1 1 1 1.47 1.21 1.79 1 1 1 1 1 1 0.76 0.66 0.87 1 1 1 1.26 1.09 1.47 0.83 0.73 0.96 1 1 1 0.65 0.6 0.71

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Table G3. Evidence of the association between nurse staffing and mortality (continued)

Author, Source to Measure Mortality, Definition of Mortality	Source to Measure Nurse Staffing, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Mortality
Cho, 2003 ³⁸ Hospital Financial Data, in hospital mortality	The State Inpatient Databases, the total productive hours worked by all nursing personnel per patient day, the total productive hours by registered nurses per patient day	Mean age 68 years % Whites 79.3 Males 48.9%	Large non-profit teaching hospitals, 76.5% RN Medium, non-profit, non-teaching, non-rural, 68.1% RN Large, non-profit, non-teaching, non- rural 72.4% RN Medium, investor-owned non-teaching non-rural hospitals, 72.7% RN	Death Rate ± SD
		Hospitals 12		5.13 ± 2.73
		79		4.4 ± 2.18
		48		4.22 ± 1.5
		48		4.45 ± 2.31
Elting, 2005 ⁹² The Texas Hospital Discharge Public Use Data File linked to the 2000 U.S. Census, In-hospital mortality	Hospital Cost Report Information System, Provider of Services files, and the American Hospital Association Survey, number of LPN/mean annual number of occupied bed days, number of RN/mean annual number of occupied bed days	Patients Surgical	Hospitals with few LPNs/occupied bed (median 0.7)	Death rate 2.3
		58	Hospitals with many LPNs/occupied bed (median 3.1)	3.1
		75	Hospitals with many RNs/occupied bed (median 3.1)	0.7
		75	Hospitals with few RNs/occupied bed (median 1.4)	1.9
		58	Hospitals with many RNs/occupied bed (median 3.1)	1.9
		75	Hospitals with few RNs/occupied bed (median 1.4)	4.5
		58	Hospitals with few RNs/occupied bed (median 1.4)	4.41
		75	Hospitals with many RNs/occupied bed (median 3.1)	1.6 0.43 0.19 0.97

Table G3. Evidence of the association between nurse staffing and mortality (continued)

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Author, Source to Measure Mortality, Definition of Mortality	Source to Measure Nurse Staffing, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Mortality
Tourangeau, 2002 ⁷⁶ Discharge abstract database linked to the Ontario Registered Persons Database, mortality within 30 days of hospital admission	The Ontario Registered Nurse Survey of Hospital Characteristics and Ontario Hospital Reporting System Total nursing staff worked hours per Ontario case weight RN inpatient hours/other nursing staff earned hours (RN + LPN + aide); number of years employed in the current clinical unit	75 hospitals	Increase by 1 year in nursing experience in teaching hospitals Increase by 10% proportion of RN/total nursing personnel Increase by 1 year in nursing experience in non-urban hospitals Increase by 1 year in experience 30 days mortality in teaching hospitals (85% RN) 30 days mortality in non-urban community hospitals (71% RN) 30 days mortality in urban community hospitals (79% RN)	Relative risk 0.99 0.95 1.00 0.99 14.02 15.27 15.05
Mark, 2005 ⁹⁰ Centers for Medicare and Medicaid Services Minimum Cost and Capital File, CMS Provider of Services File, CMS Case Mix Index File, CMS Online Survey; Certification and Reporting system (OSCAR) files, and HCUP files In-hospital mortality	The Area Resource Files, American Hospital Association Annual Survey, CMS Wage Rate File, CMS Online Survey Certification and Reporting system (OSCAR) files RN FTEs/1,000 in-patient days RN hours/patient * day = (FTE RN/1,000 patient * days * 37.5 * 48)/1,000; 37.5 hour work week on average 48 working weeks/year LPN FTEs/1,000 in-patient days LPN hours/patient * day = (FTE LPN /1,000 patient * days * 37.5 * 48)/1,000; 37.5 hour work week on average 48 working weeks/year	Hospitals 353 362 362 360 422	Lowest quartile of HMO penetration Second quartile of HMO penetration Third quartile of HMO penetration Highest quartile of HMO penetration Increase by 1 RN FTE/1,000 patient days in hospitals with high HMO penetration Increase by 1 LPN FTE/1,000 patient days in hospitals with high HMO penetration Increase by 1 RN FTE/1,000 patient days in hospitals with low HMO penetration Increase by 1 LPN FTE/1,000 patient days in hospitals with low HMO penetration 25th Quartile of RN FTE/1,000 patient days with high HMO penetration 50th Quartile of RN FTE/1,000 patient days with high HMO penetration 75th Quartile of RN FTE/1,000 patient days with high HMO penetration 25th Quartile of RN FTE/1,000 patient days with low HMO penetration 50th Quartile of RN FTE/1,000 patient	Relative risk (95% CI) 0.99 0.97 1.02 1.03 1.00 1.05 0.99 0.96 1.01 1.01 0.99 1.04 0.91 0.86 0.95 1.02 0.90 1.16 1.01 0.86 1.18 0.82 0.55 1.23 0.97 0.96 0.99 0.99 0.97 1.00 1.00 0.99 1.02 0.97 0.93 1.01 0.97 0.93 1.01

Table G3. Evidence of the association between nurse staffing and mortality (continued)

Author, Source to Measure Mortality, Definition of Mortality	Source to Measure Nurse Staffing, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Mortality
			days with high HMO penetration 75th Quartile of RN FTE/1,000 patient days with low HMO penetration Reference 1 patient/FTE nurse	0.97 0.91 1.03 1.00 1.00 1.00
Robertson, 1999 ⁶² HCFA database and Hospitals Information Reports, mortality within 30 days of hospital admission	The American Hospital Association database, hospital average of RN FTE/100 adjusted submissions, hospital average of LPN FTE/100 adjusted submissions, hospital average of aide FTE/100 adjusted submissions	Hospitals 1,791 2,133 1,791 1,784 2,133 2,133 2,133 2,133 2,133	Increase by 1 aide in aide/patient ratio in 1989 Increase by 1 aide in aide/patient ratio in 1991 Increase by 1 LPN in LPN/patient ratio in 1990 Increase by 1 LPN in LPN/patient ratio in 1989 Increase by 1 RN in RN/patient ratio in 1990 Increase by 1 RN in RN/patient ratio in 1989 Increase by 1 RN in RN/patient ratio in 1991 Increase by 1 UAP aide/patient ratio in 1990 Increase by 1 LPN in LPN/patient ratio in 1991	Relative risk 0.98 1.02 0.92 0.92 0.99 0.99 0.98 1.04 1.01

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Table G3. Evidence of the association between nurse staffing and mortality (continued)

Author, Source to Measure Mortality, Definition of Mortality	Source to Measure Nurse Staffing, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Mortality
Needleman, 2003 ⁴³ Hospital discharge data In-hospital mortality	The American Hospital Association's Annual Survey of Hospitals, Total licensed hours (RN + LPN) / adjusted patient day; RN hours / adjusted patient day calculated from FTE in hospital (2,080 hours, 52 weeks at 40 hours/ week) LPN hours / adjusted patient day calculated from FTE in hospital (2,080 hours, 52 weeks at 40/week). UPA hours/adjusted patient day calculated from FTE in hospital (2,080 hours, 52 weeks at 40/week). the proportion of hours of care by RN/licensed nurses (RN + LPN)	799 hospitals Units Medical Surgical Medical Surgical Surgical Medical	1% increase in RN hours/total licensed hours (RN + LPN) Increase in 1 hour of RN in surgical patients Increase in 1 hour of RN in medical patients 1% increase in proportion of RN/total nursing personnel Surgical patients in 799 hospitals (68% RN) Medical patients in 799 hospitals (68% RN)	Relative risk (95% CI) 0.9 0.74 1.09 1 0.99 1.01 1 0.99 1.01 0.99 0.67 1.47 Death rate 1.6 3.2
Hartz, 1989 ¹¹ Hospital discharges data from The Health Care Financing Administration (HCFA) Mortality within 30 days of hospital admission	The American Hospital Association's 1986 annual survey of hospitals Proportion of RN/total nursing personnel in hospital	3,100 hospitals	Hospitals with high proportion of RNs (upper quartile, 61%) Hospitals with high proportion of RNs (upper quartile, 61%) Hospitals with lower proportion of RNs (lower quartile, 59%) Hospitals with lower proportion of RNs (lower quartile, 59%) Hospitals with 59% of RNs Hospitals with 61% of RNs	Death rate 11.31 adjusted for severity 11.1 crude 11.94 adjusted for severity 12.16 crude 11.75 fully adjusted 11.5 fully adjusted

Table G3. Evidence of the association between nurse staffing and mortality (continued)

Author, Source to Measure Mortality, Definition of Mortality	Source to Measure Nurse Staffing, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Mortality
Krakauer, 1992 ¹² Medical records for all Medicare discharges, a random sample of 700 discharges were abstracted from the stratum that included hospitals with 700 or more discharges Mortality within 30 days of hospital admission	1986 American Hospital Association (AHA) survey, the proportion of registered nurses/total nursing personnel	84 hospitals Age 72.3 years, Whites 84%, Males 46%	Lower quartile of % of RN, claims model Upper quartile of % RN, claims model Lower quartile of % RN, clinical model Upper quartile of % RN, clinical model	Death rate 15.7 12.1 14.9 12.8
Aiken, 1994 ⁷ HCFA database Mortality within 30 days of hospital admission	1988 AHA annual survey of hospitals % of RN/total nursing personnel	79 hospitals	Control hospitals, 70.8 % RN Control hospitals, 67.1% RN Magnet hospitals, 76% RN Control hospitals, 69.2% RN Control hospitals, 69% RN Control hospitals, 68.2% RN	Death rate 0.111 0.116 0.105 0.117 0.109 0.117
Shortell, 1988 ⁵⁴ MedPAR dataset of hospital discharges In-hospital mortality	Database of the larger study of 8 multi-hospital systems Proportion of RN/total hospital employee	981 hospitals	Increase by 1% in RN/total hospital staff	Relative risk (95% CI) 0.73 (0.48;1.1)
Mark, 2004 ⁸⁹ The Healthcare Cost and Utilization Project (HCUP) National Inpatient Sample (NIS) In-hospital mortality	American Hospital Association Annual Survey, Online Survey Certification and Reporting System [OSCAR] RN FTEs/1000 inpatient days RN hours/patient * day = (FTE RN/1,000 patient*days * 37.5 * 48)/1000 LPN FTEs/1,000 inpatient days LPN hours/patient * day = (FTE LPN/1000 patient * days * 37.5 * 48)/1,000	Hospitals 357 361 361 366 373 357 357 357 357 422 422 422	RN hours/patient day Year 1993 6.05 Year 1994 6.30 Year 1992 5.76 Year 1992 5.65 Year 1990 5.44 75th quartile of RN FTE/1,000 patient days, 7.24 RN hours/patient day 50th quartile of RN FTE/1,000 patient days, 6.01 RN hours/patient day 25th quartile of RN FTE/1,000 patient days, 4.79 RN hours/patient day Year 1995 6.48 RN hours Increase by 1 RN FTE/patient day Increase by 1 LPN FTE/patient day Reference 1 RN and LPN FTE/patient day	Relative Risk (95% CI) 1.05 1.02 1.08 0.97 0.94 1.00 1.09 1.06 1.12 1.15 1.12 1.18 1.20 1.17 1.23 0.96 0.95 0.98 0.97 0.96 0.98 0.98 0.96 0.99 0.90 0.87 0.93 0.92 0.87 0.96 1.01 0.97 1.06 1.00 1.00 1.00

Table G3. Evidence of the association between nurse staffing and mortality (continued)

Author, Source to Measure Mortality, Definition of Mortality	Source to Measure Nurse Staffing, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions		Nurse Staffing Categories	Mortality
Silber, 2000 ⁶⁷ Pennsylvania Medicare claims records; the Medicare Standard Analytic Files; random sample of 50% of Medicare patients who underwent general surgical or orthopedic procedures Mortality within 30 days of hospital admission	The American Hospital Association Annual Surveys for 1991–1993, and the Pennsylvania Health Care Cost Containment Council Data Base for years 1991–1994 RN/bed ratio at hospital level	Hospitals 245	Units Surgical	Hospitals with lower RN/bed ratio Hospitals with higher RN/bed ratio	Relative risk (95% CI) 1 1 1 0.95 0.93 0.96
		258	Surgical	Indirect patients, RN/patient ratio 1.38 Directed patients, RN/patient ratio 1.4	Death rate 4.53 3.41
Hoover, 2000 ²³ The Health Care Financing Agency, HealthCareReportCards. com; MEDPAR database Mortality index = [(P -A) / P] * 100 where P = predicted mortality for each hospital according to patients characteristics, and A = actual mortality; In hospital mortality, and 6 months after submission mortality	The AHA and HCFA databases RN/LPN ratio = total number RN FTE/LPN FTE reported by the hospital and RN/total nursing staff	Hospitals 176	Units Medical	Lowest quartile of RN proportion Highest quartile of RN proportion	Relative risk 1 1 1 0.84 0.78 0.92
Aiken, 2001 ²⁷ MedPar Mortality Data file for 1997 In hospital mortality	American Hospital Association Annual survey RN FTE/daily average units census	22 hospitals		Nurse staffing – RN FTE/average daily census in units	Correlation with mortality -0.49

Table G3. Evidence of the association between nurse staffing and mortality (continued)

Author, Source to Measure Mortality, Definition of Mortality	Source to Measure Nurse Staffing, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Mortality
Bond, 1999 ⁶⁰ Hospital Medicare mortality rates from the Health Care Financing Administration In hospital mortality/1,000 admissions and number of deaths/hospital/year	Data from the AHA and HCFA data bases were matched for 3,763 hospitals FTE RN/the mean number of occupied beds for each hospital FTE LPN/the mean number of occupied beds for each hospital	3,763 hospitals	Increase by 1 RN/patient Increase by 1 LPN/patient	Change in Death rate ± SD -0.0003 ± 0.0061 0.0005 ± 0.0092
Shortell, 1994 ⁹⁴ Hospitals discharge data In hospital mortality, standardized mortality ratio (actual mortality in each unit/predicted mortality)	Hospital administrative databases; survey of nursing directors in each unit An average RN/patient ratio in unit during the study period, number of nurses who left ICU in the year of the study/number of nurses employed that year	40 hospitals, 42 ICU units; Patients Medical	Increase by 1 RN/patient ratio	Relative risk 1.14
Boyle, 2004 ⁴⁷ Patient discharges In-hospital mortality	Nurses NWI-R survey (N=390) of nurses working >1 month in the unit NWI-R 57 items questionnaire to report nurse autonomy and collaboration; NWI-R 57 items questionnaire to report nurse manager support	Single hospitals study, 21 units	Nurse manager support	Correlation with mortality -0.3
Halm, 2005 ⁵¹ The hospital's data warehouse with patients discharges Mortality within 30 days of hospital admission	Survey of 140 staff nurses (42% response rate); daily variable staffing plans and unit census records Average RN/patient ratio was calculated for each nursing unit across all 3 shifts for every week; % of RN with BSN and	Single hospital study, age 55.6 years, 37.4% Males 22.7% emergency admission Patients Surgical	Increase by 1 unit in RN/patient ratio	Relative risk 1.01

Table G3. Evidence of the association between nurse staffing and mortality (continued)

Author, Source to Measure Mortality, Definition of Mortality	Source to Measure Nurse Staffing, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Mortality
	higher; years of total nursing experience; Burnout: Maslach Burnout Inventory Manual (max 6 scores) with 3 subscales of burnout: emotional exhaustion; depersonalization; personal accomplishment (feelings of competence and successful achievement in one's work). Overall rating on a simple 4-point Likert scale, ranging from 1 (very dissatisfied) to 4 (very satisfied) and the likelihood to leave current position within the next 12 months			
Thorson, 1995 ⁵⁵ Administrative data on patient discharges from the North Carolina Medical Database Commission In-hospital mortality	The archives of the NC Board of Nursing for 100 hospitals, an average of total nursing hours/patient day in surgical and medical units, an average RN hours/patient day in surgical and medical units	100 hospitals	Increase by 1 RN hour, crude odds of death Increase by 1 RN hour, adjusted for patient characteristics odds ratio Increase by 1 RN hour, adjusted for patient and hospital characteristics odds ratio	Relative risk (95% CI) 1.004 1.003 1.004 1.009 1.008 1.010 1.008 1.007 1.010
Unruh, 2000 ⁶⁶ State Health Care Cost Containment Council In-hospital mortality	State Department of Health, American Hospital Association Total nurses FTE/1,000 APDC RN FTE/1,000 APDC LPN FTE/1,000 APDC UAP FTE/1,000 APDC % of RN FTE /total nurses FTE	1,477 hospitals, Whites: 45.4% Males: 42.43%	Year RN/patient ratio % RN 1991 2.9 69 1992 2.7 69 1993 2.7 70 1994 2.7 71 1995 2.6 72 1996 2.8 71 1997 2.7 72 Increase by 1 unit in RN/patient ratio Increase by 1 unit in RN/patient ratio in small hospitals	Death rate 3.10 2.85 2.81 2.67 2.60 2.47 2.33 Change in death rate 0.02 0.32

Table G3. Evidence of the association between nurse staffing and mortality (continued)

Author, Source to Measure Mortality, Definition of Mortality	Source to Measure Nurse Staffing, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Mortality
			Increase by 1 unit in RN/patient ratio in medium hospitals	-0.13
			Increase by 1 unit in RN/patient ratio in large hospitals	-0.03
			Increase by 1 unit in LPN/patient ratio	-0.09
			Increase by 1 unit in LPN/patient ratio in small hospitals	-0.21
			Increase by 1 unit in LPN/patient ratio in medium hospitals	-0.31
			Increase by 1 unit in LPN/patient ratio in large hospitals	-0.19
			Increase by 1 unit in UAP/patient ratio	0.04
			Increase by 1 unit in UAP/patient ratio in small hospitals	0.38
			Increase by 1 unit in UAP/patient ratio in medium hospitals	-0.07
			Increase by 1 unit in UAP/patient ratio in large hospitals	0.005
			Increase by 1% in RN proportion	0.00
			Increase by 1% in RN proportion in small hospitals	-0.00
			Increase by 1% in RN proportion in medium hospitals	0.00
			Increase by 1% in RN proportion in large hospitals	0.00

AHA = American Hospital Association; AMI = Acute Myocardial Infarction; BSN = Bachelor or Science in Nursing; CI = Confidence Interval; CMS = Centers for Medicare and Medicaid Services; FTE = Full Time Equivalent; HMO = Health Maintenance Organization; ICU = Intensive Care Unit; LPN = Licensed Practical Nurse; LVN = Licensed Vocational Nurse; MedPAR = Medicare Provider Analysis Review; NIW = nursing intensity weights; RN = Registered Nurse; SD = Standard Deviation; UAP = Unlicensed Assistive Personnel

Table G4. The relative risk of hospital related mortality among estimated categories of patients/nurse/shift ratio

Author (Patients/RN/Shift)	RR	95% CI
Pronovost ⁶¹ (2 vs. 3)	0.53	0.33; 0.83
Amaravadi ⁶⁴ (1.5 vs. 3)	0.70	0.30; 2.00
Dimick ⁷⁰ (1.5 vs. 3.5)	2.04	0.78; 5.56
Aiken ⁵ (1.5 vs. 5)	0.19	0.06; 0.61
Aiken ⁵ (1.9 vs. 5)	0.08	0.01; 0.47
Aiken ⁵ (2 vs. 3)	0.94	0.91; 0.99
Aiken ³⁹ (1 vs. 6)	0.67	0.51; 0.84
Aiken ³⁹ (1 vs. 4)	0.76	0.64; 0.89
Person ⁸⁸ (1.1 vs. 2.8)	0.91	0.86; 0.97
Person ⁸⁸ (1.6 vs. 2.8)	0.94	0.88; 1.00
Person ⁸⁸ (1.9 vs. 2.8)	0.96	0.90; 1.00
Elting ⁹² (4.3 vs. 9.5)	0.43	0.19; 0.97
Mark ⁹⁰ (4.2 vs. 13.3)	0.99	0.97; 1.02
Mark ⁹⁰ (4.1 vs. 13.3)	1.03	1.00; 1.05
Mark ⁹⁰ (3.8 vs. 13.3)	0.99	0.97; 1.01
Mark ⁹⁰ (3.6 vs. 13.3)	1.01	0.99; 1.04
Mark ⁹⁰ (6.7 vs. 13.3)	0.82	0.74; 0.91
Mark ⁹⁰ (6.7 vs. 13.3)	1.01	0.74; 1.39
Mark ⁹⁰ (5 vs. 13.3)	0.97	0.96; 0.99
Mark ⁹⁰ (4 vs. 13.3)	0.99	0.98; 1.00
Mark ⁹⁰ (3.3 vs. 13.3)	1.00	0.99; 1.02
Mark ⁹⁰ (5 vs. 13.3)	0.97	0.93; 1.01
Mark ⁹⁰ (4 vs. 13.3)	0.97	0.93; 1.01
Mark ⁹⁰ (3.3 vs. 13.3)	0.97	0.91; 1.03
Mark ⁸⁹ (4 vs. 13.3)	1.05	1.02; 1.08
Mark ⁸⁹ (3.8 vs. 13.3)	0.97	0.94; 1.00
Mark ⁸⁹ (4.2 vs. 13.3)	1.09	1.06; 1.12
Mark ⁸⁹ (4.2 vs. 13.3)	1.15	1.12; 1.18
Mark ⁸⁹ (4.4 vs. 13.3)	1.20	1.17; 1.23
Mark ⁸⁹ (3.3 vs. 13.3)	0.96	0.95; 0.98
Mark ⁸⁹ (4 vs. 13.3)	0.97	0.96; 0.98
Mark ⁸⁹ (5 vs. 13.3)	0.98	0.97; 0.99
Mark ⁸⁹ (3.7 vs. 13.3)	0.90	0.87; 0.93
Mark ⁸⁹ (6.7 vs. 13.3)	0.84	0.76; 0.93
Silber ⁶⁷ (1.6 vs. 2.7)	0.95	0.93; 0.96
Shortell ⁵⁴ (1.5 vs. 3)	1.13	0.86; 1.13
Robertson ⁶² (1.5 vs. 3)	0.97	NR
Robertson ⁶² (1.5 vs. 3)	0.98	NR
Robertson ⁶² (1.5 vs. 3)	0.96	NR
Halm ⁵¹ (0.8 vs. 4)	1.02	NR
Author (Patients/LPN/Shift)		
Person ⁸⁸ (8 vs. 11)	1.07	1.00; 1.15
Person ⁸⁸ (10 vs. 11)	1.00	0.94; 1.07
Mark ⁹⁰ (18 vs. 13)	0.99	0.97; 1.02
Mark ⁹⁰ (21 vs. 13)	1.03	1.00; 1.05
Mark ⁹⁰ (24 vs. 13)	0.99	0.96; 1.01
Mark ⁹⁰ (25 vs. 13)	1.01	0.99; 1.04
Mark ⁹⁰ (7 vs. 13)	1.05	0.82; 1.34
Mark ⁹⁰ (7 vs. 13)	0.68	0.30; 1.52
Robertson ⁶² (3 vs. 20)	0.92	NR
Mark ⁸⁹ (21 vs. 13)	1.05	1.02; 1.08
Mark ⁸⁹ (23 vs. 13)	0.97	0.94; 1.00
Mark ⁸⁹ (20 vs. 13)	1.09	1.06; 1.12
Mark ⁸⁹ (19 vs. 13)	1.15	1.12; 1.18
Mark ⁸⁹ (20 vs. 13)	1.20	1.17; 1.23
Mark ⁸⁹ (23 vs. 13)	0.90	0.87; 0.93
Mark ⁸⁹ (7 vs. 13)	1.01	0.97; 1.06

NR– not reported

Table G5. Evidence of the association between nurse/patient ratio and patient outcomes

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse/Patient Ratios	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
<p>Aiken³⁹ Discharge abstracts, Failure to rescue: deaths within 30 days of admission among patients who experienced complications; Complications: the secondary diagnosis distinguished from preexisting comorbidities Surveys of hospital nurses (the Pennsylvania Board of Nursing) The mean number of patients assigned to all staff nurses who reported caring for at least 1 but fewer than 20 patients on the last shift they worked</p>	<p>168 ICU Surgical Age 60.8 61.3 Sex 42.9 41.8 Severity 28.5 18.9</p>	<p>60% of hospital workforce with BSN or higher, 8 patients/day 40% of hospital workforce with BSN or higher, 4 patients/nurse 20% of hospital workforce with BSN or higher, 4 patients/nurse 60% of hospital workforce with BSN or higher, 6 patients/nurse 40% of hospital workforce with BSN or higher, 6 patients/nurse 20% of hospital workforce with BSN or higher, 6 patients/nurse 60% of hospital workforce with BSN or higher, 4 patients/nurse 20-29% of hospital workforce with BSN or higher <20% of hospital workforce with BSN or higher 20% of hospital workforce with BSN or higher, 8 patients/nurse >50% of hospital workforce with BSN or higher 40-49% of hospital workforce with BSN or higher 30-39% of hospital workforce with BSN or higher 40% of hospital workforce with BSN or higher</p> <p>Increase in workload of 1 patient Reference 1 RN/patient</p> <p>20-29% of hospital workforce with BSN or higher <20% of hospital workforce with BSN or higher >50% of hospital workforce with BSN or higher 40-49% of hospital workforce with BSN or higher 30-39% of hospital workforce with BSN or higher</p>	<p>Failure to rescue % 8.47 7.84 8.54 7.80 8.50 9.26 7.18 9.40 10.20 10.02 6.90 8.60 8.00 9.22 Relative Risk 1.05 1.01 1.10 1 Complications, % 22.90 22.90 25.20 22.00 22.80</p>

Table G5. Evidence of the association between nurse/patient ratio and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse/Patient Ratios	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
<p>Aiken⁴ Hospital data (Health Care Cost Containment Council); Failure to rescue: deaths within 30 days of admission among patients who experienced complications; Survey of 50% random sample of registered nurses who were on the Pennsylvania Board of Nursing rolls; The mean patient load across all staff registered nurses who reported having responsibility for at least 1 but fewer than 20 patients on the last shift they worked, regardless of the specialty or shift (day, evening, night) worked</p>	<p>168 Combined Surgical Age 59.3 Sex 43.7 Severity 27.3</p>	<p>Increase by 6 patients/nurse Increase by 1 patient/nurse Increase by 8 patients/nurse Increase by 4 patients/nurse Reference 1 RN/patient</p>	<p>Failure to rescue, Relative risk 1.50 1.13 1.87 1.07 1.02 1.11 1.72 1.17 2.30 1.31 1.08 1.52 1.00 1.00 1.00</p>
<p>Alonso-Echanove⁹ All adult patients admitted to the ICU for at least 48 hours; Bloodstream infections as secondary diagnosis after CVC. Duration of CVC- number of days from the placement date to the day when bloodstream infection occurred or to the day of CVC removal; Unit administrative records; Number of RN nurses for each patient each day; Number of patient care assistants/100 patients</p>	<p>ICU Medical Race 61 Sex 54</p>	<p>All ICU from 1997-1999 RN/patient ratio: 0.5 Patient/UAP: 14.3 Increase by 1 RN and UAP/patient</p>	<p>Bloodstream infections, rate % 2.80 Relative risk Not significant</p>

Table G5. Evidence of the association between nurse/patient ratio and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse/Patient Ratios	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
Amaravadi ⁶⁴ The Uniform Health Discharge Data Set; Postoperative pneumonia; aspiration, pulmonary failure; reintubation after unplanned extubation; cardiac arrest; Complications: respiratory, Pneumonia, reintubation, aspiration, infectious, septicemia, postoperative infection, myocardial infarction, cardiac arrest, surgical complications, acute renal failure, septicemia; Survey of ICU directors; An average nurse-to-patient ratio of greater than or equal to 1:2 versus less than 1:2 both during the day and at night	ICU Surgical Age 63 Race 77 Sex 70 Severity 12	Night time nurse to patient ratio <1:2 Night time nurse to patient ratio >1:2 Night time nurse to patient ratio <1:2 Night time nurse to patient ratio >1:2 Night time nurse to patient ratio <1:2 Night time nurse to patient ratio >1:2 Night time nurse to patient ratio <1:2 Night time nurse to patient ratio >1:2 Night time nurse to patient ratio <1:2 Night time nurse to patient ratio >1:2 Night time nurse to patient ratio <1:2 Night time nurse to patient ratio >1:2 Night time nurse to patient ratio <1:2 Night time nurse to patient ratio >1:2 Night time nurse to patient ratio <1:2 Night time nurse to patient ratio >1:2 Night time nurse to patient ratio <1:2 Night time nurse to patient ratio >1:2	Pneumonia % 16.00 8.00 Relative risk 2.40 1.20 4.70 1.00 1.00 1.00 Pulmonary failure % 25.00 22.00 Relative risk 1.20 0.70 2.00 1.00 1.00 1.00 Reintubation % 25.00 12.00 Relative risk 2.50 1.40 4.50 1.00 1.00 1.00 CPR % 0.80 0.00 Relative risk 1.20 0.60 2.20 1.00 1.00 1.00 Medical complications % 0.80 0.90 Relative risk 0.90 0.08 9.70 1.00 1.00 1.00 Surgical complications % 17.00 8.00 Relative risk 1.90 0.90 3.80 2.10 0.70 6.40

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Table G5. Evidence of the association between nurse/patient ratio and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse/Patient Ratios	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
		Night time nurse to patient ratio <1:2 Night time nurse to patient ratio >1:2 Night time nurse to patient ratio <1:2 Night time nurse to patient ratio >1:2	Sepsis, % 6.20 1.80 Relative risk 3.70 1.10 12.50 1.00 1.00 1.00
Bolton ²⁶ California Nursing Outcomes Coalition database; the California Department of Health Services; 1,253,892 inpatient days; Hospital acquired pressure ulcers: the monthly rate per 1,000 patient days for each nursing unit and each hospital. Falls: unplanned descent to the floor in adult patients; the monthly fall rate per 1,000 patient days for each nursing unit and each hospital. Data were collected at the patient level and aggregated by CalNOC staff to the unit level. California Nursing Outcomes Coalition database; the California Department of Health Services RN/patient day	Unit Patients Medical Medical ICU Medical	Medical-surgical units: 5 patients/RN, 2.4 patient/UAP Critical Care units: 1.6 patients/RN Medical-surgical units: 5 patients/RN, 2.4 patient/UAP Critical Care units: 1.6 patients/RN	Falls /100 patient days 3.70 0.10 Pressure ulcers/100 patient days 8.00 13.00

Table G5. Evidence of the association between nurse/patient ratio and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse/Patient Ratios	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes		
<p>Cheung³² Incidence reports, quality referrals, and medical record coding stores in the database Excalibur system Pressure ulcers coded as secondary diagnosis; patients falls coded as secondary diagnosis; primary bloodstream infections after admitting the unit; Automated Nurse staffing Office system and direct observation of nursing activities with Hill_Rom COMposer@nurse locator system; Number of patients assigned to RN during a shift; number of patients assigned to LPN during the shift; ratio of RN and LPN to unlicensed nursing personnel</p>	<table border="0"> <tr> <td>Unit Patients</td> <td>Combined Medical</td> </tr> </table>	Unit Patients	Combined Medical	<p>Increase by one increment in nurse staffing variables: RN/patient ratio LPN/patient ratio</p> <p>Increase by one increment in nurse staffing variables: RN/patient ratio LPN/patient ratio</p> <p>Increase by one increment in nurse staffing variables: RN/patient ratio LNPatient ratio</p>	<p>Pressure ulcers Relative risk NS NS Falls, Relative risk NS NS Primary bloodstream infection Relative risk NS NS</p>
Unit Patients	Combined Medical				

Table G5. Evidence of the association between nurse/patient ratio and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse/Patient Ratios	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions		Nurse Staffing Categories		Patient Outcomes		
Dang ⁷⁵ The Uniform Health Discharge Data Set Aspiration, atelectasis or pulmonary failure; pneumonia; pulmonary insufficiency after a procedure; tracheal reintubation; cardiac arrest; Cardiac complications: acute myocardial infarction Cardiac complications after a procedure Other: acute renal failure, platelet transfusion Any other complication Any complication; septicemia; Survey of ICU directors; An average nurse-to-patient ratio in the ICU during the daytime; low-intensity staffing (1:3 or greater on the day and night shifts); medium intensity (1:3 or greater on either the day or night shift, but not both); high-intensity staffing <1:2	Unit Patients Race Sex Severity	ICU Surgical 89 68 13	High Intensity Mixed Intensity Low Intensity	4 patients/RN 3 patients/RN 2 patients/RN	Relative risk Pulmonary failure	2.33 1.50 3.60 5.11 2.89 9.04 1.00 1.00 1.00	
Dimick ⁷⁰ The Uniform Health Discharge Data Set Postoperative pneumonia, pulmonary failure, aspiration, reintubation, cardiac arrest, myocardial infarction, acute renal failure; septicemia; Survey of ICU directors; An average nurse-to-patient	Unit: Patients: Group Age Race Severity	ICU Surgical 316 56 82 15	More nurses: RN/patient 1:1-1:2 Fewer nurses: RN/patient 1:3-1:4 More nurses: RN/patient 1:1-1:2 Fewer nurses: RN/patient 1:3-1:4 More nurses: RN/patient 1:1-1:2 Fewer nurses: RN/patient 1:3-1:4	4 patients/RN 3 patients/RN 2 patients/RN 4 patients/RN 3 patients/RN 2 patients/RN 4 patients/RN 2 patients/RN	Pneumonia, % 2.80 4.20	Relative risk 1.00 1.00 1.00 1.40 0.60 3.50 Pulmonary Failure % 1.60 5.80 Relative risk	

Table G5. Evidence of the association between nurse/patient ratio and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse/Patient Ratios	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
ratio in the ICU during the day and evening and at night; "more ICU nurses: nurse/patient ratio 1:1 or 1:2; "fewer ICU nurses": nurse/patient ratio 1:3 or 1:4		<p>More nurses: RN/patient 1:1-1:2 Fewer nurses: RN/patient 1:3-1:4</p>	<p>1.00 1.00 1.00 3.60 1.30 10.10 Extubation % 1.90 10.80 Relative risk 5.70 2.40 13.70</p> <p>CPR % 0.60 0.80 Complications % 6.60 1.20 Sepsis % 2.70 5.40</p>
Donaldson ⁹ CalNOC database Total number of patients with Stage I-IV pressure ulcers regardless of whether ulcer was acquired during hospitalization or present on admission; %/total number of surveyed patients, unplanned descent to the floor; rate/1,000 patient days. CalNOC database in 2004 and 2005 (after legislation); number of patients/RN	Hospitals 68 Unit Combined Patients Medical	<p>Medical surgical units, before mandatory ratios: 5.43 patients/RN Medical and surgical units after mandatory ratios: 4.48 patients/RN Step-down units before mandatory ratios: 4.02 patients/RN Step-down units after mandatory ratios: 3.56 patients/RN</p> <p>Medical surgical units, before mandatory ratios: 5.43 patients/RN Medical and surgical units after mandatory ratios: 4.48 patients/RN Step-down units before mandatory ratios: 4.02 patients/RN Step-down units after mandatory ratios: 3.56 patients/RN</p>	<p>Falls /100 patient days ± SD 0.31 ± 0.20 0.32 ± 0.17 0.30 ± 0.22 0.26 ± 0.16 Pressure ulcers/100 patient days ± SD 14.07 ± 11.07 14.48 ± 10.39 13.52 ± 10.78 16.29 ± 10.27</p>

Table G5. Evidence of the association between nurse/patient ratio and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse/Patient Ratios	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes														
Donaldson ⁹⁵ California Nursing Outcomes Coalition (CalNOC) Hospital acquired pressure related skin injury controlling for date of admission, % of all patients on the day of prevalence study; patient's unplanned descent to the hospital floor; were analyzed as 7 day aggregate per unit; also actually number per unit; the number of falls/1000 patient days. The California Nursing Outcomes Coalition (CalNOC)	Hospitals 25 Unit Combined Patient Medical	Increase by 1 patient/RN Increase by 1 patient/licensed staff	Change in falls rate/100 patient days ± SD 0.02 ± 0.05 0.02 ± 0.09														
Elting ⁹² The Texas Hospital Discharge Public Use Data File linked to the 2000 U.S. Census Bacteremia, wound infection, pulmonary compromise, pneumonia, deep venous thrombosis, pulmonary embolus, reoperation, postoperative coma or shock, acute myocardial infarction, arrhythmia, and cardiac arrest or shock. Hospital Cost Report Information System, Provider of Services files, and the American Hospital Association Survey; number of LPN/mean annual number	Hospitals 75 Unit Surgical Patients Surgical	<table border="0"> <tr> <td>Hospitals with many RNs/occupied bed</td> <td>3.1 RNs/patient</td> </tr> <tr> <td>Hospitals with few RNs/occupied bed</td> <td>1.4 RNs/patient</td> </tr> <tr> <td colspan="2"> </td> </tr> <tr> <td>Hospitals with many RNs/occupied bed</td> <td>3.1 RNs/patient</td> </tr> <tr> <td>Hospitals with few RNs/occupied bed</td> <td>1.4 RNs/patient</td> </tr> <tr> <td>Hospitals with many LPNs/occupied bed</td> <td>0.32 patients/LPN</td> </tr> <tr> <td>Hospitals with few LPNs/occupied bed</td> <td>1.40 patients/LPN</td> </tr> </table>	Hospitals with many RNs/occupied bed	3.1 RNs/patient	Hospitals with few RNs/occupied bed	1.4 RNs/patient			Hospitals with many RNs/occupied bed	3.1 RNs/patient	Hospitals with few RNs/occupied bed	1.4 RNs/patient	Hospitals with many LPNs/occupied bed	0.32 patients/LPN	Hospitals with few LPNs/occupied bed	1.40 patients/LPN	Failure to rescue Relative risk 1.00 1.00 1.00 0.39 0.10 0.80 Complication rate % 12.60 16.20 14.20 14.00
Hospitals with many RNs/occupied bed	3.1 RNs/patient																
Hospitals with few RNs/occupied bed	1.4 RNs/patient																
Hospitals with many RNs/occupied bed	3.1 RNs/patient																
Hospitals with few RNs/occupied bed	1.4 RNs/patient																
Hospitals with many LPNs/occupied bed	0.32 patients/LPN																
Hospitals with few LPNs/occupied bed	1.40 patients/LPN																

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Table G5. Evidence of the association between nurse/patient ratio and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse/Patient Ratios	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
of occupied bed days, number of RN/mean annual number of occupied bed days			
Flood ⁵³ Patient medical records; nosocomial infections including urinary tract infections and gangrene; congestive heart failure and arrhythmias, gastrointestinal bleeding. Staffing workload index; RN FTE/patient/shift/unit	Hospitals 1 Unit Combined Patients Medical	Understaffed unit 3.8 patient/s RN Normally staffed unit 4.94 patients/RN Understaffed unit 3.8 patients/RN Normally staffed unit 4.94 patients/RN Understaffed unit 3.8 patients/RN Normally staffed unit 4.94 patients/RN	Urinary tract infection % 0.12 0.14 Nosocomial infection % 0.16 0.19 Complication % 64.00 71.00
Fridkin ¹ Medical records of surgical patient in ICU. Cases were defined as any patient hospitalized >48 hours, in the SICU >24 hours who developed a laboratory confirmed CVC-BSI during outbreak periods. Controls were randomly selected from all SICU patients; laboratory confirmed catheter-associated bloodstream infections or clinical sepsis; rates were compared in pre- and outbreak periods. Hospital administrative records; average monthly SICU patient-to-nurse ratio; ratio in pre- and outbreak periods	Hospitals 1 Unit ICU Patients Surgical	Month's patient/nurse ratio = 1.2 Month's patient/nurse ratio = 1.5 Month's patient/nurse ratio = 2 Month's patient/nurse ratio = 1 Pre-outbreak period Outbreak period Pre-outbreak period Outbreak period	Nosocomial infection Relative risk 3.95 1.07 14.54 15.60 1.15 211.40 61.50 1.23 3,074 1.00 1.00 1.00 Rate/100 patient days 1.95 4.96 Sepsis, rate/100 patient days 0.53 1.31

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Table G5. Evidence of the association between nurse/patient ratio and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse/Patient Ratios	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
<p>Halm⁵¹ The hospital's data warehouse with patient's discharges; failure to rescue: death following complications within 30 days. Survey of 140 staff nurses (42% response rate); daily variable staffing plans and unit census records Average RN/patient ratio was calculated for each nursing unit across all 3 shifts for every week</p>	<p>Hospitals 1 Unit Surgical Patients Surgical</p>	<p>Increase by 1 unit in RN/patient ratio</p>	<p>Failure to rescue Relative risk NS</p>
<p>Hope⁵⁶ Medical Microbiology Laboratory and Infection Control Services; Discharge Abstract Database incidence rate of urinary tract infection, incidence rate of ventilator associated pneumonia, incidence rate of infections that occurred after 72 hours of hospitalization, incidence rate of surgical site infections, incidence rate of positive culture with known pathogen or two or more positive cultures with pathogens one can be considered as contaminant. The Grace Reynolds Application of the Study of Peto; Nursing Workload Office Calculated from RN utilization</p>	<p>Unit Patients Surgical Surgical Surgical Surgical Surgical Surgical Surgical Surgical Medical Medical Specialty Medical ICU Medical Surgical Medical Neonatal Medical</p>	<p>Patients/RN</p> <p>Surgery ward 1 5.64 Surgery ward 2 6.97 Surgery ward 3 5.16 Surgery ward 4 6.64 Medicine ward 1 6.79 Medicine ward 2 4.07 Medicine ward 3 6.11 Medicine ward 4 6.09 medicine ward 4 6.19 Medicine ward 5 6 Medicine ward 6 5.39 Medicine ward 7 5.54 Coronary Care Unit 4.62 ICU unit 2.45 Neonatal ICU 2.14 Neurosurgical critical care unit 6.79 Pediatrics unit 4.39</p> <p>Surgery ward 1 5.64 Surgery ward 2 6.97</p>	<p>Rate/100 patient days Urinary tract infection,</p> <p>0.65 0.88 0.91 0.66 0.00 0.65 0.50 0.64 1.27 0.68 0.72 0.74 0.42 1.13 4.03 1.33 0.27 Relative risk NS Nosocomial infection 0.01 0.06</p>

Table G5. Evidence of the association between nurse/patient ratio and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse/Patient Ratios	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories		Patient Outcomes				
as (national US standard * Utilization) / 100		Surgery ward 3	5.16	0.02				
		Surgery ward 4	6.64	0.03				
		Medicine ward 1	6.79	0.03				
		Medicine ward 2	4.07	0.02				
		Medicine ward 3	6.11	0.01				
		Medicine ward 4	6.09	0.01				
		Medicine ward 4	6.19	0.001				
		Medicine ward 5	6	0.001				
		Medicine ward 6	5.39	0.01				
		Medicine ward 7	5.54	0.04				
		Coronary Care Unit	4.62	0.001				
		ICU unit	2.45	0.20				
		Neonatal ICU	2.14	0.01				
		Neurosurgical critical care unit	6.79	0.01				
		Pediatrics unit	4.39	0.001				
						Relative Risk NS		
						Sepsis, %		
		Surgery ward 1	5.64	7.54				
		Surgery ward 2	6.97	11.80				
		Surgery ward 3	5.16	0.33				
		Surgery ward 4	6.64	4.59				
		Medicine ward 1	6.79	0.00				
		Medicine ward 2	4.07	7.21				
		Medicine ward 3	6.11	2.95				
		Medicine ward 4	6.09	1.31				
		medicine ward 4	6.19	7.87				
		Medicine ward 5	6	8.20				
		Medicine ward 6	5.39	6.56				
		Medicine ward 7	5.54	1.97				
		Coronary Care Unit	4.62	23.28				
		ICU unit	2.45	9.51				
		Neonatal ICU	2.14	4.59				
Neurosurgical critical care unit	6.79	2.30						
Pediatrics unit	4.39	UTI relative risk						
				1.14	1.02	1.26		
Higher RN Utilization (111%)				5.34				

Table G5. Evidence of the association between nurse/patient ratio and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse/Patient Ratios	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
		1% increase in RN utilization 5.94 Higher RN Utilization (111%), 5.34 Higher RN utilization (>89%) 7.14 1% increase in RN utilization 5.94 Higher RN Utilization (111%) 5.34 1% increase in RN utilization 5.94 1% increase in RN utilization, surgery wards 5.94 Higher RN Utilization (111%), surgery wards 5.34 1% increase in RN utilization, surgery wards 5.94 Higher RN utilization (>114%) in surgical units 5.16	Pneumonia relative risk 0.97 0.94 1.01 0.66 0.43 1.01 1.59 2.43 1.04 Nosocomial infection relative risk 0.97 0.96 0.99 0.62 0.31 1.23 1.01 0.99 1.03 Sepsis relative risk 0.98 0.97 0.98 0.66 0.50 0.87 0.99 0.98 1.00 0.53 0.34 0.83
Houser ⁴⁹ Nationwide Inpatient Sample of 2001 with hospital discharge records; Failure to rescue: death/1,000 patients who developed complications of care during hospitalization; cases of decubitus ulcer/1,000 discharges identified as secondary diagnosis, cases of acute respiratory failure/1,000 surgical discharges, cases of deep vein thrombosis or PE/1,000 surgical discharges. American Hospital Association Annual Survey for 2001; Hospital reported RN FTE/average daily census	Hospitals 170 Unit Combined Patients Medical Age 55.08 Race 51 Sex 42	RN/patient ratio 0.15-1.29 RN/patient ratio 1.3-1.89 RN/patient ratio 1.9-2.49 RN/patient ratio 2.5-6.5 RN/patient ratio 3.5-4.41 RN/patient ratio 4.57-5.5 RN/patient ratio 5.67-7.67 Increase by 1 unit in nurse staffing levels Reference (RN/patient=1) RN/patient ratio 0.15-1.29 RN/patient ratio 1.3-1.89 RN/patient ratio 1.9-2.49 RN/patient ratio 2.5-6.5 RN/patient ratio 3.5-4.41 RN/patient ratio 4.57-5.5 RN/patient ratio 5.67-7.67 RN/patient ratio 0.15-1.29 RN/patient ratio 1.3-1.89 RN/patient ratio 1.9-2.49	Failure to rescue % ± SD 11.61 ± 8.41 13.82 ± 5.80 12.40 ± 9.11 10.51 ± 6.82 9.01 ± 6.26 9.42 ± 10.16 5.43 ± 8.89 Relative risk 0.92 0.88 0.96 1.00 Decubitus ulcers % ± SD 2.21 ± 1.78 2.57 ± 1.62 2.14 ± 1.45 1.90 ± 1.70 1.70 ± 1.39 1.44 ± 1.48 2.24 ± 4.21 Pulmonary failure % ± SD 0.26 ± 0.65 0.33 ± 0.37 0.32 ± 0.37

Table G5. Evidence of the association between nurse/patient ratio and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse/Patient Ratios	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
		RN/patient ratio 2.5-6.5 RN/patient ratio 3.5-4.41 RN/patient ratio 4.57-5.5 RN/patient ratio 5.67-7.67 Increase by 1 unit in nurse staffing levels Reference (RN/patient = 1) RN/patient ratio 0.15-1.29 RN/patient ratio 1.3-1.89 RN/patient ratio 1.9-2.49 RN/patient ratio 2.5-6.5 RN/patient ratio 3.5-4.41 RN/patient ratio 4.57-5.5 RN/patient ratio 5.67-7.67 Increase by 1 unit in nurse staffing levels Reference (RN/patient = 1)	0.19 ± 0.42 0.15 ± 0.36 0.34 ± 0.79 0.00 Relative risk 0.94 0.77 1.15 1.00 1.00 1.00 Thrombosis % ± SD 0.52 ± 0.71 0.75 ± 0.63 0.68 ± 0.65 0.44 ± 0.78 0.38 ± 1.06 0.52 ± 1.28 0.06 ± 0.13 0.84 0.75 0.93 1.00 1.00 1.00
Kovner ³⁵ The National Inpatient Sample (NIS) Post operative discharges with UTI, pneumonia, pulmonary congestion, lung edema, or respiratory failure, and DVT in any secondary diagnosis. American Hospital Association Annual Survey of Hospitals, the part of the Health Care Utilization Project	Hospitals 5,708 Unit Surgical Patient Surgical	Increase by 1 patient/LPN Increase by 1 patient/LPN Increase by 1 patient/LPN Increase by 1 patient/LPN	Urinary tract infection relative risk 1.01 Pneumonia, relative risk 0.99 Pulmonary failure, relative risk 1 Thrombosis, relative risk 0.96

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Table G5. Evidence of the association between nurse/patient ratio and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse/Patient Ratios	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes																																													
Marcin ³ ICU Evaluation Database (controls), incidence reports (cases) Extubation where the endotracheal tube was displaced or removed from the trachea by either the patient (self-extubation) or unplanned by medical personnel (e.g., when positioning a patient for a radiograph or procedure). Archived nursing assignments, self-reported years in ICU; nurse-to-patient ratio at the time of the unplanned extubation or matching time for the control patients. Standard ratio 1:1 or 1:2	Hospitals 1 Size 220 Unit ICU Patients Combined Age 3 years	1:2 nurse/patient ratio 1:1 nurse/patient ratio	Extubation relative risk 4.24 1.00 19.10 1.00 1.00 1.00																																													
Mark ⁸⁹ The Healthcare Cost and Utilization Project (HCUP) National Inpatient Sample (NIS) Risk-adjusted observed/expected urinary tract infections, risk-adjusted observed/expected pneumonias, risk-adjusted observed/expected decubitus ulcers American Hospital Association Annual Survey, Online Survey Certification and Reporting System	Hospitals 357 Unit Combined Patients Combined	<table border="0"> <tr> <td></td> <td>RN/patient</td> <td>Patients/LPN</td> </tr> <tr> <td>Year 1993</td> <td>3.36</td> <td>1.56</td> </tr> <tr> <td>Year 1994</td> <td>3.5</td> <td>1.69</td> </tr> <tr> <td>Year 1992</td> <td>3.2</td> <td>1.52</td> </tr> <tr> <td>Year 1992</td> <td>3.14</td> <td>1.45</td> </tr> <tr> <td>Year 1990</td> <td>3.02</td> <td>1.47</td> </tr> <tr> <td>75th quartile of RN FTE/1,000 patient-days</td> <td>4.02</td> <td></td> </tr> <tr> <td>50th quartile of RN FTE/1,000 patient-days</td> <td>3.34</td> <td></td> </tr> <tr> <td>25th quartile of RN FTE/1,000 patient-days</td> <td>2.66</td> <td></td> </tr> <tr> <td>Year 1995</td> <td>3.6</td> <td>1.69</td> </tr> <tr> <td>Increase by 1 RN FTE/patient day</td> <td>2</td> <td></td> </tr> <tr> <td>Reference 1 RN FTE/patient day</td> <td>1</td> <td></td> </tr> <tr> <td>Year 1993</td> <td>3.36</td> <td>1.56</td> </tr> <tr> <td>Year 1994</td> <td>3.5</td> <td>1.69</td> </tr> <tr> <td>Year 1992</td> <td>3.2</td> <td>1.52</td> </tr> </table>		RN/patient	Patients/LPN	Year 1993	3.36	1.56	Year 1994	3.5	1.69	Year 1992	3.2	1.52	Year 1992	3.14	1.45	Year 1990	3.02	1.47	75th quartile of RN FTE/1,000 patient-days	4.02		50th quartile of RN FTE/1,000 patient-days	3.34		25th quartile of RN FTE/1,000 patient-days	2.66		Year 1995	3.6	1.69	Increase by 1 RN FTE/patient day	2		Reference 1 RN FTE/patient day	1		Year 1993	3.36	1.56	Year 1994	3.5	1.69	Year 1992	3.2	1.52	Urinary tract infection relative risk 1.14 1.08 1.20 1.11 1.05 1.17 1.17 1.11 1.23 1.17 .12 1.22 1.18 1.13 1.23 0.93 0.90 0.95 0.94 0.91 0.96 0.95 0.92 0.97 0.98 0.93 1.03 1.05 .92 1.21 1.00 Pneumonia relative risk 0.84 0.79 0.89 0.90 0.85 0.95 0.72 0.67 0.77
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Table G5. Evidence of the association between nurse/patient ratio and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse/Patient Ratios	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories		Patient Outcomes		
[OSCAR] RN FTEs/1,000 inpatient days		Year 1992 Year 1990 75th quartile of RN FTE/1,000patient-days 50th quartile of RN FTE/1,000patient-days 25th quartile of RN FTE/1,000patient-days Year 1995 Increase by 1 RN FTE/patient day Reference 1 RN FTE/patient day Year 1993 Year 1994 Year 1992 Year 1992 Year 1990 75th quartile of RN FTE/1,000patient-days 50th quartile of RN FTE/1,000patient-days 25th quartile of RN FTE/1,000patient-days Year 1995 Increase by 1 RN FTE/patient day Reference 1 RN FTE/patient day	3.14 3.02 4.02 3.34 2.66 3.6 2 1 3.36 3.5 3.2 3.14 3.02 4.02 3.34 2.66 3.6 2 1	1.45 1.47 1.69 1.56 1.69 1.52 1.45 1.47 1.69 1	0.65 0.60 0.70 0.61 0.56 0.66 0.98 0.95 1.01 0.96 0.93 0.99 0.94 0.91 0.97 0.97 0.91 1.03 1.03 0.92 1.16 Reference 1 Decubitus ulcers relative risk 0.62 0.57 0.67 0.69 0.63 0.75 0.58 0.53 0.63 0.51 0.46 0.56 0.48 0.44 0.52 0.96 0.93 0.99 0.96 0.93 0.98 0.95 0.92 0.98 0.74 0.69 0.79 1.10 0.99 1.22 1.00 1.00 1.00	
Potter ⁴⁰ Medical records (number of falls on a unit/number of patient days * 1,000 Administrative hospital data Proportion of UAP hours of direct patient care	Hospitals 1 Size 32 Unit ICU Patients Medical	Means in time period 2-4/2000 Means in time period 5-7/2000 Means in time period 8-10/2000 Means in time period 11-1/2001	Patients/UAP 1.1501 1.1078 1.134 1.1532	Falls/100 patient days 0.30 0.29 0.30 0.23		
Pronovost ⁷² The Uniform Health Discharge Data Set Acute lung edema, pulmonary insufficiency after surgery, respiratory failure not otherwise specified, reinsertion of endotracheal tube, cardio respiratory arrest Medical complications: acute	Unit ICU Patients Surgical Age 68 Race 89 Sex 66 Severity 11 Hospitals 7 31 7	Fewer nurses More nurses Fewer nurses More nurses Fewer nurses More nurses Fewer nurses More nurses	RNs/patient 1:3 or 1:4 RNs/patient 1:1 or 1:2 RNs/patient 1:3 or 1:4 RNs/patient 1:1 or 1:2 RNs/patient 1:3 or 1:4 RNs/patient 1:1 or 1:2 RNs/patient 1:3 or 1:4 RNs/patient 1:1 or 1:2	Pulmonary failure % 24.00 9.00 24.00 9.00 Pulmonary failure relative risk 2.60 2.10 3.20 1.00 1.00 1.00 4.50 2.90 6.90 1.00 1.00 1.00		

Table G5. Evidence of the association between nurse/patient ratio and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse/Patient Ratios	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
renal failure, septicemia, acute myocardial infarction, cardiac arrest Surgical complications: surgical complications after a procedure, surgical E codes, reoperation for bleeding, bloodstream infection, hemorrhage or hematoma complicating surgery. Survey to the ICU directors; An average ICU nurse-to-patient ratio during the day and evening	31	Fewer nurses RNs/patient 1:3 or 1:4 More nurses RNs/patient 1:1 or 1:2 Fewer nurses RNs/patient 1:3 or 1:4 More nurses RNs/patient 1:1 or 1:2 Fewer nurses RNs/patient 1:3 or 1:4 More nurses RNs/patient 1:1 or 1:2 Fewer nurses RNs/patient 1:3 or 1:4 More nurses RNs/patient 1:1 or 1:2 Fewer nurses RNs/patient 1:3 or 1:4 More nurses RN/patient 1:1 or 1:2 Fewer nurses RNs/patient 1:3 or 1:4 More nurses RNs/patient 1:1 or 1:2 Fewer nurses RNs/patient 1:3 or 1:4 More nurses RNs/patient 1:1 or 1:2 Fewer nurses RNs/patient 1:3 or 1:4 More nurses RNs/patient 1:1 or 1:2 Fewer nurses RNs/patient 1:3 or 1:4 More nurses RNs/patient 1:1 or 1:2 Fewer nurses RNs/patient 1:3 or 1:4 More nurses RNs/patient 1:1 or 1:2	Extubation % 21 13 21 13 Extubation relative risk 1.50 1.30 1.80 1.00 1.00 1.00 1.60 1.10 2.50 1.00 1.00 1.00 CPR % 2 1 2 1 CPR relative risk 1.40 0.60 3.00 1.00 1.00 1.00 1.70 0.70 4.70 1.00 1.00 1.00 Surgical complications % 47 34 47 34 Relative risk 1.40 1.20 1.50 1.00 1.00 1.00 1.70 1.30 2.40 1.00 1.00 1.00

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Table G5. Evidence of the association between nurse/patient ratio and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse/Patient Ratios	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
		Fewer nurses RNs/patient 1:3 or 1:4 More nurses RNs/patient 1:1 or 1:2 Fewer nurses RNs/patient 1:3 or 1:4 More nurses RNs/patient 1:1 or 1:2	Medical complications % 43 28 43 28 Relative risk 1.50 1.40 1.70 1.00 1.00 1.00 2.10 1.50 2.90 1.00 1.00 1.00
		Fewer nurses RNs/patient 1:3 or 1:4 More nurses RNs/patient 1:1 or 1:2 Fewer nurses RNs/patient 1:3 or 1:4 More nurses RNs/patient 1:1 or 1:2	Sepsis % 4 3 4 3 Relative risk 1.40 0.80 2.10 1.00 1.00 1.00 1.90 0.90 3.90 1.00 1.00 1.00
		Fewer nurses RNs/patient 1:3 or 1:4 More nurses RNs/patient 1:1 or 1:2 Fewer nurses RNs/patient 1:3 or 1:4 More nurses RNs/patient 1:1 or 1:2	Bleeding % 2 3 2 3 Relative risk 0.80 0.40 1.60 1.00 1.00 1.00 1.20 0.40 3.50 1.00 1.00 1.00

Table G5. Evidence of the association between nurse/patient ratio and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse/Patient Ratios	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
<p>Silber⁶⁷ Pennsylvania Medicare claims records; the Medicare Standard Analytic Files; random sample of 50% of Medicare patients who underwent general surgical or orthopedic procedures; Failure to rescue: 30-day death rate after complications, in-hospital complication rate: Cardiac event, CHF, Shock, DVT and PE, Stroke, TIA, Coma, Nosocomial infections, pneumonia, pulmonary failure, pressure ulcers, wound infections, sepsis, and bleeding. The American Hospital Association Annual Surveys for 1991–1993, and the Pennsylvania Health Care Cost Containment Council Data Base for years 1991–1994; RN/bed ratio at hospital level</p>	<p>Hospitals 245 Size 217,440 Unit Surgical Patients Surgical</p>	<p>Hospitals with lower RN/bed ratio 1.1 Hospitals with higher RN/bed ratio 1.87</p> <p>Indirect patients 1.38 RNs/patient Directed patients 1.4 RNs/patient</p> <p>Hospitals with lower RN/bed ratio 1.1 Hospitals with higher RN/bed ratio 1.87</p> <p>Indirect patients 1.38 RNs/patient Directed patients 1.4 RNs/patient</p>	<p>Failure to rescue relative risk 1.00 1.00 1.00 0.94 0.92 0.96 % 9.32 8.18 Complications relative risk 1.00 1.00 1.00 1.04 1.03 1.04 % 47.87 41.15</p>

Table G5. Evidence of the association between nurse/patient ratio and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse/Patient Ratios	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories			Patient Outcomes
Simmonds ⁸² Active microbiological surveillance of all chronic patients admitted for >30 days of hemodialysis; volunteering patient participation in other units, % of patients with positive colonization of vancomycin-resistant enterococci 48 hours after admission to the hospital and after surgery; Administrative reports of Patient Care Manager and Nursing Workload Specialist; Integrated Nursing System database, FTE RNs/number of beds	Hospitals 1 Unit Spec Patients Medical Age 68.75 Sex 55.8	Patient/RN Means at the beginning of the study 1.64 Means after 1 year 1.62 Means after 2 year 1.60 Means after 3 year 1.58 RN/patient ratio at the beginning of the study 1.64 RN/patient ratio after 1 year 1.62 RN/patient ratio after 2 years 1.60 RN/patient ratio after 3 years 1.58			Nosocomial infection, % 1.61 3.29 4.97 6.65 1.92 1.75 1.58 1.41
Stegenga ⁸⁵ Patients and laboratory records Nosocomial viral gastrointestinal infections (NVGIs) (CDC definition). Rate = number of NVGIs/1,000 patient days. Administrative hospital records Number of nurses/patient in each shift according to actual work schedule. Ratio was calculated 72 hours before and after infection event	Hospitals 1 Unit ICU Patients Medical	RN/patient ratio Pre infection night shifts 3.16 Post infection night shifts 3.26			Nosocomial infection /100 patient days 1.3 0
Unruh ⁸⁶ State Health Care Cost Containment Council Secondary diagnosis of	Hospitals 1,477 Unit Combined Patients Combined Race 45.37	RN/patient Patients/LPN Patients/ UAP State data in 1991 2.9 1.5 1.6 State data in 1992 2.7 1.7 1.7 State data in 1993 2.7 1.8 1.8			UTI %, Decubitus ulcer % 5.18 0.55 4.48 0.49 4.44 0.53

Table G5. Evidence of the association between nurse/patient ratio and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse/Patient Ratios	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories				Patient Outcomes			
nosocomial UTI, hospital acquired pneumonia, decubitus ulcer, adult atelectasis, and cardiac arrest	Sex 42.43	State data in 1994	2.7	2.0	1.8	4.91	0.69		
		State data in 1995	2.6	2.0	1.8	4.80	0.67		
		State data in 1996	2.8	2.1	1.8	5.14	0.73		
		State data in 1997	2.7	2.4	1.7	4.70	0.73		
		Mean RN/patient levels in medium size hospitals: 2.67				0.50	0.68		
		Reduction by 10% in LPN/patient ratio, medium size hospitals: 2.4				0.51	0.72		
		Mean LPN/patient levels in medium size hospitals: 1.9				0.50	0.68		
		Reduction by 10% in LPN/patient ratio, medium size hospitals: 2.1				0.50	0.69		
		Mean RN/patient levels: 2.81				0.51	0.69		
		Reduction by 10% in LPN/patient ratio: 2.53				0.52	0.71		
		Mean LPN/patient levels: 1.9				0.51	0.69		
		Reduction by 10% in LPN/patient ratio: 2.0				0.51	0.69		
		SWI %, Complications %				0.29	2.58		
		State data in 1991	2.9	1.5	1.6	0.26	2.40		
		State data in 1992	2.7	1.7	1.7	0.24	2.47		
		State data in 1993	2.77	1.8	1.8	0.28	2.67		
		State data in 1994	2.7	2.0	1.8	0.28	2.49		
		State data in 1995	2.6	2.0	1.8	0.31	2.79		
		State data in 1996	2.8	2.1	1.8	0.30	2.71		
		State data in 1997	2.7	2.4	1.7	0.27	2.34		
		Mean RN/patient levels in medium size hospitals: 2.67				0.27	2.37		
		Reduction by 10% in LPN/patient, medium size hospitals: 2.4				0.27	2.34		
		Mean LPN/patient levels in medium size hospitals: 1.9				0.27	2.35		
		Reduction by 10% in LPN/patient, medium size hospitals: 2.1				0.30	2.69		
		Mean RN/patient levels: 2.81				0.31	2.70		
		Reduction by 10% in RPN/patient ratio: 2.53				0.30	2.69		
		Mean LPN/patient levels: 1.9				0.32	2.70		
		Reduction by 10% in LPN/patient ratio 2.0				Pnm	Falls	PulmF	CPR
		State data in 1991	2.9	1.5	1.6	0.98	0.04	0.52	0.54
		State data in 1992	2.7	1.7	1.7	0.91	0.04	0.46	0.48
State data in 1993	2.7	1.8	1.8	0.96	0.16	0.47	0.50		
State data in 1994	2.7	2.0	1.8	1.54	0.91	0.63	0.61		
State data in 1995	2.6	2.0	1.8	1.55	0.86	0.68	0.64		
State data in 1996	2.8	2.1	1.8	1.63	0.74	0.70	0.63		
State data in 1997	2.7	2.4	1.7	1.64	0.72	0.69	0.60		

Table G5. Evidence of the association between nurse/patient ratio and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse/Patient Ratios	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes		
			UTI	Pnm	Dec UI %
		Increase by 1 unit in RN/patient ratio	-0.15	0.04	-0.07
		Increase by 1 unit in RN/patient ratio in small hospitals	0.31	0.30	0.06
		Increase by 1 unit in RN/patient ratio in medium hospitals	-0.34	-0.30	-0.15
		Increase by 1 unit in RN/patient ratio in large hospitals	-0.07	0.00	-0.04
		Increase by 1 unit in LPN/patient ratio	-0.10	0.21	0.04
		Increase by 1 unit in LPN/patient ratio in small hospitals	0.24	0.58	0.13
		Increase by 1 unit in LPN/patient ratio in medium hospitals	-0.37	-0.04	-0.12
		Increase by 1 unit in LPN/patient ratio in large hospitals	0.77	0.35	-0.12
		Increase by 1 unit in UAP/patient ratio	-0.09	0.12	0.06
		Increase by 1 unit in UAP/patient ratio in small hospitals	0.00	0.48	0.05
		Increase by 1 unit in UAP/patient ratio in medium hospitals	-0.14	0.14	0.17
		Increase by 1 unit in UAP/patient ratio in large hospitals	0.05	0.01	-0.04
			Falls	PulmF	Pressure ulcer
		Increase by 1 unit in RN/patient ratio	-0.01	-0.02	-0.01
		Increase by 1 unit in RN/patient ratio in small hospitals	0.05	0.12	0.09
		Increase by 1 unit in RN/patient ratio in medium hospitals	-0.02	-0.05	-0.04
		Increase by 1 unit in RN/patient ratio in large hospitals	0.00	-0.12	-0.01
		Increase by 1 unit in LPN/patient ratio	-0.09	0.09	0.03
		Increase by 1 unit in LPN/patient ratio in small hospitals	-0.12	-0.03	0.10
		Increase by 1 unit in LPN/patient ratio in medium hospitals	0.01	0.02	-0.07
		Increase by 1 unit in LPN/patient ratio in large hospitals	0.01	-0.46	0.16
		Increase by 1 unit in UAP/patient ratio	-0.03	0.03	0.00
		Increase by 1 unit in UAP/patient ratio in small hospitals	-0.08	0.19	0.12
		Increase by 1 unit in UAP/patient ratio in medium hospitals	0.05	0.05	-0.03
		Increase by 1 unit in UAP/patient ratio in large hospitals	-0.02	-0.15	-0.01
			SWI	CPR	Complication
		Increase by 1 unit in RN/patient ratio	-0.02	0.00	-0.03
		Increase by 1 unit in RN/patient ratio in small hospitals	-0.09	-0.04	-0.05
		Increase by 1 unit in RN/patient ratio in medium hospitals	0.00	0.00	-0.12
		Increase by 1 unit in RN/patient ratio in large hospitals	-0.02	-0.03	0.00
		Increase by 1 unit in LPN/patient ratio	-0.04	0.02	-0.18
		Increase by 1 unit in LPN/patient ratio in small hospitals	-0.03	-0.05	-0.10
		Increase by 1 unit in LPN/patient ratio in medium hospitals	0.00	0.06	-0.21
		Increase by 1 unit in LPN/patient ratio in large hospitals	0.01	-0.24	-0.52
		Increase by 1 unit in UAP/patient ratio	0.02	0.05	0.18
		Increase by 1 unit in UAP/patient ratio in small hospitals	-0.06	-0.24	-0.23
		Increase by 1 unit in UAP/patient ratio in medium hospitals	0.05	0.06	0.15
		Increase by 1 unit in UAP/patient ratio in large hospitals	0.01	0.05	0.09

Table G5. Evidence of the association between nurse/patient ratio and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse/Patient Ratios	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
Unruh ⁸¹ Health Care Cost Containment Council Yearly number of occurrences of adverse events per hospital: secondary diagnosis of diseases and disorders of the kidney and urinary tract, male reproductive system, or female reproductive system, decubitus ulcer, fall, atelectasis, infection or sepsis or septicemia following infusion, injection, transfusion, or vaccination, and complications of obstetrical surgical wounds. The Pennsylvania Department of Health (PDH) and the American Hospital Association (AHA) Number of FTE RNs + LPNs on hospital payroll as of June 30th yearly. No. FTE RNs + LPNs + NA on hospital payroll as of June 30th yearly.	Hospitals 1,477 Unit Combined Patients Medical	Reference, 3.3 licensed nurses/patient 10% increase in number of licensed nurses 10% increase in number of licensed nurses	Relative risk Reference Urinary tract infection 0.99 Pneumonia 1.01 Decubitus ulcer 0.98 Falls 0.97 Pulmonary failure 0.985

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BSI = Bloodstream Infection; BSN = Bachelor of Science in Nursing; CPR = Cardiopulmonary Resuscitation; Dec UI = Decubitus Ulcer; FTE = Full Time Equivalent; ICU = Intensive Care Unit; LPN = Licensed Practical Nurse; NA = Nursing Assistants; NS = Not Significant; Pnm = Pneumonia; PulmF = Pulmonary Failure; RN = Registered Nurse; SD = Standard Deviation; SICU = Surgical Intensive Care Unit; SWI = Surgical Wound Infection; UAP = Unlicensed Assistive Personnel; UTI = Urinary Tract Infection

Table G6. Patient outcomes corresponding to an increase by one patient/RN/shift (effects reported by authors and calculated from published results, more studies contributed to pooled analysis)

Author	Outcome	Measure	Effect	Standard Error	Significance
Pronovost ⁷²	Pulmonary failure	Relative risk	0.61	0.14	0.05
Pronovost ⁷²	Unplanned extubation	Relative risk	0.22	0.02	0.01
Pronovost ⁷²	CPR	Relative risk	0.22	0.05	0.05
Pronovost ⁷²	Complications	Relative risk	0.22	0.05	0.05
Pronovost ⁷²	Medical complications	Relative risk	0.29	0.08	0.08
Pronovost ⁷²	Surgical complications	Relative risk	-0.12	0.06	0.21
Pronovost ⁷²	Sepsis	Relative risk	0.24	0.08	0.09
Pronovost ⁷²	Bleeding	Relative risk	-0.01	0.10	0.93
Dang ⁷⁵	Pulmonary failure	Relative risk	0.43	0.24	0.13
Dang ⁷⁵	Unplanned extubation	Relative risk	0.41	0.11	0.01
Dang ⁷⁵	CPR	Relative risk	0.18	0.12	0.19
Dang ⁷⁵	Complications	Relative risk	0.06	0.14	0.69
Dang ⁷⁵	Medical Complications	Relative risk	0.18	0.12	0.19
Dang ⁷⁵	Sepsis	Relative risk	0.06	0.14	0.69
Amaravadi ⁶⁴	CPR	Rate	0.40		
Amaravadi ⁶⁴	Hospital acquired pneumonia	Rate	4.00		
Amaravadi ⁶⁴	Sepsis	Rate	2.20		
Amaravadi ⁶⁴	Pulmonary failure	Rate	1.50		
Amaravadi ⁶⁴	Unplanned extubation	Rate	6.50		
Amaravadi ⁶⁴	Hospital acquired pneumonia	Relative risk	0.44		
Amaravadi ⁶⁴	Pulmonary failure	Relative risk	0.09		
Amaravadi ⁶⁴	Unplanned extubation	Relative risk	0.46		
Amaravadi ⁶⁴	CPR	Relative risk	0.09		
Amaravadi ⁶⁴	Medical complications	Relative risk	-0.05		
Amaravadi ⁶⁴	Surgical complications	Relative risk	-0.05		
Amaravadi ⁶⁴	Sepsis	Relative risk	0.65		
Dimick ⁷⁰	CPR	Rate	0.10		
Dimick ⁷⁰	Hospital acquired pneumonia	Rate	0.70		
Dimick ⁷⁰	Sepsis	Rate	1.35		
Dimick ⁷⁰	Pulmonary failure	Rate	2.10		
Dimick ⁷⁰	Unplanned extubation	Rate	4.45		
Dimick ⁷⁰	Hospital acquired pneumonia	Relative risk	0.17		
Dimick ⁷⁰	Pulmonary failure	Relative risk	0.64		
Dimick ⁷⁰	Unplanned extubation	Relative risk	0.87		
Aiken ³⁹	Failure to rescue	Rate	0.41	0.16	0.03
Aiken ³⁹	Failure to rescue	Relative risk	0.05		
Aiken ³⁹	Failure to rescue	Relative risk	0.08	0.00	0.00
Marcin ³	Unplanned extubation	Relative risk	1.44		
Elting ⁹²	Failure to rescue	Relative risk	-0.18		
Flood ⁵³	Urinary tract infection	Rate	0.02		
Flood ⁵³	Nosocomial infection	Rate	0.03		
Fridkin ¹	Nosocomial infection	Rate	41.06		
Fridkin ¹	Sepsis	Rate	10.64		
Fridkin ¹	Sepsis	Relative risk	3.99	0.58	0.02
Mark ⁸⁹	Urinary tract infection	Relative risk	0.00	0.01	0.69
Mark ⁸⁹	Hospital acquired pneumonia	Relative risk	0.02	0.02	0.36
Donaldson ⁹	Falls	Rate	0.43	0.21	0.17
Donaldson ⁹	Pressure ulcers	Rate	-0.82	0.89	0.46
Bolton ²⁶	Falls	Rate	5.35		
Bolton ²⁶	Pressure ulcers	Rate	-1.47		
Silber ⁶⁷	Failure to rescue	Rate	36.71		
Silber ⁶⁷	Failure to rescue	Relative risk	0.06		
Silber ⁶⁷	Complications	Relative risk	-0.03		
Hope ⁸⁶	Urinary tract infection	Rate	-0.71	0.43	0.12

Table G6. Patient outcomes corresponding to an increase by one patient/RN/shift (effects reported by authors and calculated from published results, more studies contributed to pooled analysis) (continued)

Author	Outcome	Measure	Effect	Standard Error	Significance
Hope ⁸⁶	Nosocomial infection	Rate	-0.03	0.03	0.31
Hope ⁸⁶	Sepsis	Rate	-0.10	0.10	0.34
Hope ⁸⁶	Urinary tract infection	Relative risk	-0.01	0.00	0.18
Hope ⁸⁶	Hospital acquired pneumonia	Relative risk	0.07	0.02	0.00
Hope ⁸⁶	Nosocomial infection	Relative risk	0.02	0.02	0.17
Hope ⁸⁶	Surgical wound infection	Relative risk	0.02	0.04	0.67
Hope ⁸⁶	Sepsis	Relative risk	0.02	0.03	0.42
Houser ⁴⁹	Failure to rescue	Rate	0.23	0.30	0.48
Houser ⁴⁹	Pulmonary failure	Rate	0.01	0.01	0.65
Houser ⁴⁹	Deep venous thrombosis	Rate	0.01	0.03	0.69
Houser ⁴⁹	Failure to rescue	Relative risk	0.03		
Houser ⁴⁹	Pulmonary failure	Relative risk	0.02		
Houser ⁴⁹	Deep venous thrombosis	Relative risk	0.06		
Halm ⁵¹	Failure to rescue	Relative risk	0.00	0.00	0.00
Simmonds ⁸²	Nosocomial infection	Rate	-13.35	10.40	0.25
Unruh ⁶⁶	CPR	Rate	-0.32	0.03	<.0001
Unruh ⁶⁶	Falls	Rate	-0.24	0.12	0.08
Unruh ⁶⁶	Urinary tract infection	Rate	-2.13	0.58	0.00
Unruh ⁶⁶	Hospital acquired pneumonia	Rate	-0.71	0.13	0.00
Unruh ⁶⁶	Surgical wound infection	Rate	-0.17	0.02	<.0001
Unruh ⁶⁶	Pulmonary failure	Rate	-0.33	0.04	<.0001

Table G7. Patient outcomes corresponding to an increase by one patient/LPN (effects reported by authors and calculated from published results, more studies contributed to pooled analysis)

Author	Outcome	Measure	Effect	Standard Error	Significance
Needleman ²⁸	Failure to rescue	Rate	-0.07	0.07	0.36
Needleman ²⁸	Urinary tract infection	Rate	-0.07	0.04	0.10
Needleman ²⁸	Hospital acquired pneumonia	Rate	-0.06	0.03	0.03
Needleman ²⁸	Sepsis	Rate	0.00	0.01	0.86
Needleman ²⁸	Surgical wound infection	Rate	0.01	0.01	0.42
Needleman ²⁸	Pressure ulcers	Rate	-0.04	0.04	0.34
Needleman ²⁸	Upper gastrointestinal bleeding	Rate	-0.01	0.01	0.33
Needleman ²⁸	Shock	Rate	-0.01	0.01	0.14
Needleman ²⁸	Pulmonary failure	Rate	-0.05	0.04	0.21
Needleman ²⁸	Deep venous thrombosis	Rate	0.00	0.00	0.27
Kovner ³⁵	Urinary tract infection	Rate	-0.02	0.02	0.31
Kovner ³⁵	Hospital acquired pneumonia	Rate	0.02	0.01	0.32
Kovner ³⁵	Pulmonary failure	Rate	0.00	0.01	0.93
Kovner ³⁵	Deep venous thrombosis	Rate	-0.04	0.02	0.12
Langemo ⁴¹	Pressure ulcers	Rate	0.49	0.33	0.37
Mark ⁸⁹	Urinary tract infection	Relative risk	-0.04	0.01	0.05
Mark ⁸⁹	Hospital acquired pneumonia	Relative risk	0.12	0.02	0.00
Bolton ²⁶	Falls	Rate	1.60		
Bolton ²⁶	Pressure ulcers	Rate	-0.44		
Unruh ⁶⁶	CPR	Rate	0.03	0.00	<.0001
Unruh ⁶⁶	Falls	Rate	0.03	0.01	0.00
Unruh ⁶⁶	Urinary tract infection	Rate	0.14	0.06	0.03
Unruh ⁶⁶	Hospital acquired pneumonia	Rate	0.06	0.01	<.0001
Unruh ⁶⁶	Surgical wound infection	Rate	0.01	0.00	<.0001
Unruh ⁶⁶	Pulmonary failure	Rate	0.04	0.01	<.0001
Zidek ⁸⁵	Falls	Rate	0.02	0.08	0.77
Zidek ⁸⁵	Pressure ulcers	Rate	-0.01	0.04	0.82
Tallier ⁸³	Urinary tract infection	Rate	0.81	0.32	0.07
Tallier ⁸³	Pressure ulcers	Rate	-0.38	0.33	0.31

Table G8. Patient outcomes corresponding to an increase by one patient/UAP (effects reported by authors and calculated from published results, more studies contributed to pooled analysis)

Author	Outcome	Measure	Effect	Standard error	Significance
Needleman ²⁸	Failure to rescue	Rate	0.14	0.41	0.73
Needleman ²⁸	Urinary tract infection	Rate	-0.19	0.22	0.39
Needleman ²⁸	Hospital acquired pneumonia	Rate	-0.15	0.15	0.33
Needleman ²⁸	Sepsis	Rate	0.04	0.06	0.48
Needleman ²⁸	Surgical wound infection	Rate	0.02	0.03	0.57
Needleman ²⁸	Pressure ulcers	Rate	0.06	0.25	0.81
Needleman ²⁸	Gastrointestinal bleeding	Rate	-0.04	0.05	0.36
Needleman ²⁸	Shock	Rate	-0.02	0.04	0.60
Needleman ²⁸	Pulmonary failure	Rate	0.01	0.19	0.97
Needleman ²⁸	Deep venous thrombosis	Rate	-0.03	0.02	0.11
Potter ⁴⁰	Falls	Rate	0.28	0.50	0.64
Sovie ⁷¹	Falls	Rate	-0.08	0.34	0.82
Sovie ⁷¹	Urinary tract infection	Rate	-0.17	0.13	0.26
Sovie ⁷¹	Pressure ulcers	Rate	-0.25	0.26	0.41
Ritter-Teitel ⁶⁹	Falls	Rate	-0.07	0.04	0.18
Ritter-Teitel ⁶⁹	Urinary tract infection	Rate	-0.41	0.02	<.0001
Ritter-Teitel ⁶⁹	Pressure ulcers	Rate	0.25	0.13	0.12
Unruh ⁶⁶	CPR	Rate	0.03	0.00	<.0001
Unruh ⁶⁶	Falls	Rate	0.03	0.01	0.02
Unruh ⁶⁶	Urinary tract infection	Rate	0.28	0.02	<.0001
Unruh ⁶⁶	Hospital acquired pneumonia	Rate	0.07	0.01	0.00
Unruh ⁶⁶	Surgical wound infection	Rate	0.02	0.00	<.0001
Unruh ⁶⁶	Pulmonary failure	Rate	0.03	0.00	<.0001
Zidek ⁸⁵	Falls	Rate	0.00	0.01	0.97
Zidek ⁸⁵	Pressure ulcers	Rate	0.00	0.01	0.44
Stratton ⁹¹	Nosocomial infection	Rate	0.04	0.11	0.70
Tallier ⁸³	Urinary tract infection	Rate	0.21	3.58	0.96
Tallier ⁸³	Pressure ulcers	Rate	-1.23	2.57	0.66

Table G9. The association between nurse staffing and length of stay

Author, Definition of Length of Stay, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Length of Stay
Amaravadi ⁶⁴ The Uniform Health Discharge Data Set; hospital length of stay, survey of ICU directors; average nurse-to-patient ratio of ≥1:2 versus <1:2 both during the day and at night	Hospitals 1 Unit ICU Patients Surgical	Night time nurse to patient ratio <1:2 Night time nurse to patient ratio >1:2 Night time nurse to patient ratio <1:2 Night time nurse to patient ratio >1:2	15 9 Relative increase in length of stay 1.39 1.19 1.61 1 1 1
ANA ⁶⁵ Uniform Hospital Discharge Data Set; an average length of stay in hospital, American Hospital Association survey, hospitals cost reports; total nursing hours per Nursing Intensity Weight, % RN Hours/total nursing hours		Increase by 1 hour in total nursing hours in Massachusetts, 1992 Massachusetts, 1994 New York, 1992 New York, 1994 California, 1992 California, 1994 Increase by 1% in RN in Massachusetts, 1992 Massachusetts, 1994 New York, 1992 New York, 1994 California, 1992 California, 1994	Relative increase in length of stay 0.903 1 0.9354 0.956 0.9518 0.946 0.9973 0.9981 0.9981 0.9989 0.9993 0.9984
Barkell ⁷⁷ Medical records; length of stay in the unit: the number of midnights a patient was on the unit as an inpatient, hospital administrative database, proportion of RN/total nursing staff	Hospitals 1 Unit Surgical Patients Surgical	Team nursing model with patient care associate assisting RNs in delivery of patient care (66% of RN) Total patient care model, 79% RN	Length of stay, days ± SD 6.8 ± 3.1 7.1 ± 2.9

Table G9. The association between nurse staffing and length of stay (continued)

Author, Definition of Length of Stay, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Length of Stay
Beckman ³⁷ Medical records, length of stay in unit, unit administrators and nurses survey, hospital administrative data; scheduled RNs/patients in unit, % of RN/total nursing personnel	Hospital 1 Unit ICU Unit Surgical Surgical Specialty Medical Medical Surgical Surgical	RN + Case manager RN + MSW RN + Clinical nurse specialist RN + mixed support (rehabilitation nurse) Advanced practice nurse + clinical nurse specialist Advanced practice nurse + social worker Advanced practice nurse + mixed support RN staff with no support Patient/RN % RN 0.86 60 0.85 66 0.63 69 1.04 61.5 1.16 58.5 0.91 69 1.39 57	Length of stay, days ± SD 29 ± 32.6 35 ± 42 11 ± 2.1 17 ± 8.5 11 ± 6 7 ± 0 14 ± 0 9 ± 7.4 13.25 ± 5.73 7.92 ± 6.64 28.53 ± 33.72 10.50 ± 5.87 9.77 ± 8.17 12.29 ± 9.42 4.23 ± 3.00
Cho ³⁰ The State Inpatient Databases in hospital length of stay, Hospital Financial Data; the total productive hours worked by RN per patient day; contracted hours = productive nursing hours (direct care to patient) worked by nursing personnel contracted on a temporary basis. Contract hours * % of RN; RN hours divided by all hours	Unit Combined Patients Combined	RN hours % RN % contract hours 7.2 76.5 3.60 6 68.1 3.30 6.6 72.4 3.20 6.2 72.7 5.00	Length of stay, days ± SD 8.6 ± 1.5 7.2 ± 1.3 7.6 ± 9 7.8 ± 1.5

Table G9. The association between nurse staffing and length of stay (continued)

Author, Definition of Length of Stay, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Length of Stay
Cimiotti ⁸⁷ Patients discharges and medical records review by study's nurse epidemiologist; the length of stay as the 1 day of admission and all succeeding days except the day of discharge, nurse staffing office and sign-in/out sheet from each supplemental nursing agency; total nursing hours worked by direct care providers adjusted for Nursing Intensity Weights categorized as below and above median; RN hours/patient day adjusted for Nursing Intensity Weights categorized as below and above median; % of RN hours among total nursing hours adjusted for Nursing Intensity Weights; hours/patient day worked by float pool and agency RN not regularly assigned to the NICU	Hospitals 1 Unit Neonatal Patients Medical	Nurse hours RN hours % RN 10.68 10.68 100 10.97 10.56 96 8.705 12.95 8.5 12.74 % of contract nurses 0.19 24.07 14.19 12.13	Length of stay, days ± SD 17.23 ± 24.39 19.6 ± 28.28 10.01 ± 13.45 21.3 ± 29.03 15.75 ± 24.47 18.05 ± 24.69 17.23 ± 24.39 19.6 ± 28.28 12.52 ± 16.09 17.1 ± 30.75
Dimick ⁷⁰ The Uniform Health Discharge Data Set; In-hospital length of stay; survey of ICU directors; average nurse-to-patient ratio in the ICU during the day and evening and at night.	Hospitals 32 Unit ICU Patients Surgical	More nurses: RNs/patient 1:1-1:2 Fewer nurses: RNs/patient 1:1-3-1:4	Relative increase in length of stay 1 1 1 1.09 0.89 1.12
Flood ⁵³ Patient medical records; length of stay in unit, staffing workload index; RN FTE/patient per shift per unit	Hospitals 1 Unit Combined Patients Medical	Nurse hours % RN 6.9 60.45 6.7 42.32	Length of stay, days ± SD 8.56 ± 7.81 9.49 ± 8.74
Gandjour ²⁴ Health Care Financing Administration database; average hospital length of stay; Joint Annual Report of Hospital Data; number of administrative full time employees RN (FTE)/1,000 patient days	Hospitals 77 Unit Combined Patients Combined	Nurse hours Patients/nurse 19 2.86 19 2.85 8.9 3.22 8.4 3.44 4 3.2	Length of stay, days 5.49 5.54 5.43 5.13 5.29

Table G9. The association between nurse staffing and length of stay (continued)

Author, Definition of Length of Stay, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Length of Stay
Grillo-Peck ¹⁰ Review of risk management records and medication records 6 months before and after implementation of nursing model; length of stay in unit; hospital administrative records; decrease in % of RN in the unit within new partnership model with increase patient care technicians and service associates; RN spent more time on direct patient care	Hospitals 1 Unit Specialized Patients Medical	% RN 80 60	Length of stay, days 9.46 8.76
Halpine ¹⁴ The Hospital Medical Records Institute database; in average length of stay in units; The Hospital Medical Records Institute; GRASP workload system; total nursing hours/patient day	Hospitals 5 Unit Patients Spec Medical Surgical Surgical Surgical Surgical Surgical Surgical Surgical Surgical Surgical Surgical Neonatal Medical Surgical Surgical Specialty Surgical Surgical Surgical Surgical Surgical Surgical Surgical Surgical Surgical Neonatal Medical ICU Medical Surgical Surgical ICU Medical Specialty Medical Specialty Medical Medical Medical Surgical Surgical Surgical Surgical Medical Medical Medical Medical Neonatal Medical Surgical Surgical Medical Medical Surgical Surgical	Hour 8.64 8.51 7.57 6.92 6.64 6.56 6.32 6.14 6.07 5.87 5.78 5.78 5.47 4.67 4.66 4.58 4.52 4.51 4.41 4.38 9.28 9.19 7.51 7.32 6.49 6.33 6.32 6.15	Length of stay, days 39.25 1.86 13.33 15 9.24 12.2 7.58 21.79 19.79 16.71 14.31 26.5 2.19 4.74 12.34 6.72 10.1 12.49 17.86 6.67 9.75 10.76 2.56 1.32 3.06 1.52 3.34 2.1

Table G9. The association between nurse staffing and length of stay (continued)

Author, Definition of Length of Stay, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions		Nurse Staffing Categories		Length of Stay
	Neonatal Medical Medical Medical Surgical Neonatal Neonatal ICU Medical Surgical Specialty Surgical	Medical Medical Surgical Medical Surgical Medical Medical Medical Medical Surgical Medical Surgical	6.01 5.78 5.59 5.58 5.53 5.49 5.45 5.41 5.34 5.13 5.1 5.06	2.52 4.42 2.17 4.33 9 2.26 2.86 9.42 2.75 17.11 2.6 3.23	
Hoover ²³ The Health Care Financing Agency, HealthCareReportCards.com; MEDPAR database, the Medicare Average Length of Stay (ALOS) = total number of Medicare discharge days/total number of Medicare discharges for each hospital. The AHA and HCFA databases; RN/LPN ratio = total number RN FTE/LPN FTE reported by the hospital and RN/total nursing staff	Unit Patients Hospitals	Combined Medical 54 52 70 176 176	% RN 79.6 69.8 72.83 81.8 62.9	Length of stay, days ± SD 5.67 ± 0.36 5.69 ± 0.67 6.31 ± 0.47 5.82 ± 0.09 6.18 ± 0.09	
Houser ⁴⁹ Nationwide Inpatient Sample of 2001 with hospital discharge records; average length of stay in the hospital in days; American Hospital Association Annual Survey for 2001; hospital reported RN FTE/RN + LPN	Unit Patients Hospitals	Combined Medical 170 172 174 171 39 14 8	RN/patient ratio 0.15-1.29 RN/patient ratio 1.3-1.89 RN/patient ratio 1.9-2.49 RN/patient ratio 2.5-6.5 RN/patient ratio 3.5-4.41 RN/patient ratio 4.57-5.5 RN/patient ratio 5.67-7.67	LOS, days ± SD 4.64 ± 2.68 4.54 ± 0.97 4.38 ± 2.59 3.84 ± 2.19 4.08 ± 4 3.47 ± 1.25 2.76 ± 0.88	

Table G9. The association between nurse staffing and length of stay (continued)

Author, Definition of Length of Stay, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Length of Stay																																																																																							
Lichtig ⁶³ The Uniform Hospital Discharge Data Set; The California Office of Statewide Health Planning and Development; the Statewide Planning and Research Cooperative System Administratively Releasable file; a relative length of stay (LOS) index was calculated as the ratio of the actual-to-expected geometric mean LOS; The Annual Hospital Disclosure Report, Institutional Cost Reports; total nursing hours per NIW-adjusted patient day; RN hours as a percentage of total nursing hours per NIW-adjusted patient day.	<table border="0"> <tr> <td>Unit</td> <td>Surgical</td> </tr> <tr> <td>Patients</td> <td>Surgical</td> </tr> <tr> <td>Hospitals</td> <td>126</td> </tr> <tr> <td></td> <td>131</td> </tr> <tr> <td></td> <td>352</td> </tr> <tr> <td></td> <td>295</td> </tr> <tr> <td></td> <td>126</td> </tr> <tr> <td></td> <td>131</td> </tr> <tr> <td></td> <td>352</td> </tr> <tr> <td></td> <td>295</td> </tr> </table>	Unit	Surgical	Patients	Surgical	Hospitals	126		131		352		295		126		131		352		295	<p>Increase by 1 hour in total nursing hours in</p> <table border="0"> <tr> <td>New York, 1992</td> <td>12.50</td> </tr> <tr> <td>New York, 1994</td> <td>13.00</td> </tr> <tr> <td>California, 1992</td> <td>12.00</td> </tr> <tr> <td>California, 1994</td> <td>6.50</td> </tr> <tr> <td>New York, 1992</td> <td>13.50</td> </tr> <tr> <td>New York, 1994</td> <td>12.80</td> </tr> </table> <p>Increase by 1% in proportion of RNs, California, 1992</p> <p>Increase by 1% in proportion of RNs, California, 1994</p>	New York, 1992	12.50	New York, 1994	13.00	California, 1992	12.00	California, 1994	6.50	New York, 1992	13.50	New York, 1994	12.80	<p>Relative change in length of stay</p> <table border="0"> <tr> <td>0.94</td> </tr> <tr> <td>0.96</td> </tr> <tr> <td>0.95</td> </tr> <tr> <td>0.95</td> </tr> <tr> <td>1.00</td> </tr> <tr> <td>1.00</td> </tr> <tr> <td>Not significant</td> </tr> <tr> <td>Not significant</td> </tr> </table>	0.94	0.96	0.95	0.95	1.00	1.00	Not significant	Not significant																																															
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Mark ⁹⁰ Centers for Medicare Services, Minimum Cost and Capital File, CMS Provider of Services File, CMS Case Mix Index File, CMS Online Survey; Certification and Reporting system (OSCAR) files, and HCUP files. risk-adjusted ratio of observed/expected length of stay; Area Resource Files, American Hospital Association Annual Survey, CMS Wage Rate File, CMS Online Survey; Certification and Reporting system (OSCAR) files; RN FTEs/1,000 in-patient days, RN hours/patient * day = (FTE RN/1,000patient * days * 37.5 * 48)/1,000; 37.5 hours work week in average 48 working weeks/year, LPN FTEs/1,000 in-patient days, LPN hours/patient * day = (FTE LPN/1,000 patients * days * 37.5 * 48)/1,000; 37.5 hours work week in average 48 working weeks/year	<table border="0"> <tr> <td>Unit</td> <td>Patients</td> </tr> <tr> <td>Combined</td> <td>Medical</td> </tr> </table>	Unit	Patients	Combined	Medical	<table border="0"> <tr> <td>Pt/RN</td> <td>RN hours</td> <td>Pt/LPN</td> <td>LPN hours</td> </tr> <tr> <td>0.31</td> <td>5.74</td> <td>1.32</td> <td>1.36</td> </tr> <tr> <td>0.31</td> <td>5.88</td> <td>1.57</td> <td>1.15</td> </tr> <tr> <td>0.28</td> <td>6.36</td> <td>1.81</td> <td>0.99</td> </tr> <tr> <td>0.27</td> <td>6.59</td> <td>1.87</td> <td>0.96</td> </tr> </table> <p>Increase by 1 RN FTE/1,000 patient days in hospitals with high HMO penetration</p> <p>Increase by 1 LPN FTE/1,000 patient days in hospitals with high HMO penetration</p> <p>Increase by 1 RN FTE/1,000 patient days in hospitals with low HMO penetration</p> <p>Increase by 1 LPN FTE/1,000 patient days in hospitals with low HMO penetration</p> <table border="0"> <tr> <td>Nurse hours</td> <td>Patient/RN</td> <td>RN hours</td> </tr> <tr> <td>14.60</td> <td>0.38</td> <td>4.79</td> </tr> <tr> <td>9.60</td> <td>0.30</td> <td>6.01</td> </tr> <tr> <td>17.60</td> <td>0.25</td> <td>7.24</td> </tr> <tr> <td>7.80</td> <td>0.38</td> <td>4.79</td> </tr> <tr> <td>10.90</td> <td>0.30</td> <td>6.01</td> </tr> <tr> <td></td> <td>0.25</td> <td>7.24</td> </tr> </table>	Pt/RN	RN hours	Pt/LPN	LPN hours	0.31	5.74	1.32	1.36	0.31	5.88	1.57	1.15	0.28	6.36	1.81	0.99	0.27	6.59	1.87	0.96	Nurse hours	Patient/RN	RN hours	14.60	0.38	4.79	9.60	0.30	6.01	17.60	0.25	7.24	7.80	0.38	4.79	10.90	0.30	6.01		0.25	7.24	<p>Relative change in length of stay</p> <table border="0"> <tr> <td>0.78</td> <td>0.76</td> <td>0.78</td> </tr> <tr> <td>0.83</td> <td>0.82</td> <td>0.83</td> </tr> <tr> <td>0.81</td> <td>0.79</td> <td>0.81</td> </tr> <tr> <td>0.80</td> <td>0.79</td> <td>0.80</td> </tr> <tr> <td>0.97</td> <td>0.95</td> <td>0.99</td> </tr> <tr> <td>1.03</td> <td>0.98</td> <td>1.09</td> </tr> <tr> <td>0.99</td> <td>0.97</td> <td>1.01</td> </tr> <tr> <td>1.04</td> <td>0.99</td> <td>1.09</td> </tr> <tr> <td>0.99</td> <td>0.99</td> <td>1.00</td> </tr> <tr> <td>0.99</td> <td>0.99</td> <td>1.00</td> </tr> <tr> <td>1.00</td> <td>0.99</td> <td>1.00</td> </tr> <tr> <td>1.00</td> <td>0.99</td> <td>1.01</td> </tr> <tr> <td>1.00</td> <td>0.99</td> <td>1.00</td> </tr> <tr> <td>1.00</td> <td>0.99</td> <td>1.00</td> </tr> </table>	0.78	0.76	0.78	0.83	0.82	0.83	0.81	0.79	0.81	0.80	0.79	0.80	0.97	0.95	0.99	1.03	0.98	1.09	0.99	0.97	1.01	1.04	0.99	1.09	0.99	0.99	1.00	0.99	0.99	1.00	1.00	0.99	1.00	1.00	0.99	1.01	1.00	0.99	1.00	1.00	0.99	1.00
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Table G9. The association between nurse staffing and length of stay (continued)

Author, Definition of Length of Stay, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories			Length of Stay
Mark ⁸⁰ The hospital's incident reporting system and patient survey; total patient days divided by the number of discharges, administrative hospital data, nursing survey; proportion of RNs to the total complement of nursing staff, as a ratio of the number of nurses who left during the period divided by the number of nurses employed at the end of the year; availability of support services was evaluated with a 27-item, 3-point checklist 24 in which staff nurses (n = 1,682) indicated whether a variety of support services was available, not available, or inconsistently available (alpha = .85)	Hospitals 64 Unit Combined Patients Medical	Nurse hours 10.00	% RN 58.00	% BSN 21.00	Length of stay, days ± SD 5.31 ± 1.47
Melberg ²⁰ Hospital discharge data; average length of stay in hospital; hospital administrative data; FTE RN/100 occupied bed in acute units; % of RN/total nursing personnel	Hospitals 1 Unit ICU Patients Medical	Patient/RN 0.41 0.44 0.36 0.42 0.42	% RN 96.00 73.00 64.00 76.00 82.00		Length of stay, days 5.97 6.70 6.15 5.20 6.30
Needleman ²⁸ 799 hospitals (11 states, all-patients + Medicare patients) – hospital level analysis; 256 California hospitals (part of the 11 state sample) – unit level analysis; national sample of 3,357 hospitals (Medicare patients) - hospital level analysis; length of stay in hospital; nurse hours calculation: (2,080 hours * each FTE category) + (1,040 hours * number of part-time employees). Total nursing hours/patient-day NIW adjusted including RNs, clinical nurse specialists, general duty nurses, nurse practitioner excluding nursing directors, managers, administrators,	Hospitals Patient 32 Medical 280 Medical 83 Medical 128 Medical 68 Medical 86 Medical 145 Medical 154 Medical 25 Medical 127 Medical 488 Medical 3,357 Medical 3,296 Surgical 127 Surgical 280 Surgical 83 Surgical	Nevada New York Maryland Virginia West Virginia South Carolina Wisconsin Missouri Arizona Massachusetts California Medicare patients Medicare patients Massachusetts New York Maryland			Length of stay, days ± SD 4.5 ± 1.26 6.31 ± 1.42 4.34 ± 0.70 4.62 ± 1.16 5.72 ± 1.57 4.71 ± 0.72 4.03 ± 0.84 5.38 ± 1.67 3.63 ± 0.92 4.79 ± 1.10 4.81 ± 2.71 5.79 ± 2.92 7.68 ± 2.90 4.15 ± 0.59 5.35 ± 0.97 4.25 ± 0.92

Table G9. The association between nurse staffing and length of stay (continued)

Author, Definition of Length of Stay, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Length of Stay	
supervisors, instructors, anesthetists, and midwives; RN hours/patient day NIW adjusted; licensed hours/patient-day NIW adjusted including LPN/LVN, excluding the director of nursing. LPN/LVN hours/patient day NIW adjusted; RN hours per day/total hours per day; RN hours/licensed hours = RN hours per day/licensed hours per day (RN + LPN)	128	Surgical	Virginia	4.32 ± 0.92
	68	Surgical	West Virginia	8.09 ± 3.15
	86	Surgical	South Carolina	4.62 ± 1.10
	145	Surgical	Wisconsin	4.38 ± 0.74
	154	Surgical	Missouri	4.52 ± 0.76
	25	Surgical	Arizona	3.91 ± 0.50
	32	Surgical	Nevada	5.35 ± 0.79
	488	Surgical	California	4.27 ± 1.19
				Relative change in length of stay
	4,156	Medical	Increase by 1 hour of RN hours	0.90 0.86 0.93
	4,156	Surgical	Increase by 1 hour in RN hours	0.97 0.95 1.00
	4,156	Medical	Increase by 1 hour in LPN hours	0.98 0.91 1.05
	4,156	Surgical	Increase by 1 hour in LPN hours	1.05 0.94 1.18
	4,156	Medical	Increase by 1 hour in aide hours	1.07 1.02 1.13
	4,156	Surgical	Increase by 1 hour in aide hours	1.00 0.95 1.06
	4,156	Medical	Increase by 1 hour in total nursing hrs	0.95 0.92 0.98
	4,156	Surgical	Increase by 1 hour in total nursing hrs	0.99 0.96 1.02
	4,156	Medical	Increase by 1% in RNs	0.12 0.05 0.29
	4,156	Surgical	Increase by 1% in RNs	0.84 0.39 1.78
	4,156	Medical	Increase by 1 hour in licensed hour	0.91 0.88 0.94
	4,156	Medical	increase by 1% of RN/licensed hour	0.28 0.12 0.65
	4,156	Surgical	Increase by 1 hour in licensed hour	0.99 0.96 1.02
	4,156	Surgical	Increase by 1% in RN/licensed hour	0.48 0.20 1.17
	3,357	Medical	Increase by 1 hour in RN hours	0.94 0.92 0.96
	3,357	Medical	Increase by 1 hour in LPN hours	0.99 0.97 1.02
	3,357	Medical	Increase by 1 hour in licensed hours	0.95 0.93 0.97
	3,357	Medical	Increase by 1% in RN/licensed hours	0.45 0.28 0.73
	3,357	Medical	Increase in total nurse hours	0.94 0.90 0.98
	3,357	Medical	Increase by 1% in RNs	0.07 0.03 0.19
	3,357	Medical	Increase by 1 hours in aide hours	1.09 1.02 1.17
	3,357	Surgical	Increase by 1 hour in RN hours	0.98 0.95 1.00
	3,357	Surgical	Increase by 1 hour in LPN hours	0.97 0.93 1.02
3,357	Surgical	Increase by 1 hour in licensed hours	0.98 0.95 1.00	
3,357	Surgical	Increase by 1% in RN/licensed hours	0.93 0.51 1.72	
3,357	Surgical	Increase by hour in aide hours	0.99 0.92 1.07	
3,357	Surgical	Increase by 1 hour in total nursing hrs	0.64 0.41 0.99	
3,357	Surgical	Increase by 1% in RNs	0.73 0.17 3.11	
			California hospitals	
256	Medical	Increase by hour in RN hours	0.80 0.64 1.00	
256	Medical	Increase by 1 hour in LPN hours	1.54 0.60 3.92	
256	Medical	Increase by 1 hour in aide hours	0.99 0.78 1.25	

Table G9. The association between nurse staffing and length of stay (continued)

Author, Definition of Length of Stay, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Length of Stay			
	256	Medical	Increase by 1 hour in nursing hours	0.92	0.76	1.11
	256	Medical	Increase by 1% in RNs	0.00	0.00	0.89
	256	Medical	Increase by 1 hour of licensed hours	0.47	0.24	0.96
	256	Medical	Increase by 1% of RNs/licensed hour	0.00	0.00	0.11
	256	Medical	Increase by 1 hour of RN hours	0.71	0.56	0.90
	256	Medical	Increase by 1 hour in LPN hours	1.14	0.57	2.29
	256	Medical	Increase by 1 hour in aide hours	0.93	0.65	1.33
	256	Medical	Increase by 1 hour nursing hours	0.82	0.70	0.96
	256	Medical	Increase by 1% in RNs	0.00	0.00	0.70
	256	Medical	Increase by 1 hour/licensed hour	0.19	0.04	0.83
	256	Medical	Increase by 1% of RN hours/licensed hr	0.01	0.00	0.16
	256	Surgical	Increase by 1 hour of RNs	1.00	0.97	1.03
	256	Surgical	Increase by 1 hour in LPN hours	1.20	1.00	1.44
	256	Surgical	Increase by 1 hour in aide hours	0.92	0.80	1.05
	256	Surgical	Increase by 1 hour in total nursing	1.00	0.97	1.02
	256	Surgical	hours Increase by 1% in RNs	0.16	0.03	1.04
	256	Surgical	Increase by 1 hour in licensed hours	1.03	0.99	1.07
	256	Surgical	Increase by 1% in RNs	0.31	0.08	1.22
	Unit level analysis:					
	256	Surgical	Increase by 1 hour of RN hours	1.00	0.95	1.04
	256	Surgical	Increase by 1 hour in LPN hours	3.12	1.14	8.52
	256	Surgical	Increase by 1 hour in aide hours	0.89	0.78	1.02
	256	Surgical	Increase by 1 hour in total nursing hours	0.98	0.93	1.03
	256	Surgical	Increase by 1% in RNs	2.47	0.86	7.12
	256	Surgical	Increase by 1 hour in licensed hours	1.02	0.97	1.06
256	Surgical	Increase by 1% in RNs	0.48	0.18	1.26	
Needleman ⁴³ Hospital discharge data from 11 states (all patients and Medicare sample) and MedPAR national database (all Medicare patients); adjusted length of stay; state hospital staffing surveys or financial reports. American Hospital Association Annual Survey; Licensed hours (RN + LPN)/patient days adjusted for nursing case-mix index for each hospital, proportion of RN hours/licensed hours (RN + LPN) adjusted for nursing case-mix index for each hospital	Hospitals 799 Unit Combined Patients Medical	1% increase in RN hours/licensed hour Increase in 1 licensed hour Increase in 1 licensed hour 1% increase in RN hours/licensed hour Increase in 1 licensed hour 1% increase in RN hours/licensed hour 1% increase in RN hours/licensed hour Increase in 1 licensed hour 1% increase in RN hours/licensed hour Increase in 1 licensed hour Increase in 1 licensed hour 1% increase in RN hours/licensed hour 1% increase in RN hours/licensed hour Increase in 1 licensed hour	Relative change in length of stay 0.24 0.10 0.57 0.99 0.96 1.01 0.97 0.94 1.00 0.94 0.51 1.73 0.99 0.93 1.05 0.46 0.15 1.38 0.58 0.25 1.35 0.95 0.93 0.97 0.44 0.33 0.59 0.87 0.83 0.91 0.91 0.88 0.94 0.11 0.04 0.36 0.33 0.14 0.79 0.91 0.88 0.95			

Table G9. The association between nurse staffing and length of stay (continued)

Author, Definition of Length of Stay, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Length of Stay
Oster ³¹ Electronic medical records system; length of stay in the hospital for each patient; hospital administrative daily statistic reports; total productive nursing hours/patient day; total number of productive hours worked by nursing personnel with direct patient care/number of patients; % of RN hours/total nursing hours per patient day; % of contract agencies nurses; % of full time nurses	Hospitals 1 Unit Patients Emergency Medical Surgical Surgical Surgical Surgical Intensive Care Unit Medical Intensive Care Unit Medical Specialty Medical Specialty Medical	% RN % contract hrs % full-time hrs 67.00 18.30 70.00	Length of stay, Days ± SD 5.24 ± 3.95 0.03 -0.02 -0.02 0.01 -0.19 -0.11
Pronovost ¹² The Uniform Health Discharge Data Set; Hospital length of stay, survey to the ICU directors, average ICU nurse-to-patient ratio during the day and evening	Unit ICU Patients Surgical Hospitals 7 31 7 31	More nurses: RNs/patient 1:1 or 1:2, adjusted Fewer nurses: RNs/patient 1:3 or 1:4, adjusted	Length of stay, days Unit Hospital 3.00 8.00 3.00 8.00
Pronovost ⁵¹ The Uniform Hospital Health discharge Data Set; in-hospital length of stay; in ICU length of stay; survey of ICU directors; average nurse to patient ratio in day, in evening. decreased nurse to patient ratio in evening	Unit ICU Patients Surgical Hospitals 8 31 14 25	Nurse to patient ratio <1:2 during the day Nurse to patient ratio >1:2 during the day Nurse to patient ratio <1:2 in evening Nurse to patient ratio >1:2 in evening	Relative change in length of stay in unit 1.49 1.17 1.91 1.00 1.00 1.00 Relative change in LOS in hospital 9.60 1.20 1.07 8.00 1.00 1.00
Ridge ²⁵ Patient survey 2 weeks after discharge with computerized phone interview system; length of stay in hospital; hospital administrative database, finance reports, Health Care Information Access database, unit nurse manager reports; educational level by degree learned: AD, BSN; number of individual staff hired annually/total number of staff, staffing adequacy - RN worked hours/RN target hours	Hospitals 1 Unit Surgical Patients Surgical	% BSN Experience % full time 44.00 8.70 86.00	Length of stay, Days ± SD 4.10 ± 3.90

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Table G9. The association between nurse staffing and length of stay (continued)

Author, Definition of Length of Stay, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Length of Stay
Shamian ¹⁵ The National Comparative Database for Nursing Resource Consumption; average length of stay in unit. GRASP work Load Measurement System, The National Comparative Database for Nursing Resource Consumption; the amount of nursing services for each patient during 24 hours	Hospitals 58	Rehabilitation units Psychiatric units Neonatal units Pediatric units Obstetrics Oncology Neurological Intensive Care Unit Medical surgical Orthopedics Cardiac step-down	Length of stay, days 24.8 12.5 14.0 3.7 3.0 7.9 6.6 3.8 6.6 6.1 6.0
Shortell ⁹⁴ Hospitals discharge data; length of stay in unit for survivors (observed length of stay/expected length of stay) hospital administrative databases; survey of nursing directors in each unit	Hospitals 40 Unit ICU Patients Medical	Increase by 1 RN/patient ratio	Relative change in length of stay 1.06
Stratton ⁹¹ Medical records, hospital incidence and infection control records, surveys; average length of stay in units; payroll records from the National Association of Children's Hospitals and Related Institutions (NACHRI); average in each quarter 2002 of total hours of productive nursing care/patient day adjusted for short-stay patients; average in each quarter 2002 of % of RN productive hours/total nursing hours/patient day; % of RN productive hours worked by supplemental nurse staffing (total nursing overtime hours and percentages of hours from float/agency/traveler RN hours)	Hospitals 7 Unit Combined Specialty ICU Patients Combined Surgical Medical	Experience Medical/Surgical units 7.6 years Oncology units 6.6 years ICU units 8.3 years	Length of stay, Days ± SD 3.58 ± 0.94 4.47 ± 0.77 6.48 ± 4.80

Table G9. The association between nurse staffing and length of stay (continued)

Author, Definition of Length of Stay, Definition of Nurse Staffing	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories			Length of Stay
Tschanen ⁴⁸ Patients medical records; patient's episode of care on the study unit; actual patients days were calculated as the time from admission to the time of discharge from the unit; nursing surveys, daily staff assignment sheets, census logs, and payroll records; proportion of RNs working in the unit; self reported years working in the present job category	Hospitals 2 Unit ICU Patients Medical	Experience in years 15.91 12.58 7.42 10.31 Increase by 1 hour in total nursing hours Increase by 1% in RNs			Length of stay, Days ± SD 2.67 ± 2.20 2.83 ± 2.10 2.86 ± 2.20 3.11 ± 2.60 Relative change in length of stay 1.18 0.97
Unruh ⁶⁶ State Health Care Cost Containment Council; average length of stay in hospital. State Department of Health, American Hospital Association; total nurses FTE/1,000 APDC, RN FTE/1,000 APDC, LPN FTE/1,000 APDC	Hospitals 211 Unit Combined Patients Medical	Patient/RN % RNs 0.34 68.50 0.37 69.20 0.37 70.20 0.37 71.20 0.38 71.50 0.36 71.40 0.38 71.80			Length of stay, days 6.70 6.90 6.50 6.10 5.80 5.40 5.50
Zidek ⁸⁵ Patient records and chart audits, individuals length of stay in the hospital, administrative records; total nursing hours/patient day; RN hours calculated from % of RN FTE/total FTE	Hospitals 1 Unit Combined Patients Medical	Nurse hours RN hours % RN 6.60 2.05 31.00 8.40 2.62 31.00 7.30 2.03 28.00 8.20 2.63 32.00 6.90 2.07 30.00 10.20 3.05 30.00 8.30 2.58 31.00 9.00 2.97 33.00 7.30 2.32 32.00 8.80 2.72 31.00 11.20 3.70 33.00 8.50 2.54 30.00			

APDC = Adjusted Patient Day Care; FTE = Full Time Equivalent; hrs = hours; ICU = Intensive Care Unit; LPN = Licensed Practical Nurse; LOS = Length of Stay; LVN = Licensed Vocational Nurse; MSW = Master of Social Work; NICU = Neonatal Intensive Care Unit; NIW = Nursing Intensity Weight; RN = Registered Nurse; SD = Standard Deviation

Table G10. Calculated change in hospital related mortality corresponding to an increase by 1 nursing hour/patient day (results from individual studies)

Author	Increase by 1 Nurse Hour		Increase by 1 RN Hour				Increase by 1 LPN Hour		Increase by 1 UAP Hour	
	Death rate	p value	Death rate	p value	RR	p value	Death rate	p value	Death rate	p value
Berney ⁸⁴					0.98	<0.05				
Blegen ⁵⁹		NS		NS						
Cho ³⁸		NS		NS						
Mark ⁹⁰					1.01	NS				
Mark ⁸⁹					0.94	NS				
Needleman ²⁸		NS		NS	1.00	NS		NS		NS
Needleman ²⁹		NS		NS	1.00	NS		NS		
Seago ³⁴					0.98	<0.05				
Thorson ⁵⁵					1.01	<0.05				

LPN = Licensed Practical Nurse; NS = Not Significant; RN = Registered Nurse; RR = Relative Risk; UAP = Unlicensed Assistive Personnel

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
<p>ANA⁶⁵ HCFA and MEDPAR national data sets; Urinary tract infections, bacterial unspecified pneumonia, pressure ulcers, postoperative infections, vascular complications, anoxic brain damage; communicable conditions; complications in post-partum period; diabetic complications; joint effusion; metabolic imbalances, personal care complications; psychiatric secondary diagnosis; transfusion reactions; trauma in non-trauma patients RN % of licensed hours</p>	<p>Hospitals 1,384 Unit Combined Patients Combined</p>	<p>Increase by 1 hour in total nursing hours in New York, 1992 Increase by 1 hour in total nursing hours in New York, 1994 Increase by 1 hour in total nursing hours in California, 1992 Increase by 1 hour in total nursing hours in California, 1994</p> <p>Increase by 1 hour in total nursing hours in New York, 1992 Increase by 1 hour in total nursing hours in New York, 1994 Increase by 1 hour in total nursing hours in California, 1992 Increase by 1 hour in total nursing hours in California, 1994</p>	<p>Relative Risk UTI Nosocomial infection NS NS NS NS NS NS Pneumonia Pressure ulcers 1.00 0.82 1.00 1.00 1.00 1.00 1.08 0.84</p>
<p>Archibald⁵⁷ Retrospective review of patient and microbiology records from December 1994 through December 1995. The total number of nosocomial infections caused by <i>Serratia marcescens</i>; number of infections per 1,000 patient days. Retrospective review of administrative records from December 1994 through December 1995 RN hours worked by the registered nursing staff of this unit; monthly nursing hours/patient day ratio</p>	<p>Hospitals 1 Unit ICU Patients Combined</p>	<p>Median RN hours/patient day, 15.2 Increase by 1 hour in RNs/patient day, 16.2</p>	<p>Nosocomial Infection, rate/100 patient days 0.69 0.67</p>

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories		Patient Outcomes																								
Berney ⁸⁴ The New York Statewide Planning and Research Cooperative System Actual number of events identified as secondary DRG: Death among patients with shock, sepsis, pneumonia, deep vein thrombosis/pulmonary embolism, or gastrointestinal bleeding The New York State Institutional Cost Reports RN total hours in inpatient cost units/patients days in units adjusted for nursing acuity	Hospitals 161 Unit Medical Patients Medical Patients Surgical Patients Medical Patients Surgical Patients Medical Patients Surgical Patients Medical Patients Medical	1 hour increase in RN hours/patient day 1 hour increase in RN hours/patient day 1 hour increase in RN hours/patient day 1 hour increase in RN hours/patient day 1 hour increase in RN hours/patient day 1 hour increase in RN hours/patient day 1 hour increase in RN hours/patient day 1 hour increase in RN hours/patient day		Relative risk Urinary tract infection 0.99 0.98 1.01 0.98 0.96 1.00 Gastro-intestinal bleeding - - - 0.95 0.92 0.99 Failure to rescue 0.98 0.97 0.99 0.98 0.97 0.99 Sepsis 0.96 0.94 0.98 0.97 0.95 0.99																								
Blegen ⁸⁸ Comparative occurrence reporting service (CORS) The number of patient falls on the unit in quarter/1,000 patient days, the number of arrests on the unit in quarter/1,000 patient days Hospital reports (Institute for Quality Healthcare database) Hours of patient care for each unit provided by all personnel were added for each quarter and divided by patient days for that unit in that quarter	Hospitals 11 Unit Patients Combined Combined Combined Combined Neonatal Surgical ICU Surgical Combined Medical	<table border="0"> <thead> <tr> <th></th> <th>Hours</th> <th>RN hours</th> </tr> </thead> <tbody> <tr> <td>Mean of outcome in units</td> <td>8.6</td> <td>6.0</td> </tr> <tr> <td>Increase by 1% in proportion of RN</td> <td></td> <td>1.1</td> </tr> <tr> <td>Increase by 1 hour in total nursing care</td> <td>1.0</td> <td></td> </tr> <tr> <td>Mean of outcome in units</td> <td>5.7</td> <td>2.1</td> </tr> <tr> <td>Mean of outcome in units</td> <td>11.3</td> <td>9.9</td> </tr> <tr> <td>Mean of outcome in units</td> <td>18.0</td> <td>16.2</td> </tr> <tr> <td>Mean of outcome in units</td> <td>10.8</td> <td>7.8</td> </tr> </tbody> </table>			Hours	RN hours	Mean of outcome in units	8.6	6.0	Increase by 1% in proportion of RN		1.1	Increase by 1 hour in total nursing care	1.0		Mean of outcome in units	5.7	2.1	Mean of outcome in units	11.3	9.9	Mean of outcome in units	18.0	16.2	Mean of outcome in units	10.8	7.8	Rate per 100 patient days Falls CPR 0.27 0.04 -0.05 -0.01 0.00 -0.01 0.40 0.03 0.04 0.00 0.14 0.58 0.22 0.16
	Hours	RN hours																										
Mean of outcome in units	8.6	6.0																										
Increase by 1% in proportion of RN		1.1																										
Increase by 1 hour in total nursing care	1.0																											
Mean of outcome in units	5.7	2.1																										
Mean of outcome in units	11.3	9.9																										
Mean of outcome in units	18.0	16.2																										
Mean of outcome in units	10.8	7.8																										

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
Blegen ⁷³ Discharge databases of participating hospitals The number of patient falls on the unit in quarter/1,000patient days. Hospitals were members of the Institute for Quality Healthcare	Hospitals 11 Unit Combined Patients Combined	Total hours -11, RN hours -7.8 Increase by 1% of RN hours/total nursing hours Increase by 1 nurse hour/patient day Increase by 1% of RN hours/total nursing hours Total hours -11, RN hours -7.7	Falls rate per 100 patient days 0.220 -0.028 -0.005 -0.019 0.270
Blegen ⁵⁹ Hospital records; The number of patient complaints standardized as a rate per 1,000 patient days, new incidences of skin breakdown secondary to pressure or exposure to urine or feces, suddenly and involuntarily leaving a position and coming to rest on the floor or some object. All reported falls were included whether or not injuries resulted, nosocomial infections that express themselves in hospitalized patients in whom the infection was not present or incubating at the time of admission. A record of hours worked for each individual employee was completed by the staffing clerk and approved by the employee and nurse manager before being entered into the computerized payroll database The hours of care per patient day from all nursing	Hospitals 1 Unit Combined Patients Combined Acuity 4.19	Increase by 1 hour in total nursing hours Total hours: 10.74, RN hours: 7.7 Increase by 1 hour in total nursing hours Total hours: 10.74, RN hours: 7.7	Rate per 100 patient days UTI Pneumonia Dec ulcer 0.34 0.26 0.03 Falls Nosocomial infection 0.01 0.05 0.27 0.60

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories			Patient Outcomes	
personnel: hours of direct patient care by RNs, LPNs, and nursing assistants each month divided by the patient days of care on the unit for the month The hours of direct patient care from RNs divided by patient days excluding hours for non patient care (meetings, vacation, sick leave, and holidays)						
Bolton ²⁶ California Nursing Outcomes Coalition database; the California Department of Health Services. Hospital-acquired pressure ulcers, unplanned descent to the floor in adult patients; the monthly fall rate per 1,000 patient days for each nursing unit and each hospital. Data are collected at the patient level and aggregated by CalNOC staff to the unit level. California Nursing Outcomes Coalition database; the California Department of Health Services Productive hours worked by the nursing staff who provide direct patient care on the defined unit RN hours/patient day % of UAP hours/total nursing hours	Medical-surgical units ICU	Hours 8 16.8	RN hours 4.7 15.3	LPN hours 0.88 1.51	Rate/100 patient days Falls 3.70 0.10	Pressure ulcer 8 13

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Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
<p>Cheung³² Incidence reports, quality referrals, and medical record coding stores in the database Excalibur system Pressure ulcers, falls, primary bloodstream infections after admitting the unit as secondary diagnosis. Automated Nurse staffing Office system and direct observation of nursing activities with Hill_Rom COMposer@nurse locator system Total nursing personnel on the unit for each shift including the number of RN, LPN, aides, and unit secretaries RN hours/patient day LPN hours/patient day Aide hours/patient day</p>	<p>Hospitals 1 Unit Combined Patients Medical</p>	<p>Increase by 1 hour in total nursing hours Increase by 1 hour in total nursing hours Increase by 1 hour in total nursing hours</p>	<p>Relative risk Decubitus ulcer NS Falls NS Nosocomial Infections NS</p>
<p>Cho^{30,38} The State Inpatient Databases ICD-9-CM for UTI, pressure ulcers, falls and injury, surgical wound infection, sepsis, adverse drug event. Hospital Financial Data The total productive hours worked by all nursing personnel per patient day; the total productive hours by registered nurses per patient day</p>	<p>Hospitals-232 Unit Combined Patients Combined Age 67.9 Race 79.3 Sex 48.9 Severity 49.7</p>	<p>RN hours/patient day Large, nonprofit, non-teaching, non-rural, 4 Large, nonprofit, non-teaching, non-rural, 5 Large, nonprofit, non-teaching, non-rural, 6 Large, nonprofit, non-teaching, non-rural, 8 Large, nonprofit, non-teaching, non-rural, 7 Medium, nonprofit, non-teaching, non-rural, 8 Medium, investor-owned, non-teaching, non-rural, 4 Medium, investor-owned, non-teaching, non-rural, 5 Medium, investor-owned, non-teaching, non-rural, 6 Medium, investor-owned, non-teaching, non-rural, 7 Medium, investor-owned, non-teaching, non-rural, 8 Medium, investor-owned, non-teaching, non-rural, 8 Large, nonprofit, teaching, non-rural, 5 Large, nonprofit, teaching, non-rural, 6</p>	<p>Pneumonia 2.06 1.88 1.72 1.43 1.57 1.33 2.09 1.91 1.74 1.59 1.45 2.16 1.98 1.81</p>

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes		
		Large, nonprofit, teaching, non-rural, 8	1.51		
		Medium, nonprofit, non-teaching, non-rural, 4	1.91		
		Medium, nonprofit, non-teaching, non-rural, 5	1.75		
		Medium, nonprofit, non-teaching, non-rural, 6	1.59		
		Medium, nonprofit, non-teaching, non-rural, 7	1.45		
		Large, nonprofit, teaching, non-rural, 4	2.17		
		Large, nonprofit, teaching, non-rural, 7	1.65		
		Total hours RN hours	UTI %	SWI %	
		Increase in 1 hour of total nurse hours			
		large nonprofit teaching hospitals 10 7.2	2.50	1.60	
		Medium, nonprofit, non-teaching, non-rural 9 6	1.60	1.10	
		Large, nonprofit, non-teaching, non-rural 9 6.6	2.00	1.50	
		Medium, investor-owned non-teaching non-rural hospitals 9 6.2	2.10	1.10	
		Large nonprofit teaching hospitals 10 7.2	Falls %	Sepsis %	
		Medium, nonprofit, non-teaching, non-rural 9 6	0.20	1.20	
		Large, nonprofit, non-teaching, non-rural 9 6.6	0.20	0.80	
		Medium, investor-owned non-teaching non-rural hospitals 9 6.2	0.20	1.10	
		Large nonprofit teaching hospitals 10 7.2	0	1.00	
		Medium, nonprofit, non-teaching, non-rural 9 6	Pneumonia	Pressure ulcer	
		Large, nonprofit, non-teaching, non-rural 9 6.6	3.10	0.10	
		Medium, investor-owned non-teaching non-rural hospitals 9 6.2	2.70	0.30	
		Large nonprofit teaching hospitals 10 7.2	2.80	0.30	
		Medium, nonprofit, non-teaching, non-rural 9 6	2.80	0.20	
		Large, nonprofit, non-teaching, non-rural 9 6.6	Relative risk		
		Medium, investor-owned non-teaching non-rural hospitals 9 6.2	Urinary tract infection		
		Increase in 1 hour of total nurse hours	1.02	0.95	1.08
		Increase in 1 hour of RN hours	1.01	0.93	1.08
		Increase in 1 hour of total nurse hours	Pneumonia		
		Increase in 1 hour of RN hours	0.96	0.91	1.01
			0.91	0.85	0.97
			Falls		
		Increase in 1 hour of total nurse hours	1.08	0.99	1.18
		Increase in 1 hour of RN hours	1.07	0.96	1.19
			Pulmonary Failure		
		Increase in 1 hour of total nurse hours	1.13	1.01	1.27

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
		Increase in 1 hour of RN hours Increase in 1 hour of total nurse hours Increase in 1 hour of RN hours Increase in 1 hour of total nurse hours Increase in 1 hour of RN hours	1.11 0.97 1.27 SWI 1.00 0.95 1.06 0.97 0.91 1.04 Sepsis 1.01 0.95 1.08 1.02 0.95 1.09
Cimiotti ⁸⁷ Patient discharges and medical records review by study's nurse epidemiologist Infections occurring in an infant 48 hours or longer after admission to the NICU including bloodstream infections, device associated pneumonia, CNS and skin infections, conjunctivitis; Nurse staffing office and sign-in/out sheet from each supplemental nursing agency; Total nursing hours worked by direct care providers adjusted for Nursing Intensity Weights categorized as below and above median RN hours/patient day adjusted for Nursing Intensity Weights categorized as below and above median	Hospitals 1 Unit Neonatal ICU Patients Medical	NICU A, 10.7 nursing hours/patient day NICU B, 11 nursing hours/patient day Mean staffing levels, 10.8 nursing hours/patient day Low nursing hours, 8.7/patient day High nursing hours, 12.9/patient day Low RN hours, 8.5 hours/patient day High RN hours, 12.7 hours/patient day NICU A, 10.7 nursing hours/patient day NICU B, 11 nursing hours/patient day Mean staffing levels, 10.8 nursing hours/patient day Low nursing hours, 8.7/patient day High nursing hours, 12.9/patient day Low RN hours, 8.5 hours/patient day High RN hours, 12.7 hours/patient day	Sepsis 10.50 5.50 1.00 2.56 1.38 3.71 1.74 % Pneumonia Nosocomial infection 0.50 18.30 0.90 15.10 Relative risk Nosocomial infection, relative risk 1.00 1.25 0.84 1.75 1.08

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Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
Donaldson ⁹ CalNOC database; Total number of patients with Stage I-IV pressure ulcers regardless of whether ulcer was acquired during hospitalization or present on admission;%/total number of surveyed patients, unplanned descent to the floor; rate/1,000 patient days. CalNOC database in 2004 and 2005 (after legislation); Productive hours worked by total nursing staff who have direct patient care responsibilities on the defined units and are included in the staffing matrix, total number of productive RN hours worked by all RNs (including contracted staff) with direct patient care responsibilities, total number of productive LPN hours worked by all LPNs (including contracted staff) with direct patient care responsibilities	Hospitals 68 Unit Combined Patients Medical	<p>Medical surgical units, before mandatory ratios Hour RN hours licensed hours 8.08 4.76 5.44</p> <p>Medical and surgical units after mandatory ratios Hour RN hours licensed hours 8.68 5.75 6.41</p> <p>Step-down units before mandatory ratios Hour RN hours licensed hours 9.59 6.59 6.98</p> <p>Step-down units after mandatory ratios Hour RN hours licensed hours 10.11 7.28 7.59</p> <p>Medical surgical units before mandatory ratios Hour RN hours licensed hours 8.08 4.76 5.44</p> <p>Medical and surgical units after mandatory ratios Hour RN hours licensed hours 8.68 5.75 6.41</p> <p>Step-down units before mandatory ratios Hour RN hours licensed hours 9.59 6.59 6.98</p> <p>Step-down units after mandatory ratios Hour RN hours licensed hours 10.11 7.28 7.59</p>	<p>Rate/100 patient days ± SD Falls</p> <p>0.31 ± 0.20</p> <p>0.32 ± 0.17</p> <p>0.30 ± 0.22</p> <p>0.26 ± 0.16 Pressure ulcers</p> <p>14.07 ± 11.07</p> <p>14.48 ± 10.39</p> <p>13.52 ± 10.78</p> <p>16.29 ± 10.27</p>

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
<p>Donaldson^{9b} California Nursing Outcomes Coalition (CalNOC) Hospital acquired pressure related skin injury controlling for date of admission, % of all patients on the day of prevalence study Patient's unplanned descent to the hospital floor; were analyzed as 7 day aggregate per unit; also actual number per unit; the number of falls/1,000 patient days. The California Nursing Outcomes Coalition (CalNOC); hours worked by RNs, LPNs, and others (aides and other direct care providers) that have direct patient care responsibilities/ assignments on the defined unit and are included in the staffing matrix.</p>	<p>Hospitals 25 Unit Combined Patients Medical</p>	<p>Increase by 1 hour in total RN hours/patient day Increase by 1 hour in total licensed hours of care/patient day Increase by 1 hour in total nursing hours patient day</p>	<p>Rate/100 patient days ± SD -0.02 ± 0.05 -0.02 ± 0.05 -0.01 ± 0.07</p>

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
Fridkin ¹ Medical records of the patients in surgical intensive care unit. Cases were defined as any patient hospitalized >48 hours, in the SICU >24 hours who developed a laboratory confirmed CVC-BSI during outbreak periods. Controls were randomly selected from all SICU patients; Laboratory confirmed catheter-associated bloodstream infections or clinical sepsis; rates were compared in pre- and outbreak periods. Hospital administrative records; RN hours/patient day	Hospitals 1 Unit ICU Patients Surgical	Pre-outbreak period, 20 RN hours/patient day Outbreak period, 17 RN hours/patient day RN hours Month's patient/nurse ratio = 1.2 20 Month's patient/nurse ratio = 1.5 16 Month's patient/nurse ratio = 2 12 Month's patient/nurse ratio = 1 24	Rate/100 patient days Nosocomial infection Sepsis 1.95 0.53 4.96 1.31 Relative risk 3.95 1.07 14.54 15.60 1.15 211.4 61.50 1.23 3,074 1.00 1.00 1.00

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
Kovner ³⁵ The National Inpatient Sample (NIS) Post operative discharges with urinary tract infection, pneumonia, pulmonary congestion, lung edema, or respiratory failure, and DVT in any secondary diagnosis. American Hospital Association Annual Survey of Hospitals, the part of the Health Care Utilization Project	Hospitals 5,708 Unit Surgical Patient Surgical	Increase by 1 hour in LPN hours/patient day Increase by 1 hour in LPN hours/patient day Increase by 1 hour in LPN hours/patient day Increase by 1 hour in LPN hours/patient day Year RN hours LPN hours 1990 5.84 1.24 1991 6.01 1.23 1992 5.9 1.13 1993 6.13 1.09 1994 6.13 1.01 1995 6.39 1.01 1996 6.56 0.97 1990 5.84 1.24 1991 6.01 1.23 1992 5.9 1.13 1993 6.13 1.09 1994 6.13 1.01 1995 6.39 1.01 1996 6.56 0.97	UTI, relative risk 1.01 Pneumonia, relative risk 0.99 Pulmonary failure, RR 1 Thrombosis, relative risk 0.96 Rate, % UTI Pneumonia 3.77 0.75 3.75 0.77 3.84 0.78 3.72 0.95 3.81 1.05 3.57 1.13 3.68 1.24 Pulmonary failure DVT 0.62 0.32 0.65 0.33 0.72 0.35 0.81 0.35 0.80 0.37 0.95 0.40 1.00 0.42

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
<p>Kovner²² The Nationwide Inpatient Sample of hospital discharges; UTI, gastrointestinal hemorrhage or ulceration, pneumonia, invasive vascular procedure, pulmonary congestion, lung edema, respiratory insufficiency or failure, DVT or PE, AMI as secondary diagnoses after surgery. American Hospital Association data RN FTE working in the hospital and outpatient departments/adjusted patient day, LPN FTE working in the hospital and outpatient departments/ adjusted patient day.</p>	<p>Hospitals 589 Unit Surgical Patients Surgical</p>	<p>Reference 5.8 RN hours/adjusted patient day Increase by 0.5 RN hour/adjusted patient day</p> <p>Reference 5.8 RN hours/adjusted patient day Increase by 0.5 RN hour/adjusted patient day</p> <p>Reference 5.8 RN hours/adjusted patient day Increase by 0.5 RN hour/adjusted patient day</p> <p>Reference 5.8 RN hours/adjusted patient day Increase by 0.5 RN hour/adjusted patient day Increase by 1 LPN hour/patient day</p>	<p>Rate ± SD Urinary tract infection 3.58 ± 4.91 3.42 ± 4.91 Pneumonia 0.95 ± 1.91 0.91 ± 1.91 Pulmonary failure 0.82 ± 1.40 0.81 ± 1.40 Deep vein thrombosis 0.32 ± 0.59 0.31 ± 0.59 All outcomes NS</p>
<p>Langemo⁴¹ The Midwest Research Institute/National Database of Nursing Quality Indicators; % of patients who had a pressure ulcer on a given day to all patients assessed for a pressure ulcer; pressure ulcers that occurred post admission were documented as hospital-acquired. The Midwest Research Institute/National Database of Nursing Quality Indicators; Total nursing hours/patient day</p>	<p>Hospital 1 Patients Medical Unit ICU</p>	<p>Medical-surgical units in hospitals with <100 bed Hours RN hours LPN hours 9.6 5 1.7 ICU in hospitals with 200-299 beds Hours RN hours LPN hours 18 17.6 0.1 ICU units in hospitals <100 beds Hours RN hours LPN hours 15 8.7 0.7 Medical-surgical units in hospitals with 200-299 beds Hours RN hours LPN hours 7.8 4.8 1.2</p>	<p>Pressure ulcers, rate,% 4.10 0.00 13.10 0.00</p>

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
Langemo ³³ The North Dakota Nurses Association (NDNA) Research Council; Any lesion which is caused by unrelieved pressure that results in damage to underlying tissues; unplanned descent to the floor recorded in incidence reports. The North Dakota Nurses Association (NDNA) Research Council; Total number of productive hours worked by nursing staff with direct patient care responsibilities	Hospitals 6 Unit ICU Patients Medical Age 61.9 Sex 41	Acute care units 11 total nursing hours and 5.42 RN hours/patient day The authors compared the rate with published studies	Pressure ulcers, rate, % 8.60

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
Lichtig ⁶³ The Uniform Hospital Discharge Data Set; The California Office of Statewide Health Planning and Development; the Statewide Planning and Research Cooperative System Administratively Releasable file Urinary tract infection as the likely adverse patient outcomes of the hospital stay (secondary diagnosis), pneumonia as the likely adverse patient outcomes of the hospital stay (secondary diagnosis), pressure ulcers as the likely adverse patient outcomes of the hospital stay (secondary diagnosis), any secondary diagnosis of infection in surgical patients as the likely adverse patient outcomes of the hospital stay. The Annual Hospital Disclosure Report Institutional Cost Reports; Total RN hours per NIW-adjusted patient day	Unit Surgical Patients Surgical Hospitals 126 131 352 295	Increase by 1 hour in total nursing hours in New York, 1992 Increase by 1 hour in total nursing hours in New York, 1994 Increase by 1 hour in total nursing hours in California, 1992 Increase by 1 hour in total nursing hours in California, 1994 Increase by 1 hour in total nursing hours in New York, 1992 Increase by 1 hour in total nursing hours in California, 1994	Relative risk, Urinary tract infection, pneumonia, surgical wound infections, and pressure ulcers NS NS NS NS Rate, % Pressure ulcer Pneumonia -17.89 -15.59 7.65

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

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Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories					Patient Outcomes	
Mark ⁸⁹ The Healthcare Cost and Utilization Project (HCUP) National Inpatient Sample (NIS); Risk-adjusted observed/expected urinary tract infections, pneumonias, decubitus ulcers. American Hospital Association Annual Survey, Online Survey Certification and Reporting System [OSCAR]; RN hours/patient * day = (FTE RN/1,000patient * days * 37.5 * 48) / 1,000 LPN hours/patient * day = (FTE LPN/1,000 patient * days * 37.5 * 48) / 1,000	Hospitals 357 Unit Combined Patients Combined	Year	RN hours	LPN hours	Relative risk, 95% CI Urinary tract infection			
	1990	5.4	1.2	1.18	1.13	1.23		
	1992	5.8	1.2	1.17	1.11	1.23		
	1992	5.7	1.2	1.17	1.12	1.22		
	1993	6.0	1.1	1.14	1.08	1.20		
	1994	6.3	1.1	1.11	1.05	1.17		
	1995	6.5	1.1	0.98	0.93	1.03		
	1990	5.4	1.2	Pneumonia				
	1992	5.8	1.2	0.61	0.56	0.66		
	1992	5.7	1.2	0.72	0.67	0.77		
	1993	6.0	1.1	0.65	0.60	0.70		
	1994	6.3	1.1	0.84	0.79	0.89		
	1995	6.5	1.1	0.90	0.85	0.95		
	1995	6.5	1.1	0.97	0.91	1.03		
	1990	5.4	1.2	Decubitus ulcers				
	1992	5.8	1.2	0.48	0.44	0.52		
	1992	5.7	1.2	0.58	0.53	0.63		
	1993	6.0	1.1	0.51	0.46	0.56		
1994	6.3	1.1	0.62	0.57	0.67			
1995	6.5	1.1	0.69	0.63	0.75			
1995	6.5	1.1	0.74	0.69	0.79			
Needleman ²⁸ 799 hospitals (11 states, all-patients + Medicare patients) – hospital level analysis; 256 California hospitals (part of the 11 state sample) – unit level analysis; National sample of 3,357 hospitals (Medicare patients) – hospital level analysis. Urinary tract infection coded in discharge abstract as secondary diagnosis, acute gastric ulcer, duodenal ulcer, peptic ulcer, gastrojejunal ulcer, hemorrhagic gastritis,	Hospitals Patients	Sample	Hours	RN hours	LPN hours	UAP hours	Rate % ± SD Urinary tract infection	
	32	Medical	Nevada	12.8	9.6	1.1	2.3	4.92 ± 0.99
	280	Medical	New York	11.3	7.2	1.2	2.8	5.67 ± 1.87
	83	Medical	Maryland	11.2	8.2	0.6	2.4	6.10 ± 1.72
	128	Medical	Virginia	12.2	8.6	1.9	1.9	6.14 ± 1.88
	68	Medical	West Virginia	11.8	7.1	2.2	2.9	5.85 ± 2.18
	86	Medical	South Carolina	11.7	7.7	2	2.2	6.27 ± 2.30
	145	Medical	Wisconsin	12.7	8.9	0.9	3	5.89 ± 1.78
	154	Medical	Missouri	12.7	8.9	0.9	2.9	7.46 ± 2.28
	25	Medical	Arizona	12.4	9.9	0.7	1.9	4.99 ± 1.25
	127	Medical	Massachusetts	10.9	7.6	0.8	2.3	5.52 ± 1.76
	488	Medical	California	10.7	7.5	1	2.2	6.92 ± 2.83
	3,357	Medical	Medicare, medical patients	10.6	7.8	1.7		8.81 ± 3.01
		Medicare, surgical patients						

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions		Nurse Staffing Categories					Patient Outcomes
erosive gastritis, unspecified GI-hemorrhage, esophageal hemorrhage coded in discharge abstract as secondary diagnosis, aspiration pneumonia 507.0, post-operative pneumonia 997.3, hypostatic pneumonia 514, bacterial pneumonia 482, bronchopneumonia 485, unspecified pneumonia 486 coded in discharge abstract as secondary diagnosis, cardiac arrest, shock without mention of trauma, shock, unspecified, cardiogenic shock. shock, other, respiratory arrest, nonmechanical methods of resuscitation, cardiopulmonary resuscitation, closed chest massage, death in patients with sepsis, pneumonia, GI bleeding, shock or DVT coded in discharge abstract as secondary diagnosis, pressure ulcers coded with ICD 682 and 707.0 in discharge abstract as secondary diagnosis, pulmonary congestion/hypostasis, acute edema of lung, unspecified pulmonary insufficiency following trauma and surgery, respiratory failure, posttraumatic (958.3), postoperative (998.5), V.	3,296	Surgical		10.6	7.8	1.7		7.75 ± 5.94
	127	Surgical	Massachusetts	10.9	7.6	0.8	2.3	3.31 ± 1.72
	280	Surgical	New York	11.3	7.2	1.2	2.8	3.01 ± 1.31
	83	Surgical	Maryland	11.2	8.2	0.6	2.4	2.87 ± 1.63
	128	Surgical	Virginia	12.2	8.6	1.9	1.9	3.49 ± 2.28
	68	Surgical	West Virginia	11.8	7.1	2.2	2.9	6.95 ± 3.55
	86	Surgical	South Carolina	11.7	7.7	2	2.2	3.62 ± 3.30
	145	Surgical	Wisconsin	12.7	8.9	0.9	3	2.73 ± 1.63
	154	Surgical	Missouri	12.7	8.9	0.9	2.9	4.05 ± 2.33
	25	Surgical	Arizona	12.4	9.9	0.7	1.9	2.89 ± 1.44
	32	Surgical	Nevada	12.8	9	1.1	2.3	2.80 ± 0.84
	488	Surgical	California	10.7	7.5	1	2.2	2.95 ± 1.72
								Gastrointestinal bleeding
			Nevada	12.8	9.6	1.1	2.3	0.70 ± 0.34
			New York	11.3	7.2	1.2	2.8	1.05 ± 0.54
			Maryland	11.2	8.2	0.6	2.4	1.22 ± 0.43
			Virginia	12.2	8.6	1.9	1.9	0.96 ± 0.41
			West Virginia	11.8	7.1	2.2	2.9	0.52 ± 0.26
			South Carolina	11.7	7.7	2	2.2	0.89 ± 0.51
			Wisconsin	12.7	8.9	0.9	3	0.84 ± 0.44
			Missouri	12.7	8.9	0.9	2.9	1.21 ± 0.58
			Arizona	12.4	9.9	0.7	1.9	0.81 ± 0.41
			Massachusetts	10.9	7.6	0.8	2.3	0.83 ± 0.41
			California	10.7	7.5	1	2.2	1.18 ± 0.81
			Medicare, medical patients	10.6	7.8	1.7		1.53 ± 0.85
			Medicare, surgical patients	10.6	7.8	1.7		1.37 ± 1.78
			Massachusetts	10.9	7.6	0.8	2.3	0.35 ± 0.27
			New York	11.3	7.2	1.2	2.8	0.49 ± 0.42
		Maryland	11.2	8.2	0.6	2.4	0.58 ± 0.50	
		Virginia	12.2	8.6	1.9	1.9	0.38 ± 0.35	
		West Virginia	11.8	7.1	2.2	2.9	1.56 ± 1.09	
		South Carolina	11.7	7.7	2	2.2	0.44 ± 0.63	
		Wisconsin	12.7	8.9	0.9	3	0.36 ± 0.25	
		Missouri	12.7	8.9	0.9	2.9	0.49 ± 0.50	
		Arizona	12.4	9.9	0.7	1.9	0.32 ± 0.26	
		Nevada	12.8	9	1.1	2.3	0.59 ± 0.29	

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories					Patient Outcomes
iliaca-451.81, V. fem-451.11, V. pop.-451.19, post-op PE-415.11, PE-415.1, DVT NEC-453.8 coded in discharge abstract as secondary diagnosis, cardiac arrest, shock without mention of trauma, shock, unspecified cardiogenic shock, shock, other respiratory arrest, nonmechanical methods of resuscitation, cardiopulmonary resuscitation, closed chest massage, CNS complications (coma and stupor, acute delirium, reactive confusion, reactive depression); physiologic/metabolic derangement	California	10.7	7.5	1	2.2	0.48 ± 0.40	
	Nevada	12.8	9.6	1.1	2.3	2.61 ± 0.85	
	New York	11.3	7.2	1.2	2.8	2.36 ± 0.94	
	Maryland	11.2	8.2	0.6	2.4	2.38 ± 0.75	
	Virginia	12.2	8.6	1.9	1.9	2.58 ± 1.04	
	West Virginia	11.8	7.1	2.2	2.9	1.89 ± 0.84	
	South Carolina	11.7	7.7	2	2.2	2.19 ± 0.99	
	Wisconsin	12.7	8.9	0.9	3	1.89 ± 0.65	
	Missouri	12.7	8.9	0.9	2.9	3.57 ± 1.56	
	Arizona	12.4	9.9	0.7	1.9	2.01 ± 0.64	
	Massachusetts	10.9	7.6	0.8	2.3	0.56 ± 0.40	
	California	10.7	7.5	1	2.2	2.54 ± 0.98	
	Medicare, medical patients	10.6	7.8	1.7		3.72 ± 1.79	
	Medicare, surgical patients	10.6	7.8	1.7		3.42 ± 3.84	
	Massachusetts	10.9	7.6	0.8	2.3	0.12 ± 0.16	
	New York	11.3	7.2	1.2	2.8	0.98 ± 0.68	
	Maryland	11.2	8.2	0.6	2.4	1.18 ± 0.91	
	Virginia	12.2	8.6	1.9	1.9	1.32 ± 0.91	
	West Virginia	11.8	7.1	2.2	2.9	5.35 ± 2.92	
	South Carolina	11.7	7.7	2	2.2	2.00 ± 7.81	
	Wisconsin	12.7	8.9	0.9	3	0.74 ± 0.54	
	Missouri	12.7	8.9	0.9	2.9	1.56 ± 1.48	
	Arizona	12.4	9.9	0.7	1.9	0.84 ± 0.52	
	Nevada	12.8	9	1.1	2.3	1.68 ± 0.67	
	California	10.7	7.5	1	2.2	1.00 ± 0.68	
	Nevada	12.8	9.6	1.1	2.3	0.59 ± 0.30	
	New York	11.3	7.2	1.2	2.8	0.57 ± 0.32	
	Maryland	11.2	8.2	0.6	2.4	0.56 ± 0.27	
	Virginia	12.2	8.6	1.9	1.9	0.52 ± 0.42	
	West Virginia	11.8	7.1	2.2	2.9	0.18 ± 0.16	
South Carolina	11.7	7.7	2	2.2	0.49 ± 0.30		
Wisconsin	12.7	8.9	0.9	3	0.41 ± 0.23		
Missouri	12.7	8.9	0.9	2.9	0.48 ± 0.31		
Arizona	12.4	9.9	0.7	1.9	0.55 ± 0.24		

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Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories					Patient Outcomes
	Massachusetts	10.9	7.6	0.8	2.3	0.08 ± 0.08	
	California	10.7	7.5	1	2.2	0.80 ± 1.32	
	Medicare, medical patients	10.6	7.8	1.7		0.94 ± 0.72	
	Medicare, surgical patients	10.6	7.8	1.7		1.23 ± 1.97	
	Massachusetts	10.9	7.6	0.8	2.3	0.06 ± 0.09	
	New York	11.3	7.2	1.2	2.8	0.39 ± 0.33	
	Maryland	11.2	8.2	0.6	2.4	0.45 ± 0.40	
	Virginia	12.2	8.6	1.9	1.9	0.35 ± 0.43	
	West Virginia	11.8	7.1	2.2	2.9	1.56 ± 1.15	
	South Carolina	11.7	7.7	2	2.2	0.27 ± 0.33	
	Wisconsin	12.7	8.9	0.9	3	0.38 ± 0.62	
	Missouri	12.7	8.9	0.9	2.9	0.50 ± 0.63	
	Arizona	12.4	9.9	0.7	1.9	0.42 ± 0.34	
	Nevada	12.8	9	1.1	2.3	0.83 ± 0.34	
	California	10.7	7.5	1	2.2	0.59 ± 0.42	
						Failure to rescue	
	Nevada	12.8	9.6	1.1	2.3	18.68 ± 2.11	
	New York	11.3	7.2	1.2	2.8	22.62 ± 5.92	
	Maryland	11.2	8.2	0.6	2.4	18.83 ± 3.46	
	Virginia	12.2	8.6	1.9	1.9	16.54 ± 5.42	
	West Virginia	11.8	7.1	2.2	2.9	13.63 ± 6.21	
	South Carolina	11.7	7.7	2	2.2	19.05 ± 6.10	
	Wisconsin	12.7	8.9	0.9	3	16.15 ± 5.80	
	Missouri	12.7	8.9	0.9	2.9	16.10 ± 5.28	
	Arizona	12.4	9.9	0.7	1.9	16.76 ± 4.56	
	Massachusetts	10.9	7.6	0.8	2.3	14.74 ± 4.59	
	California	10.7	7.5	1	2.2	18.98 ± 5.37	
	Medicare, medical patients	10.6	7.8	1.7		19.97 ± 7.57	
	Medicare, surgical patients	10.6	7.8	1.7		22.75 ± 13.65	
	Massachusetts	10.9	7.6	0.8	2.3	13.02 ± 19.01	
	New York	11.3	7.2	1.2	2.8	20.88 ± 14.58	
	Maryland	11.2	8.2	0.6	2.4	20.72 ± 12.24	
	Virginia	12.2	8.6	1.9	1.9	19.51 ± 13.80	
	West Virginia	11.8	7.1	2.2	2.9	22.48 ± 12.19	

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories					Patient Outcomes
	South Carolina	11.7	7.7	2	2.2	16.59 ± 12.53	
	Wisconsin	12.7	8.9	0.9	3	13.00 ± 10.24	
	Missouri	12.7	8.9	0.9	2.9	17.36 ± 11.19	
	Arizona	12.4	9.9	0.7	1.9	18.39 ± 9.31	
	Nevada	12.8	9	1.1	2.3	21.58 ± 9.25	
	California	10.7	7.5	1	2.2	22.57 ± 11.85	
						Decubitus ulcer	
	Nevada	12.8	9.6	1.1	2.3	6.31 ± 3.80	
	New York	11.3	7.2	1.2	2.8	7.52 ± 4.13	
	Maryland	11.2	8.2	0.6	2.4	9.01 ± 3.62	
	Virginia	12.2	8.6	1.9	1.9	6.61 ± 2.58	
	West Virginia	11.8	7.1	2.2	2.9	5.22 ± 2.90	
	South Carolina	11.7	7.7	2	2.2	6.57 ± 4.44	
	Wisconsin	12.7	8.9	0.9	3	4.57 ± 2.86	
	Missouri	12.7	8.9	0.9	2.9	6.37 ± 2.94	
	Arizona	12.4	9.9	0.7	1.9	4.43 ± 2.56	
	Massachusetts	10.9	7.6	0.8	2.3	3.08 ± 1.63	
	California	10.7	7.5	1	2.2	9.20 ± 5.21	
	Medicare, surgical patients					Pulmonary failure	
		10.6	7.8	1.7		3.53 ± 3.20	
	Massachusetts	10.9	7.6	0.8	2.3	0.18 ± 0.23	
	New York	11.3	7.2	1.2	2.8	1.09 ± 0.82	
	Maryland	11.2	8.2	0.6	2.4	1.57 ± 1.15	
	Virginia	12.2	8.6	1.9	1.9	1.17 ± 0.95	
	West Virginia	11.8	7.1	2.2	2.9	2.19 ± 2.09	
	South Carolina	11.7	7.7	2	2.2	2.04 ± 7.81	
	Wisconsin	12.7	8.9	0.9	3	0.72 ± 0.51	
	Missouri	12.7	8.9	0.9	2.9	1.23 ± 0.85	
	Arizona	12.4	9.9	0.7	1.9	1.09 ± 0.62	
	Nevada	12.8	9	1.1	2.3	3.90 ± 1.44	
	California	10.7	7.5	1	2.2	1.24 ± 0.84	
						Pressure ulcers	
	Nevada	12.8	9.6	1.1	2.3	6.31 ± 3.80	
	New York	11.3	7.2	1.2	2.8	7.52 ± 4.13	
	Maryland	11.2	8.2	0.6	2.4	9.01 ± 3.62	
	Virginia	12.2	8.6	1.9	1.9	6.61 ± 2.58	
	West Virginia	11.8	7.1	2.2	2.9	5.22 ± 2.90	
	South Carolina	11.7	7.7	2	2.2	6.57 ± 4.44	

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories					Patient Outcomes
		Wisconsin	12.7	8.9	0.9	3	4.75 ± 2.86
		Missouri	12.7	8.9	0.9	2.9	6.37 ± 2.94
		Arizona	12.4	9.9	0.7	1.9	4.43 ± 2.56
		Massachusetts	10.9	7.6	0.8	2.3	3.08 ± 1.63
		California	10.7	7.5	1	2.2	9.20 ± 5.21
		Medicare, medical patients	10.6	7.8	1.7		6.78 ± 5.34
		Medicare, surgical patients	10.6	7.8	1.7		8.13 ± 8.31
		Massachusetts	10.9	7.6	0.8	2.3	2.99 ± 4.10
		New York	11.3	7.2	1.2	2.8	6.55 ± 5.01
		Maryland	11.2	8.2	0.6	2.4	7.07 ± 6.35
		Virginia	12.2	8.6	1.9	1.9	6.47 ± 9.22
		West Virginia	11.8	7.1	2.2	2.9	6.97 ± 6.19
		South Carolina	11.7	7.7	2	2.2	4.63 ± 4.31
		Wisconsin	12.7	8.9	0.9	3	2.87 ± 3.18
		Missouri	12.7	8.9	0.9	2.9	3.89 ± 4.87
		Arizona	12.4	9.9	0.7	1.9	4.11 ± 3.25
		Nevada	12.8	9	1.1	2.3	6.24 ± 6.06
		California	10.7	7.5	1	2.2	6.93 ± 7.98
							Deep vein thrombosis, pulmonary embolism
		Nevada	12.8	9.6	1.1	2.3	0.57 ± 0.31
		New York	11.3	7.2	1.2	2.8	0.48 ± 0.24
		Maryland	11.2	8.2	0.6	2.4	0.59 ± 0.34
		Virginia	12.2	8.6	1.9	1.9	0.50 ± 0.22
		West Virginia	11.8	7.1	2.2	2.9	0.43 ± 0.23
		South Carolina	11.7	7.7	2	2.2	0.40 ± 0.17
		Wisconsin	12.7	8.9	0.9	3	0.52 ± 0.39
		Missouri	12.7	8.9	0.9	2.9	0.64 ± 0.44
		Arizona	12.4	9.9	0.7	1.9	0.45 ± 0.19
		Massachusetts	10.9	7.6	0.8	2.3	0.34 ± 0.19
		California	10.7	7.5	1	2.2	0.51 ± 0.32
		Medicare, medical patients	10.6	7.8	1.7		0.68 ± 0.47
		Medicare, surgical patients	10.6	7.8	1.7		0.85 ± 1.10
		Massachusetts	10.9	7.6	0.8	2.3	0.19 ± 0.20

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories					Patient Outcomes
		New York	11.3	7.2	1.2	2.8	0.44 ± 0.30
		Maryland	11.2	8.2	0.6	2.4	0.49 ± 0.39
		Virginia	12.2	8.6	1.9	1.9	0.36 ± 0.37
		West Virginia	11.8	7.1	2.2	2.9	0.77 ± 0.86
		South Carolina	11.7	7.7	2	2.2	0.36 ± 0.30
		Wisconsin	12.7	8.9	0.9	3	0.46 ± 0.47
		Missouri	12.7	8.9	0.9	2.9	0.41 ± 0.36
		Arizona	12.4	9.9	0.7	1.9	0.27 ± 0.24
		Nevada	12.8	9	1.1	2.3	0.77 ± 0.42
		California	10.7	7.5	1	2.2	0.35 ± 0.39
		Surgical wounds infection					
		Medicare, surgical patients	10.6	7.8	1.7		1.09 ± 1.30
		Massachusetts	10.9	7.6	0.8	2.3	0.85 ± 0.46
		New York	11.3	7.2	1.2	2.8	0.91 ± 0.58
		Maryland	11.2	8.2	0.6	2.4	0.91 ± 0.52
		Virginia	12.2	8.6	1.9	1.9	0.70 ± 0.53
		West Virginia	11.8	7.1	2.2	2.9	0.38 ± 0.52
		South Carolina	11.7	7.7	2	2.2	0.69 ± 0.52
		Wisconsin	12.7	8.9	0.9	3	0.73 ± 0.45
		Missouri	12.7	8.9	0.9	2.9	0.67 ± 0.56
		Arizona	12.4	9.9	0.7	1.9	0.72 ± 0.39
		Nevada	12.8	9	1.1	2.3	0.85 ± 0.40
		California	10.7	7.5	1	2.2	0.83 ± 0.58
		Sepsis					
		Nevada	12.8	9.6	1.1	2.3	1.47 ± 0.49
		New York	11.3	7.2	1.2	2.8	1.30 ± 0.56
		Maryland	11.2	8.2	0.6	2.4	1.53 ± 0.63
		Virginia	12.2	8.6	1.9	1.9	1.04 ± 0.78
		West Virginia	11.8	7.1	2.2	2.9	0.49 ± 0.35
		South Carolina	11.7	7.7	2	2.2	1.12 ± 0.54
		Wisconsin	12.7	8.9	0.9	3	1.00 ± 0.73
		Missouri	12.7	8.9	0.9	2.9	1.10 ± 0.60
		Arizona	12.4	9.9	0.7	1.9	1.58 ± 0.78
		Massachusetts	10.9	7.6	0.8	2.3	0.35 ± 0.19
		California	10.7	7.5	1	2.2	1.71 ± 1.04
		Medicare, medical patients	10.6	7.8	1.7		1.33 ± 0.98

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
		Medicare, surgical patients	
		10.6 7.8 1.7	2.37 ± 2.35
		Massachusetts 10.9 7.6 0.8 2.3	0.15 ± 0.23
		New York 11.3 7.2 1.2 2.8	1.06 ± 0.80
		Maryland 11.2 8.2 0.6 2.4	1.35 ± 0.85
		Virginia 12.2 8.6 1.9 1.9	0.91 ± 0.98
		West Virginia 11.8 7.1 2.2 2.9	1.30 ± 1.07
		South Carolina 11.7 7.7 2 2.2	0.79 ± 0.62
		Wisconsin 12.7 8.9 0.9 3	0.65 ± 0.47
		Missouri 12.7 8.9 0.9 2.9	0.85 ± 0.83
		Arizona 12.4 9.9 0.7 1.9	0.94 ± 0.60
		Nevada 12.8 9 1.1 2.3	1.84 ± 0.80
		California 10.7 7.5 1 2.2	1.19 ± 0.82
			Relative risk, 95% CI
		Increase by 1 hour of RN hours in medical patients	0.99 0.98 0.99
		Increase by 1 hour in RN hours in surgical patients	1.00 0.98 1.02
		Increase by 1 hour in LPN hours in medical patients	1.06 1.04 1.09
		Increase by 1 hour in LPN hours in surgical patients	1.04 1.01 1.08
		Increase by 1 hour in UAP hours in medical patients	1.00 0.98 1.01
		Increase by 1 hour in UAP hours in surgical patients	1.00 0.98 1.02
		Increase by 1 hour in total nursing hours in medical patients	1.00 1.00 1.01
		Increase by 1 hour in total nursing hours in surgical patients	1.01 1.00 1.02
		Increase by 1 hour in licensed hours/patient-day in medical patients	1.00 0.99 1.01
		increase by 1% of RN hours/total licensed hours per patient day in medical patients	0.48 0.38 0.61
		Increase by 1 hour in licensed hours/patient-day in surgical patients	1.01 0.99 1.02
		Increase by 1 hour in RN hours in medical patients	0.99 0.99 1.00
		Increase by 1 hour in LPN hours in medical patients	1.01 1.00 1.02
		Increase by 1 hour in licensed hours in medical patients	1.00 0.99 1.00
		Increase in total nurse hours in medical patients	1.00 0.99 1.01
		Increase by 1 hour in UAP hours in medical patients	0.99 0.98 1.01
		Increase by 1 hour in RN hours in surgical patients	0.99 0.98 1.00
		Increase by 1 hour in LPN in surgical patients	1.00 0.99 1.01
		Increase by 1 hour in licensed hours in surgical patients	0.99 0.99 1.00
		Increase by 1 hour in UAP hours in surgical patients	1.00 0.98 1.02
		Increase by 1 hour in total nursing hours	1.00 0.99 1.02
		Increase by 1 hour in RN hours in medical patients, hospital level analysis, California hospitals	0.99 0.97 1.00

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes		
		Increase by 1 hour in LPN hours in medical patients, hospital level analysis, California hospitals	1.10	1.03	1.17
		Increase by 1 hour in UAP hours in medical patients, hospital level analysis, California hospitals	1.00	0.97	1.03
		Increase by 1 hour in total nursing hours in medical patients, hospital level analysis, California hospitals	1.00	0.98	1.01
		Increase by 1 hour of licensed nursing hours in medical patients, hospital level analysis, California hospitals	1.00	0.99	1.02
		Increase by 1 hour of RN hours in medical patients, unit level analysis, California hospitals	0.98	0.96	1.00
		Increase by 1 hour in LPN hours in medical patients, unit level analysis, California hospitals	1.05	0.99	1.12
		Increase by 1 hour in UAP hours/patient-day in medical patients, unit level analysis, California hospitals	0.99	0.95	1.02
		Increase by 1 hour in total nursing hours in medical patients, unit level analysis, California hospitals.	0.99	0.97	1.01
		Increase by 1 hour of total licensed hours in medical patients, unit level analysis, California hospitals	0.99	0.97	1.01
		Increase by 1 hour of RN hours in surgical patients, hospital level analysis, California hospitals	0.87	0.77	0.99
		Increase by 1 hour in LPN hours in surgical patients, hospital level analysis, California hospitals	1.02	0.93	1.11
		Increase by 1 hour in UAP hours in surgical patients, hospital level analysis, California hospitals	1.00	0.95	1.05
		Increase by 1 hour in total nursing hours in surgical patients, hospital level analysis, California hospitals	1.00	0.98	1.03
		Increase by 1 hour in licensed hours in surgical patients, hospital level analysis, California hospitals	0.89	0.80	0.99
		Increase by 1% in RN hours/licensed hours in surgical patients, hospital level analysis, California hospitals	0.64	0.30	1.37
		Increase by 1 hour of RN hours in surgical patients, unit level analysis, California hospitals	0.77	0.59	0.99
		Increase by 1 hour in LPN hours in surgical patients, unit level analysis, California hospitals	1.03	0.94	1.13
		Increase by 1 hour in UAP hours in surgical patients, unit level analysis, California hospitals	1.01	0.95	1.08
		Increase by 1 hour in total nursing hours in surgical patients, unit level analysis, California hospitals	0.81	0.66	0.98

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes		
		Increase by 1 hour in licensed hours in surgical patients, unit level analysis, California hospitals	0.70	0.48	1.04
		1% increase in RN hours/total licensed hours (RN + LPN)	0.49	0.37	0.61
		Increase by 1 licensed hour (RN + LPN)/patient day	1.01	0.99	1.02
		Increase by 1 licensed hour (RN + LPN)/patient day	0.99	0.99	1.00
		Increase by 1 licensed hour (RN + LPN)/patient day	1.00	0.99	1.02
		Increase by 1 licensed hour (RN + LPN)/patient day	1.00	0.99	1.00
		Increase by 1 licensed hour (RN + LPN)/patient day	1.00	0.99	1.01
		Increase by 1 licensed hour (RN + LPN)/patient day	1.00	0.99	1.01
		Increase by 1 hour of RN in surgical patients	1.00	0.98	1.02
		Increase by 1 hour of RN in medical patients	0.99	0.98	1.00
			Gastrointestinal bleeding		
		Increase by 1 hour of RN hours in medical patients	0.98	0.97	0.99
		Increase by 1 hour in RN hours in surgical patients	0.98	0.96	1.01
		Increase by 1 hour in LPN hours in medical patients	1.02	0.98	1.06
		Increase by 1 hour in LPN hours in surgical patients	1.03	0.96	1.10
		Increase by 1 hour in UAP hours in medical patients	1.00	0.98	1.02
		Increase by 1 hour in UAP hours in surgical patients	1.00	0.97	1.04
		Increase by 1 hour in total nursing hours in medical patients	0.99	0.98	1.01
		Increase by 1 hour in total nursing hours in surgical patients	0.99	0.97	1.01
		Increase by 1 hour in licensed hours/patient-day in medical patients	0.99	0.97	1.00
		increase by 1% of RN hours/total licensed hours per patient day in medical patients	0.66	0.45	0.96
		Increase by 1 hour in licensed hours/patient day in surgical patients	0.99	0.96	1.01
		Increase by 1 hour in RN hours in medical patients	0.99	0.99	1.00
		Increase by 1 hour in LPN hours in medical patients	0.99	0.98	1.01
		Increase by 1 hour in licensed hours in medical patients	0.99	0.99	1.00
		Increase in total nurse hours in medical patients	0.99	0.97	1.00
		Increase by 1 hour in UAP hours in medical patients	1.00	0.97	1.02
		Increase by 1 hour in RN hours in surgical patients	0.98	0.98	0.99
		Increase by 1 hour in LPN in surgical patients	1.00	0.98	1.02
		Increase by 1 hour in licensed hours in surgical patients	0.99	0.98	0.99
		Increase by 1 hour in UAP hours in surgical patients	1.00	0.95	1.04
		Increase by 1 hour in total nursing hours	0.99	0.97	1.02
		Increase by 1 hour in RN hours in medical patients, hospital level analysis, California hospitals	0.98	0.96	1.00
		Increase by 1 hour in LPN hours in medical patients, hospital level analysis, California hospitals	1.02	0.93	1.11

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes		
		Increase by 1 hour in UAP hours in medical patients, hospital level analysis, California hospitals	0.99	0.95	1.04
		Increase by 1 hour in total nursing hours in medical patients, hospital level analysis, California hospitals	0.99	0.97	1.01
		Increase by 1 hour of licensed nursing hours in medical patients, hospital level analysis, California hospitals	0.98	0.96	1.01
		Increase by 1 hour of RN hours in medical patients, unit level analysis, California hospitals	0.98	0.95	1.01
		Increase by 1 hour in LPN hours in medical patients, unit level analysis, California hospitals	1.01	0.92	1.10
		Increase by 1 hour in UAP hours/patient-day in medical patients, unit level analysis, California hospitals	0.99	0.93	1.04
		Increase by 1 hour in total nursing hours in medical patients, unit level analysis, California hospitals.	0.99	0.96	1.01
		Increase by 1 hour of total licensed hours in medical patients, unit level analysis, California hospitals	0.98	0.95	1.02
		Increase by 1 hour of RN hours in surgical patients, hospital level analysis, California hospitals	1.01	0.98	1.05
		Increase by 1 hour in LPN hours in surgical patients, hospital level analysis, California hospitals	1.05	0.91	1.20
		Increase by 1 hour in UAP hours in surgical patients, hospital level analysis, California hospitals	1.00	0.93	1.08
		Increase by 1 hour in total nursing hours in surgical patients, hospital level analysis, California hospitals	0.85	0.67	1.09
		Increase by 1 hour in licensed hours in surgical patients, hospital level analysis, California hospitals	1.02	0.98	1.06
		Increase by 1% in RN hours/licensed hours in surgical patients, hospital level analysis, California hospitals	0.72	0.22	2.37
		Increase by 1 hour of RN hours in surgical patients, unit level analysis, California hospitals	1.03	0.98	1.08
		Increase by 1 hour in LPN hours in surgical patients, unit level analysis, California hospitals	1.09	0.94	1.26
		Increase by 1 hour in UAP hours in surgical patients, unit level analysis, California hospitals	0.96	0.88	1.06
		Increase by 1 hour in total nursing hours in surgical patients, unit level analysis, California hospitals	0.74	0.57	0.96
		Increase by 1 hour in licensed hours in surgical patients, unit level analysis, California hospitals	1.04	0.99	1.09

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes		
		1% increase in RN hours/total licensed hours (RN + LPN)	0.66	0.41	0.90
		Increase by 1 licensed hour (RN + LPN)/patient day	0.99	0.96	1.01
		Increase by 1 licensed hour (RN + LPN)/patient day	0.99	0.98	0.99
		Increase by 1 licensed hour (RN + LPN)/patient day	0.99	0.96	1.02
		Increase by 1 licensed hour (RN + LPN)/patient day	0.99	0.99	1.00
		Increase by 1 licensed hour (RN + LPN)/patient day	0.99	0.97	1.00
		Increase by 1 licensed hour (RN + LPN)/patient day	0.99	0.97	1.00
		Increase by 1 hour of RN in medical patients	0.98	0.97	0.99
			Pneumonia		
		Increase by 1 hour of RN hours in medical patients	0.99	0.98	1.00
		Increase by 1 hour in RN hours in surgical patients	1.00	0.98	1.03
		Increase by 1 hour in LPN hours in medical patients	1.05	1.01	1.08
		Increase by 1 hour in LPN hours in surgical patients	1.07	1.01	1.14
		Increase by 1 hour in UAP hours in medical patients	1.00	0.99	1.02
		Increase by 1 hour in UAP hours in surgical patients	1.00	0.97	1.04
		Increase by 1 hour in total nursing hours in medical patients	1.00	0.99	1.01
		Increase by 1 hour in total nursing hours in surgical patients	1.02	1.00	1.05
		Increase by 1 hour in licensed hours/patient-day in medical patients	1.00	0.99	1.01
		increase by 1% of RN hours/total licensed hours per patient day in medical patients	0.59	0.44	0.80
		Increase by 1 hour in licensed hours/patient day in surgical patients	1.02	0.99	1.04
		Increase by 1 hour in RN hours in medical patients	1.00	0.99	1.00
		Increase by 1 hour in LPN hours in medical patients	1.01	1.00	1.02
		Increase by 1 hour in licensed hours in medical patients	1.00	0.99	1.00
		Increase in total nurse hours in medical patients	1.10	1.01	1.19
		Increase by 1 hour in UAP hours in medical patients	1.00	1.10	0.91
		Increase by 1 hour in RN hours in surgical patients	0.99	0.98	1.00
		Increase by 1 hour in LPN in surgical patients	0.99	0.98	1.01
		Increase by 1 hour in licensed hours in surgical patients	0.99	0.98	1.00
		Increase by 1 hour in UAP hours in surgical patients	1.01	0.97	1.05
		Increase by 1 hour in total nursing hours	1.03	1.00	1.05
		Increase by 1 hour in RN hours in medical patients, hospital level analysis, California hospitals	0.99	0.97	1.01
		Increase by 1 hour in LPN hours in medical patients, hospital level analysis, California hospitals	1.08	1.01	1.15
		Increase by 1 hour in UAP hours in medical patients, hospital level analysis, California hospitals	0.99	0.96	1.02
		Increase by 1 hour in total nursing hours in medical patients,	1.00	0.99	1.01

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes		
		hospital level analysis, California hospitals	1.00	0.99	1.02
		Increase by 1 hour of licensed nursing hours in medical patients, hospital level analysis, California hospitals			
		Increase by 1 hour of RN hours in medical patients, unit level analysis, California hospitals	0.98	0.96	1.00
		Increase by 1 hour in LPN hours in medical patients, unit level analysis, California hospitals	1.04	0.97	1.10
		Increase by 1 hour in UAP hours/patient day in medical patients, unit level analysis, California hospitals	0.98	0.95	1.02
		Increase by 1 hour in total nursing hours in medical patients, unit level analysis, California hospitals.	0.99	0.97	1.01
		Increase by 1 hour of total licensed hours in medical patients, unit level analysis, California hospitals	0.99	0.97	1.01
		Increase by 1 hour of RN hours in surgical patients, hospital level analysis, California hospitals	1.02	0.99	1.04
		Increase by 1 hour in LPN hours in surgical patients, hospital level analysis, California hospitals	1.06	0.95	1.19
		Increase by 1 hour in UAP hours in surgical patients, hospital level analysis, California hospitals	1.07	1.01	1.14
		Increase by 1 hour in total nursing hours in surgical patients, hospital level analysis, California hospitals	1.03	1.01	1.06
		Increase by 1 hour in licensed hours in surgical patients, hospital level analysis, California hospitals	1.02	0.99	1.05
		Increase by 1% in RN hours/licensed hours in surgical patients, hospital level analysis, California hospitals	0.66	0.26	1.69
		Increase by 1 hour of RN hours in surgical patients, unit level analysis, California hospitals	1.02	0.98	1.07
		Increase by 1 hour in LPN hours in surgical patients, unit level analysis, California hospitals	1.06	0.95	1.19
		Increase by 1 hour in UAP hours in surgical patients, unit level analysis, California hospitals	1.06	0.98	1.14
		Increase by 1 hour in total nursing hours in surgical patients, unit level analysis, California hospitals	1.03	0.99	1.08
		Increase by 1 hour in licensed hours in surgical patients, unit level analysis, California hospitals	1.03	0.99	1.07
		1% increase in RN hours/total licensed hours (RN + LPN)	0.61	0.42	0.79
		Increase by 1 licensed hour (RN + LPN)/patient day	1.02	0.99	1.04
		Increase by 1 licensed hour (RN + LPN)/patient day	0.99	0.98	0.99

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes		
		Increase by 1 licensed hour (RN + LPN)/patient day	1.02	0.99	1.04
		Increase by 1 licensed hour (RN + LPN)/patient day	1.00	0.99	1.00
		Increase by 1 licensed hour (RN + LPN)/patient day	1.00	0.99	1.01
		Increase by 1 licensed hour (RN + LPN)/patient day	1.00	0.99	1.01
		Increase by 1 hour of RN in medical patients	0.99	0.98	1.00
			Shock		
		Increase by 1 hour of RN hours in medical patients	0.98	0.96	1.00
		Increase by 1 hour in RN hours in surgical patients	0.99	0.96	1.02
		Increase by 1 hour in LPN hours in medical patients	1.07	1.01	1.12
		Increase by 1 hour in LPN hours in surgical patients	1.04	0.98	1.11
		Increase by 1 hour in UAP hours in medical patients	1.02	0.98	1.05
		Increase by 1 hour in UAP hours in surgical patients	0.98	0.94	1.03
		Increase by 1 hour in total nursing hours in medical patients	0.84	0.71	0.99
		Increase by 1 hour in total nursing hours in surgical patients	0.99	0.97	1.01
		Increase by 1 hour in licensed hours/patient-day in medical patients	1.00	0.97	1.02
		Increase by 1% of RN hours/total licensed hours per patient day in medical patients	0.46	0.27	0.81
		Increase by 1 hour in licensed hours/patient day in surgical patients	1.00	0.97	1.02
		Increase by 1 hour in RN hours in medical patients	0.99	0.98	1.00
		Increase by 1 hour in LPN hours in medical patients	1.03	1.01	1.05
		Increase by 1 hour in licensed hours in medical patients	1.00	0.99	1.01
		Increase in total nurse hours in medical patients	1.00	0.99	1.02
		Increase by 1 hour in UAP hours in medical patients	1.03	0.99	1.06
		Increase by 1 hour in RN hours in surgical patients	0.99	0.98	1.00
		Increase by 1 hour in LPN in surgical patients	1.03	1.01	1.04
		Increase by 1 hour in licensed hours in surgical patients	1.00	0.99	1.00
		Increase by 1 hour in UAP hours in surgical patients	1.01	0.96	1.06
		Increase by 1 hour in total nursing hours	1.00	0.98	1.03
		Increase by 1 hour in RN hours in medical patients, hospital level analysis, California hospitals	0.97	0.94	1.00
		Increase by 1 hour in LPN hours in medical patients, hospital level analysis, California hospitals	1.17	1.04	1.31
		Increase by 1 hour in UAP hours in medical patients, hospital level analysis, California hospitals	1.08	1.01	1.16
		Increase by 1 hour in total nursing hours in medical patients, hospital level analysis, California hospitals	1.02	0.99	1.04
		Increase by 1 hour of licensed nursing hours in medical patients, hospital level analysis, California hospitals	1.00	0.97	1.03

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes		
		Increase by 1 hour of RN hour in medical patients, unit level analysis, California hospitals	0.97	0.92	1.01
		Increase by 1 hour in LPN hours in medical patients, unit level analysis, California hospitals	1.08	0.95	1.21
		Increase by 1 hour in UAP hours/patient day in medical patients, unit level analysis, California hospitals	1.08	1.00	1.17
		Increase by 1 hour in total nursing hours in medical patients, unit level analysis, California hospitals.	1.01	0.97	1.05
		Increase by 1 hour of total licensed hours in medical patients, unit level analysis, California hospitals	0.99	0.27	3.62
		Increase by 1 hour of RN hours in surgical patients, hospital level analysis, California hospitals	0.97	0.94	1.00
		Increase by 1 hour in LPN hours in surgical patients, hospital level analysis, California hospitals	1.18	1.06	1.32
		Increase by 1 hour in UAP hours in surgical patients, hospital level analysis, California hospitals	1.01	0.94	1.08
		Increase by 1 hour in total nursing hours in surgical patients, hospital level analysis, California hospitals	1.00	0.97	1.03
		Increase by 1 hour in licensed hours in surgical patients, hospital level analysis, California hospitals	0.99	0.96	1.03
		Increase by 1% in RN hours/licensed hours in surgical patients, hospital level analysis, California hospitals	0.22	0.09	0.57
		Increase by 1 hour of RN hours in surgical patients, unit level analysis, California hospitals	1.55	1.12	2.15
		Increase by 1 hour in LPN hours in surgical patients, unit level analysis, California hospitals	1.21	1.07	1.36
		Increase by 1 hour in UAP hours in surgical patients, unit level analysis, California hospitals	1.94	1.11	3.40
		Increase by 1 hour in total nursing hours in surgical patients, unit level analysis, California hospitals	1.01	0.97	1.06
		Increase by 1 hour in licensed hours in surgical patients, unit level analysis, California hospitals	1.68	1.05	2.69
		1% increase in RN hours/total licensed hours (RN + LPN)	0.49	0.21	0.77
		Increase by 1 licensed hour (RN + LPN)/patient day	1.00	0.97	1.02
		Increase by 1 licensed hour (RN + LPN)/patient day	1.00	0.99	1.00
		Increase by 1 licensed hour (RN + LPN)/patient day	1.00	0.97	1.03
		Increase by 1 licensed hour (RN + LPN)/patient day	1.00	0.99	1.01
		Increase by 1 licensed hour (RN + LPN)/patient day	1.00	0.97	1.02

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes		
		Increase by 1 licensed hour (RN +LPN)/patient day	1.00	0.97	1.02
		Increase by 1 hour of RN in medical patients	0.98	0.96	1.01
			Failure to rescue		
		Increase by 1 hour of RN hours in medical patients	1.00	0.99	1.01
		Increase by 1 hour in RN hours in surgical patients	0.98	0.96	0.99
		Increase by 1 hour in LPN hours in medical patients	1.02	1.00	1.04
		Increase by 1 hour in LPN hours in surgical patients	1.01	0.97	1.06
		Increase by 1 hour in UAP hours in medical patients	1.01	1.00	1.03
		Increase by 1 hour in UAP hours in surgical patients	1.02	0.99	1.04
		Increase by 1 hour in total nursing hours in medical patients	1.01	1.00	1.01
		Increase by 1 hour in total nursing hours in surgical patients	0.99	0.98	1.01
		Increase by 1 hour in licensed hours/patient-day in medical patients	1.00	0.99	1.01
		Increase by 1% of RN hours/total licensed hours per patient day in medical patients	0.81	0.66	1.00
		Increase by 1 hour in licensed hours/patient day in surgical patients	0.98	0.97	1.00
		Increase by 1 hour in RN hours in medical patients	1.00	0.99	1.00
		Increase by 1 hour in LPN hours in medical patients	1.01	1.00	1.01
		Increase by 1 hour in licensed hours in medical patients	1.00	1.00	1.00
		Increase in total nurse hours in medical patients	1.01	1.00	1.01
		Increase by 1 hour in UAP hours in medical patients	1.01	1.00	1.03
		Increase by 1 hour in RN hours in surgical patients	0.97	0.95	1.00
		Increase by 1 hour in LPN in surgical patients	1.01	1.00	1.02
		Increase by 1 hour in licensed hours in surgical patients	1.00	0.99	1.00
		Increase by 1 hour in UAP hours in surgical patients	1.01	0.98	1.04
		Increase by 1 hour in total nursing hours	0.99	0.97	1.00
		Increase by 1 hour in RN hours in medical patients, hospital level analysis, California hospitals	0.99	0.98	1.00
		Increase by 1 hour in LPN hours in medical patients, hospital level analysis, California hospitals	1.05	1.00	1.11
		Increase by 1 hour in UAP hours in medical patients, hospital level analysis, California hospitals	1.03	1.01	1.06
		Increase by 1 hour in total nursing hours in medical patients, hospital level analysis, California hospitals	1.01	0.99	1.02
		Increase by 1 hour of licensed nursing hours in medical patients, hospital level analysis, California hospitals	1.00	0.98	1.01
		Increase by 1 hour of RN hours in medical patients, unit level analysis, California hospitals	0.99	0.97	1.01
		Increase by 1 hour in LPN hours in medical patients, unit level	1.04	0.99	1.09

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes		
		analysis, California hospitals			
		Increase by 1 hour in UAP hours/patient day in medical patients, unit level analysis, California hospitals	1.03	1.00	1.06
		Increase by 1 hour in total nursing hours in medical patients, unit level analysis, California hospitals.	1.00	0.99	1.02
		Increase by 1 hour of total licensed hours in medical patients, unit level analysis, California hospitals	1.00	0.98	1.02
		Increase by 1 hour of RN hours in surgical patients, hospital level analysis, California hospitals	0.96	0.94	0.99
		Increase by 1 hour in LPN hours in surgical patients, hospital level analysis, California hospitals	1.09	1.00	1.19
		Increase by 1 hour in UAP hours in surgical patients, hospital level analysis, California hospitals	1.00	0.96	1.05
		Increase by 1 hour in total nursing hours in surgical patients, hospital level analysis, California hospitals	1.90	1.29	2.79
		Increase by 1 hour in licensed hours in surgical patients, hospital level analysis, California hospitals	1.12	1.03	1.22
		Increase by 1% in RN hours/licensed hours in surgical patients, hospital level analysis, California hospitals	0.45	0.22	0.92
		Increase by 1 hour of RN hours in surgical patients, unit level analysis, California hospitals	0.96	0.92	0.99
		Increase by 1 hour in LPN hours in surgical patients, unit level analysis, California hospitals	1.07	0.97	1.17
		Increase by 1 hour in UAP hours in surgical patients, unit level analysis, California hospitals	1.01	0.95	1.06
		Increase by 1 hour in total nursing hours in surgical patients, unit level analysis, California hospitals	0.98	0.95	1.01
		Increase by 1 hour in licensed hours in surgical patients, unit level analysis, California hospitals	1.41	1.00	1.99
		1% increase in RN hours/total licensed hours (RN + LPN)	0.80	0.64	0.97
		Increase by 1 licensed hour (RN + LPN)/patient day	0.98	0.97	1.00
		Increase by 1 licensed hour (RN + LPN)/patient day	1.00	0.99	1.00
		Increase by 1 licensed hour (RN + LPN)/patient day	0.98	0.96	1.00
		Increase by 1 licensed hour (RN + LPN)/patient day	1.00	1.00	1.00
		Increase by 1 licensed hour (RN + LPN)/patient day	1.00	0.99	1.01
		Increase by 1 licensed hour (RN + LPN)/patient day	1.00	1.00	1.01
		Increase by 1 hour of RN in surgical patients	0.98	0.96	0.99
		Increase by 1 hour of RN in medical patients	1.00	0.99	1.01

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes		
			Deep vein thrombosis, pulmonary embolism		
		Increase by 1 hour of RN hours in medical patients	1.01	0.99	1.03
		Increase by 1 hour in RN hours in surgical patients	1.03	1.00	1.06
		Increase by 1 hour in LPN hours in medical patients	0.97	0.93	1.01
		Increase by 1 hour in LPN hours in surgical patients	1.01	0.94	1.08
		Increase by 1 hour in UAP hours in medical patients	1.01	0.98	1.03
		Increase by 1 hour in UAP hours in surgical patients	1.01	0.96	1.05
		Increase by 1 hour in total nursing hours in medical patients	1.00	0.98	1.02
		Increase by 1 hour in total nursing hours in surgical patients	1.02	1.00	1.05
		Increase by 1 hour in licensed hours/patient-day in medical patients	1.01	0.99	1.02
		Increase by 1% of RN hours/total licensed hours per patient day in medical patients	1.39	0.92	2.11
		Increase by 1 hour in licensed hours/patient day in surgical patients	1.03	1.00	1.05
		Increase by 1 hour in RN hours in medical patients	1.00	0.99	1.01
		Increase by 1 hour in LPN hours in medical patients	0.99	0.97	1.00
		Increase by 1 hour in licensed hours in medical patients	1.00	0.99	1.01
		Increase in total nurse hours in medical patients	1.00	0.99	1.02
		Increase by 1 hour in UAP hours in medical patients	1.00	0.97	1.04
		Increase by 1 hour in RN hours in surgical patients	1.00	0.99	1.01
		Increase by 1 hour in LPN in surgical patients	0.97	0.95	0.99
		Increase by 1 hour in licensed hours in surgical patients	1.00	0.99	1.01
		Increase by 1 hour in UAP hours in surgical patients	0.99	0.95	1.04
		Increase by 1 hour in total nursing hours in surgical patients	1.01	0.99	1.04
		Increase by 1 hour in RN hours in medical patients, hospital level analysis, California hospitals	1.00	0.98	1.03
		Increase by 1 hour in LPN hours in medical patients, hospital level analysis, California hospitals	0.91	0.83	1.01
		Increase by 1 hour in UAP hours in medical patients, hospital level analysis, California hospitals	1.01	0.95	1.07
		Increase by 1 hour in total nursing hours in medical patients, hospital level analysis, California hospitals	1.00	0.97	1.02
		Increase by 1 hour of licensed nursing hours in medical patients, hospital level analysis, California hospitals	0.99	0.96	1.02
		Increase by 1 hour of RN hours in medical patients, unit level analysis, California hospitals	1.02	0.98	1.06
		Increase by 1 hour in LPN hours in medical patients, unit level analysis, California hospitals	0.50	0.27	0.95

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes		
		Increase by 1 hour in UAP hours/patient day in medical patients, unit level analysis, California hospitals	1.04	0.96	1.12
		Increase by 1 hour in total nursing hours in medical patients, unit level analysis, California hospitals.	1.02	0.98	1.06
		Increase by 1 hour of total licensed hours in medical patients, unit level analysis, California hospitals	1.01	0.97	1.05
		Increase by 1 hour of RN hours in surgical patients, hospital level analysis, California hospitals	1.07	1.03	1.11
		Increase by 1 hour in LPN hours in surgical patients, hospital level analysis, California hospitals	1.05	0.85	1.29
		Increase by 1 hour in UAP hours in surgical patients, hospital level analysis, California hospitals	1.02	0.93	1.12
		Increase by 1 hour in total nursing hours in surgical patients, hospital level analysis, California hospitals	1.06	1.02	1.10
		Increase by 1 hour in licensed hours in surgical patients, hospital level analysis, California hospitals	1.07	1.02	1.12
		Increase by 1% in RN hours/licensed hours in surgical patients, hospital level analysis, California hospitals	0.03	0.00	0.66
		Increase by 1 hour of RN hours in surgical patients, unit level analysis, California hospitals	1.11	1.05	1.17
		Increase by 1 hour in LPN hours in surgical patients, unit level analysis, California hospitals	1.09	0.89	1.33
		Increase by 1 hour in UAP hours in surgical patients, unit level analysis, California hospitals	1.03	0.92	1.14
		Increase by 1 hour in total nursing hours in surgical patients, unit level analysis, California hospitals	1.09	1.03	1.15
		Increase by 1 hour in licensed hours in surgical patients, unit level analysis, California hospitals	1.55	0.18	13.15
		1% increase in RN hours/total licensed hours (RN + LPN)	Sepsis		
		Increase by 1 hour of RN hours in medical patients	1.04	1.01	1.08
		Increase by 1 hour in RN hours in surgical patients	1.01	0.98	1.03
		Increase by 1 hour in LPN hours in medical patients	0.96	0.93	1.00
		Increase by 1 hour in LPN hours in surgical patients	1.00	0.95	1.05
		Increase by 1 hour in UAP hours in medical patients	1.01	0.98	1.03
		Increase by 1 hour in UAP hours in surgical patients	0.99	0.96	1.03
		Increase by 1 hour in total nursing hours in medical patients	1.00	0.98	1.01
		Increase by 1 hour in total nursing hours in surgical patients	1.00	0.98	1.02
		Increase by 1 hour in licensed hours/patient day in medical patients	0.99	0.98	1.00
			1.34	0.91	1.97

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes		
		Increase by 1% of RN hours/total licensed hours per patient day in medical patients	1.01	0.99	1.03
		Increase by 1 hour in licensed hours/patient day in surgical patients	1.00	0.99	1.01
		Increase by 1 hour in RN hours in medical patients	0.98	0.97	0.99
		Increase by 1 hour in LPN hours in medical patients	0.99	0.99	1.00
		Increase by 1 hour in licensed hours in medical patients	0.99	0.98	1.01
		Increase in total nurse hours in medical patients	1.01	0.99	1.04
		Increase by 1 hour in UAP hours in medical patients	0.99	0.98	0.99
		Increase by 1 hour in RN hours in surgical patients	0.98	0.96	0.99
		Increase by 1 hour in LPN in surgical patients	0.96	0.95	0.97
		Increase by 1 hour in licensed hours in surgical patients	1.01	0.97	1.04
		Increase by 1 hour in UAP hours in surgical patients	0.99	0.97	1.01
		Increase by 1 hour in total nursing hours	1.01	0.99	1.04
		Increase by 1 hour in RN hours in medical patients, hospital level analysis, California hospitals	0.96	0.88	1.06
		Increase by 1 hour in LPN hours in medical patients, hospital level analysis, California hospitals	1.02	0.97	1.07
		Increase by 1 hour in UAP hours in medical patients, hospital level analysis, California hospitals	1.01	0.99	1.03
		Increase by 1 hour in total nursing hours in medical patients, hospital level analysis, California hospitals	1.00	0.98	1.03
		Increase by 1 hour of licensed nursing hours in medical patients, hospital level analysis, California hospitals	1.02	0.98	1.05
		Increase by 1 hour of RN hours in medical patients, unit level analysis, California hospitals	0.96	0.88	1.05
		Increase by 1 hour in LPN hours in medical patients, unit level analysis, California hospitals	1.02	0.96	1.08
		Increase by 1 hour in UAP hours/patient day in medical patients, unit level analysis, California hospitals	1.01	0.98	1.04
		Increase by 1 hour in total nursing hours in medical patients, unit level analysis, California hospitals	1.01	0.97	1.04
		Increase by 1 hour of total licensed hours in medical patients, unit level analysis, California hospitals	1.01	0.98	1.04
		Increase by 1 hour of RN hours in surgical patients, hospital level analysis, California hospitals	1.00	0.89	1.13
		Increase by 1 hour in LPN hours in surgical patients, hospital level analysis, California hospitals	1.02	0.96	1.08
		Increase by 1 hour in UAP hours in surgical patients, hospital level	0.59	0.31	1.14

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes		
		analysis, California hospitals Increase by 1 hour in total nursing hours in surgical patients, hospital level analysis, California hospitals Increase by 1 hour in licensed hours in surgical patients, hospital level analysis, California hospitals Increase by 1% in RN hours/licensed hours in surgical patients, hospital level analysis, California hospitals Increase by 1 hour of RN hours in surgical patients, unit level analysis, California hospitals Increase by 1 hour in LPN hours in surgical patients, unit level analysis, California hospitals Increase by 1 hour in UAP hours in surgical patients, unit level analysis, California hospitals Increase by 1 hour in total nursing hours in surgical patients, unit level analysis, California hospitals Increase by 1 hour in licensed hours in surgical patients, unit level analysis, California hospitals 1% increase in RN hours/total licensed hours (RN + LPN) Increase by 1 licensed hour (RN + LPN)/patient day Increase by 1 licensed hour (RN + LPN)/patient day	1.01 0.12 1.03 1.06 1.02 1.03 1.04 1.39 1.01 0.99 0.99 0.99 0.99 0.99	0.98 0.01 0.98 0.94 0.95 0.99 1.00 0.85 0.98 0.98 0.96 0.99 0.97 0.98	1.04 1.01 1.08 1.19 1.08 1.07 1.09 1.94 1.03 0.99 1.01 1.00 1.00 1.00 1.01
Potter ⁴⁰ Medical records; (number of falls on a unit/number of patient days) * 1,000. Administrative hospital data; an average number of nursing care per patient day on the day shift, proportion of UAP hours of direct patient care	Hospitals 1 Unit ICU Patients Medical	Period Hour RN hour Means in time period Feb-Apr 2000 3 1.67 Means in time period May-Jul 2000 3 1.61 Means in time period Aug-Oct 2000 3 1.69 Means in time period Nov 2000-Jan 2001 3 1.77	Falls, rate/100 patient days 0.30 0.29 0.30 0.23		
Ritter-Teitel ⁶⁹ Hospital Incidence reports; % of patients with urinary tract infections not presented at admission among total discharged or sampled	Hospitals 28	Time, Place Hour RN hours UAP hours 1997 9.3 5.1 2.4 1998 9.6 5.3 2.6 Medical Units 1997 9.2 5.0 2.5 Medical Units 1998 9.8 5.5 2.7	Rate, % ± SD Urinary tract infection 2.09 ± 2.25 2.53 ± 2.29 2.25 ± 2.36 2.61 ± 2.46		

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories			Patient Outcomes	
patients, % of patients with pressure ulcers, number of events/1,000 patient days. Labor Productivity Program Database and nurse survey; Total nursing hours worked/patient-day, RN hours worked/patient day, UAP hours worked/patient day		Surgical Units 1997	9.4	5.2	2.3	1.93 ± 2.18
		Surgical Units 1998	9.4	5.1	2.6	2.45 ± 2.16
		1997	9.3	5.1	2.4	Falls 0.32 ± 0.20
		1998	9.6	5.3	2.6	0.34 ± 0.16
		Medical Units 1997	9.2	5.0	2.5	0.40 ± 0.21
		Medical Units 1998	9.8	5.5	2.7	0.41 ± 0.17
		Surgical Units 1997	9.4	5.2	2.3	0.24 ± 0.14
		Surgical Units 1998	9.4	5.1	2.6	0.27 ± 0.12
		1997	9.3	5.1	2.4	Pressure ulcers 2.42 ± 2.10
		1998	9.6	5.3	2.6	2.06 ± 1.66
		Medical Units 1997	9.2	5.0	2.5	2.33 ± 2.12
		Medical Units 1998	9.8	5.5	2.7	2.23 ± 1.94
		Surgical Units 1997	9.4	5.2	2.3	2.50 ± 2.11
		Surgical Units 1998	9.4	5.1	2.6	1.88 ± 1.33
		Increase by 1 hour in RN hours				Urinary tract infection -0.18 ± 1.24
		Increase by 1 hour in RN hours				Falls -0.42 ± 0.90
		Increase by 1 hour in RN hours				-0.24 ± 1.18
		Increase by 1 hour in RN hours in medical units				Falls -0.49 ± 0.87
		Increase by 1 hour in RN hours in surgical units				-0.15 ± 0.96

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories		Patient Outcomes	
Robert ⁶ Case—all patients hospitalized in ICU >3 days with a primary BSI during the study period. Controls—randomly selected patients hospitalized ≥3 days in the same unit; primary bloodstream infections (BSIs) (CDC), Index date for cases—the day of 1 positive blood culture; for controls = (cases LOS before BSI/total cases LOS) * control total LOS. Administrative hospital data; total nursing hours-patient day	Hospitals 1 Unit ICU Patients Surgical	Hour/patient day		Nosocomial infection Rate/100 patient days 1.00 3.20 Relative risk 1.00 1.00 1.00 3.20 1.20 8.20	
Seago ⁹³ Incident reporting system; Decubitus ulcers, rate/1,000 patient days. ANSOS/TSI database; Both RN and non-RN hours divided by total patient day, RN hours divided by total patient days	Hospitals 1 Unit Combined Patients Medical	Nursing hours RN hours		Rate per 100 patient days ± SD Decubitus ulcer 0.78 ± 0.09 0.02 ± 0.05 0.05 ± 0.08 Falls 0.35 ± 0.20 0.19 ± 0.19 0.45 ± 0.25	
		Medical surgical unit A	8	6	
		Medical surgical unit B	8	8	
		Medical surgical unit C	7	5	
		Medical surgical unit A	8	6	
		Medical surgical unit B	8	8	
		Medical surgical unit C	7	5	

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
Operations Benchmarking Database Reports; the office of the chief nurse executives; nursing survey; Hours Worked per patient day, RN hours worked per patient day, UAP hours worked per patient day		Hospital nursing department, 1997	Falls
		Nurse hours RN hours UAP hours 14 8.45 3	2.88 ± 1.20
		Hospital nursing department, 1998	
		Nurse hours RN hours UAP hours 13 8.09 3	2.95 ± 0.91
		Medical units, 1997	
		Nurse hours RN hours UAP hours 9.1 5.1 2	3.97 ± 2.10
		Medical units 1998	
		Nurse hours RN hours UAP hours 9.8 5.52 3	4.11 ± 1.68
		Surgical units, 1997	
		Nurse hours RN hours UAP hours 9.3 5.18 2	2.42 ± 1.41
		Surgical units, 1998	
		Nurse hours RN hours UAP hours 9.4 5.15 3	2.69 ± 1.19
		Hospital nursing department, 1997	Pressure Ulcers
		Nurse hours RN hours UAP hours 14 8.45 3	3.53 ± 1.82
		Hospital nursing department, 1998	
		Nurse hours RN hours UAP hours 13 8.09 3	3.14 ± 2.63
		Medical units, 1997	
		Nurse hours RN hours UAP hours 9.1 5.1 2	2.61 ± 2.56
Medical units 1998			
Nurse hours RN hours UAP hours 9.8 5.52 3	2.23 ± 1.94		
Surgical units, 1997			
Nurse hours RN hours UAP hours 9.3 5.18 2	2.68 ± 2.22		
Surgical units, 1998			
Nurse hours RN hours UAP hours 9.4 5.15 3	1.88 ± 1.33		

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes																
		Increase by 1 hour in RN hours Increase by 1 hour in total nursing hours Increase by 1 hour in total nursing hours Increase by 1 hour in total nursing hours	Falls -0.43 ± 0.18 UTI -0.65 ± 0.23 Falls -0.33 ± 0.14 Pressure ulcers -0.32 ± 0.15																
Stegenga ⁷⁸ Patients and laboratory records Nosocomial viral gastrointestinal infections (NVGIs) (CDC definition). Rate = number of NVGIs / 1,000 patient days. Administrative hospital records; Total nursing hours/patient day. Total hours included educational and overtime hours but not vacation. Total hours were calculated 72 hours before and after infection event	Hospitals 1 Unit ICU Patients Medical	<table border="0"> <tr> <td></td> <td style="text-align: right;">Nursing hours</td> </tr> <tr> <td>Preinfection night shifts</td> <td style="text-align: right;">12.5</td> </tr> <tr> <td>Postinfection night shifts</td> <td style="text-align: right;">13</td> </tr> <tr> <td>Nursing hours/patient days >10.5</td> <td style="text-align: right;">12</td> </tr> <tr> <td>Nursing hours/patient days <10.5</td> <td style="text-align: right;">6.5</td> </tr> <tr> <td colspan="2"> </td> </tr> <tr> <td>Nursing hours/patient days >10.5</td> <td style="text-align: right;">12</td> </tr> <tr> <td>Nursing hours/patient days <10.5</td> <td style="text-align: right;">6.5</td> </tr> </table>		Nursing hours	Preinfection night shifts	12.5	Postinfection night shifts	13	Nursing hours/patient days >10.5	12	Nursing hours/patient days <10.5	6.5			Nursing hours/patient days >10.5	12	Nursing hours/patient days <10.5	6.5	Nosocomial infection/100 patient days 1.30 0.00 1.01 3.21 Relative risk, 95% CI 1.00 1.00 1.00 2.94 2.16 4.01
	Nursing hours																		
Preinfection night shifts	12.5																		
Postinfection night shifts	13																		
Nursing hours/patient days >10.5	12																		
Nursing hours/patient days <10.5	6.5																		
Nursing hours/patient days >10.5	12																		
Nursing hours/patient days <10.5	6.5																		

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories				Patient Outcomes
Stratton ⁹¹ Medical records, hospital incidence and infection control records, surveys rate/1,000 patient days of respiratory, gastrointestinal, bloodstream and central line infections in hospitalized patients not present at time of admission; rate/1,000 patient days of bloodstream and central line infections in hospitalized patients not present at time of admission. Payroll records from the National Association of Children's Hospitals and Related Institutions (NACHRI); Average in each quarter 2002 of total hours of productive nursing care/patient day adjusted for short-stay patients	Hospitals = 7 Units	Nursing hours	RN hours	LPN hours	Aide hours	Nosocomial infection Rate/100 patient days ± SD 0.75 ± 0.69
	Medical/surgical units, quarter 1	9.54	7.04	0.22	2.28	0.53 ± 0.67
	Medical/surgical units, quarter 2	9.98	7.26	0.21	2.51	0.71 ± 0.77
	Medical/surgical units, quarter 3	10.5	7.65	0.22	2.63	0.64 ± 0.43
	Medical/surgical units, quarter 4	9.97	7.46	0.19	2.33	0.65 ± 0.23
	Oncology units, quarter 1	11.33	9.4	0.33	1.55	0.62 ± 0.39
	Oncology units, quarter 2	11.37	8.93	0.47	1.92	0.71 ± 0.59
	Oncology units, quarter 3	12.77	10.1	0.46	2.16	0.85 ± 0.50
	Oncology units, quarter 4	12.41	9.9	0.36	2.06	0.73 ± 0.56
	ICU units, quarter 1	18.86	16.8	0.02	2.02	1.03 ± 0.96
	ICU units, quarter 2	19.37	17.1	0.03	2.3	0.80 ± 0.69
	ICU units, quarter 3	20.2	17.6	0.03	2.55	0.95 ± 0.71
	ICU units, quarter 4	19.59	17.3	0.02	2.32	0.51 ± 0.08
	All units, quarter 1	13.1				0.79 ± 0.17
	All units, quarter 2	13.5				0.66 ± 0.12
All units, quarter 3	14.25				0.56 ± 0.17	
All units, quarter 4	13.72				0.01 ± 0.03	
		Increase by 1 hour in total nursing hours				

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories					Patient Outcomes
Tallier ⁸³ Hospital acquired retrospective data; Nosocomial urinary tract infection, incidence rate/1,000 patient day developed 72 hours after admission Pressure ulcers-Incidence rate/1,000 patient days developed more than 72 hours after admission. Nursing Care hours reports, Nursing Daily Staffing Sheets; total productive nursing hours/patient day	Hospitals 1 Unit Combined Patients Medical	Time 2000, 4 th quarter 2001, 1 st quarter October 2000 November 2000 December 2000 January 2001 February 2001 March 2001 2000, 4 th quarter 2001, 1 st quarter October 2000 November 2000 December 2000 January 2001 February 2001 March 2001	Nurse hours 5.84 5.67 6.2 5.77 5.76 5.69 5.27 6.05 5.84 5.67 6.2 5.77 5.76 5.69 5.27 6.05	RN hours 5.85 5.87 5.5 6.88 6.64 6.83 5.85 5.87 5.5 6.88 6.64 6.83	LPN hours 0.87 1 0.93 1.08 1.04 1.11 0.87 1 0.93 1.08 1.04 1.11	UAP hours 3.58 3.31 3.29 3.67 3.29 3.41 3.58 3.31 3.29 3.67 3.29 3.41	Rate/100 patient days UTI 0.78 0.24 1.10 0.90 1.50 0.70 0.30 0.30 Pressure ulcers 0.17 0.29 0.10 0.60 0.10 0.90 0.60 0.10
Wan ⁵² Hospital records; Falls, incidence/1,000 patient days adjusted for severity of incident Hospital staffing records; Nursing hours/patient day, LPN hours/total nursing hours	Hospitals 45 Unit Combined Patients Combined	Increase by 1 hour in total nursing hours			Nurse hours 4.93 RN hours 2.56 LPN hours 1.63	Falls, rate/100 patient days 0.03 0.31 ± 0.05	

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
Whitman ³⁶ Hospital discharge data; The number of hospital-acquired pressure ulcers (≥grade II) divided by the number of patients visually assessed by the nursing staff for skin breakdown; number of unplanned descents to the floor with or without injury times 1,000 divided by the total number of patient days on each unit; number of nosocomial CLI times 1,000 divided by the number of central catheter line days (the number of days central intravenous catheters were in place in patients). Hospitals system's finance department; Total worked hours (paid hours minus sick, vacation, and holiday hours) for all personnel (RN, licensed practical nurses, nursing aides, secretaries): total worked hours/the monthly patient days for each unit	Hospitals: 10	Nurse hours Mean in noncardiac ICU 18.8 Mean in noncardiac ICU 18.9 Mean in noncardiac IMC 8.9 Mean in cardiac IMC 8.4 Mean in medical/surgical 4 Mean in noncardiac ICU 18.8 Mean in noncardiac ICU 18.9 Mean in noncardiac IMC 8.9 Mean in cardiac IMC 8.4 Mean in medical/surgical 4	Rate/100 patient days ± SD Falls 0.01 ± 0.12 0.07 ± 0.06 0.31 ± 0.17 0.35 ± 0.13 0.49 ± 0.48 Pressure ulcers 0.07 ± 0.05 0.11 ± 0.09 0.05 ± 0.05 0.03 ± 0.03 0.03 ± 0.03

Table G11. Evidence of the association between nurse hours/patient day and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes, Source to Measure Nurse Staffing, Definition of Nurse Hours	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories				Patient Outcomes		
			Nurse hours	RN hours	LPN hours	UAP hours	Rate, %	
Zidek ⁸⁵ Patient records and chart audits New incidence of skin breakdown acquired over the course of the hospital stay, number of reported unplanned descent to the floor during the course of the hospital stay. Administrative records; total nursing hours/patient day calculated from % of RN FTE/total FTE calculated from % of LPN FTE/total FTE calculated from % of UAP FTE/total FTE	Hospitals 1 Unit Combined Patients Medical and surgical	1999, 1 st quarter 1999, 2 nd quarter 1999, 3 rd quarter 1999, 4 th t quarter 2000, 1 st quarter 2000, 2 nd quarter 2000, 3 rd quarter 2000, 4 th quarter 2001, 1 st quarter 2001, 2 nd quarter 2001, 3 rd quarter 2001, 4 th quarter	6.6 8.4 7.3 8.2 6.9 10.2 8.3 9 7.3 8.8 11.2 8.5	2.1 2.6 2 2.6 2.1 3.1 2.6 3 2.3 2.7 3.7 2.5	3.84 4.73 4.06 4.85 4.14 5.90 4.45 5.13 4.21 5.09 6.17 4.91	0.73 1.1 1.16 0.74 0.69 1.22 1.25 0.9 0.73 0.96 1.35 1.02	Falls 0.59 0.45 0.83 0.52 0.28 0.25 0.23 0.63 0.61 0.62 0.66 0.66	Pressure ulcers 0.18 0.05 0.26 0.09 0.00 0.06 0.17 0.37 0.09 0.24 0.18 0.11

Dec Ulcer = Decubitus Ulcer; DRG = Diagnosis Related Group; DVT = Deep Vein Thrombosis; ICU = Intensive Care Unit; IMC = Intermediate Care; LPN = Licensed Practical Nurse; NICU = Neonatal Intensive Care Unit; NS = Not Significant; RN = Registered Nurse; RR = Relative Risk; SD = Standard Deviation; SWI = Surgical Wound Infection; UAP = Unlicensed Assistive Personnel; UTI = Urinary Tract Infection

Table G12. Patient outcomes corresponding to an increase by 1 nursing hour/patient day (calculated from published results, more studies contributed to pooled analysis)

Studies	Outcomes	Measure	Effect	Significance
Simmonds ⁸²	Nosocomial infection	Rate		NS
Ritter-Teitel ⁶⁹	Pressure ulcers	Rate	0.29	<.0001
Ritter-Teitel ⁶⁹	Urinary tract infection	Rate	0.30	<.0001
Ritter-Teitel ⁶⁹	Falls	Rate	0.08	<.0001
Cho ³⁰	Sepsis	Rate		NS
Cho ³⁰	Pressure ulcers	Rate		NS
Cho ³⁰	Pneumonia	Rate		NS
Cho ³⁰	Urinary tract infection	Rate		NS
Cho ³⁰	Falls	Rate		NS
Zidek ⁸⁵	Pressure ulcers	Rate		NS
Zidek ⁸⁵	Falls	Rate		NS
Tallier ⁸³	Pressure ulcers	Rate*		NS
Tallier ⁸³	Urinary tract infection	Rate*		NS
Cimiotti ⁸⁷	Sepsis	Rate		NS
Cimiotti ⁸⁷	Nosocomial infection	Rate		NS
Cimiotti ⁸⁷	Nosocomial infection	Relative risk	0.92	0.001
Cimiotti ⁸⁷	Pneumonia	Rate		NS
Stratton ⁹¹	Nosocomial infection	Rate*	0.04	<.0001
Blegen ⁵⁹	Nosocomial infection	Rate*		NS
Blegen ⁵⁹	Urinary tract infection	Rate*	0.24	0.010
Blegen ⁵⁸	Falls	Rate*		NS
Blegen ⁵⁸	CPR	Rate*		NS
Robert ⁶	Sepsis	Rate*		NS
Robert ⁶	Sepsis	Relative risk		NS
Robert ⁶	Nosocomial infection	Rate*		NS
Robert ⁶	Nosocomial infection	Relative risk		NS
Blegen ⁷³	Falls	Rate*	0.03	0.010
Bolton ²⁶	Pressure ulcers	Rate*		NS
Bolton ²⁶	Falls	Rate*		NS
Sovie ⁷¹	Pressure ulcers	Rate	0.29	<.0001
Sovie ⁷¹	Urinary tract infection	Rate	0.24	0.010
Sovie ⁷¹	Falls	Rate		NS
Stegenga ⁷⁸	Nosocomial infection	Rate*		NS
Stegenga ⁷⁸	Nosocomial infection	Relative risk		NS
Whitman ³⁶	Pressure ulcers	Rate*		NS
Whitman ³⁶	Falls	Rate*	-0.03	0.001
Potter ⁴⁰	Falls	Rate*		NS
Langemo ⁴¹	Pressure ulcers	Rate		NS
Seago ⁹³	Falls	Rate*		NS
Donaldson ⁹	Pressure ulcers	Rate*		NS
Donaldson ⁹	Falls	Rate*	-0.02	0.031
Needleman ²⁸	Sepsis	Rate		NS
Needleman ²⁸	Shock	Rate		NS
Needleman ²⁸	Gastrointestinal bleeding	Rate		NS
Needleman ²⁸	Pressure ulcers	Rate		NS

Table G12. Patient outcomes corresponding to an increase by 1 nursing hour/patient day (calculated from published results, more studies contributed to pooled analysis) (continued)

Studies	Outcomes	Measure	Effect	Significance
Needleman ²⁸	Surgical wound infection	Relative risk		NS
Needleman ²⁸	Deep vein thrombosis	Rate		NS
Needleman ²⁸	Pulmonary Failure	Rate		NS
Needleman ²⁸	Pneumonia	Rate		NS
Needleman ²⁸	Urinary tract infection	Rate		NS
Needleman ²⁸	Failure to rescue	Rate		NS

CPR = Cardiopulmonary Resuscitation; NS = Not Significant

* Rate per 100 patient days

Table G13. Relative risk of patient outcomes corresponding to an increase by 1 nurse hour/patient day as reported by authors

Author	Data	Analytic unit	Hospitals	Unit	Patients	Outcome	Relative Risk	95% CI
Needleman ²⁸	Administrative	Hospital	4,156	Medical	Medical	UTI	1.00	1.00; 1.01
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	UTI	1.01	1.00; 1.02
Needleman ²⁸	Administrative	Hospital	3,357	Medical	Medical	UTI	1.00	0.99; 1.01
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	UTI	1.00	0.99; 1.02
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	UTI	1.00	0.98; 1.01
Needleman ²⁸	Administrative	Unit	256	Medical	Medical	UTI	0.99	0.97; 1.01
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	UTI	1.00	0.98; 1.03
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	UTI	0.81	0.66; 0.98
Cho ³⁸	Administrative	Patient	232	Combined	Combined	UTI	1.02	0.95; 1.08
Needleman ²⁸	Administrative	Hospital	4,156	Medical	Medical	GIB	0.99	0.98; 1.01
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	GIB	0.99	0.97; 1.01
Needleman ²⁸	Administrative	Hospital	3,357	Medical	Medical	GIB	0.99	0.97; 1.00
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	GIB	0.99	0.97; 1.02
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	GIB	0.99	0.97; 1.01
Needleman ²⁸	Administrative	Unit	256	Medical	Medical	GIB	0.99	0.96; 1.01
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	GIB	0.85	0.67; 1.09
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	GIB	0.74	0.57' 0.96
Needleman ²⁸	Administrative	Hospital	4,156	Medical	Medical	Pneumonia	1.00	0.99; 1.01
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	Pneumonia	1.02	1.00; 1.05
Needleman ²⁸	Administrative	Hospital	3,357	Medical	Medical	Pneumonia	1.10	1.01; 1.19
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	Pneumonia	1.03	1.00; 1.05
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Pneumonia	1.00	0.99; 1.01
Needleman ²⁸	Administrative	Unit	256	Medical	Medical	Pneumonia	0.99	0.97; 1.01
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	Pneumonia	1.03	1.01; 1.06
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	Pneumonia	1.03	0.99; 1.08
Cho ³⁸	Administrative	Patient	232	Combined	Combined	Pneumonia	0.96	0.91; 1.01
Needleman ²⁸	Administrative	Hospital	4,156	Medical	Medical	Shock	0.84	0.71; 0.99
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	Shock	0.99	0.97; 1.01
Needleman ²⁸	Administrative	Hospital	3,357	Medical	Medical	Shock	1.00	0.99; 1.02
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	Shock	1.00	0.98; 1.03
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Shock	1.02	0.99; 1.04

Table G13. Relative risk of patient outcomes corresponding to an increase by 1 nurse hour/patient day as reported by authors (continued)

Author	Data	Analytic unit	Hospitals	Unit	Patients	Outcome	Relative Risk	95% CI
Needleman ²⁸	Administrative	Unit	256	Medical	Medical	Shock	1.01	0.97; 1.05
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	Shock	1.00	0.97; 1.03
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	Shock	1.01	0.97; 1.06
Needleman ²⁸	Administrative	Hospital	4,156	Medical	Medical	Failure to rescue	1.01	1.00; 1.01
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	Failure to rescue	0.99	0.98; 1.01
Needleman ²⁸	Administrative	Hospital	3,357	Medical	Medical	Failure to rescue	1.01	1.00; 1.01
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	Failure to rescue	0.99	0.97; 1.00
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Failure to rescue	1.01	0.99; 1.02
Needleman ²⁸	Administrative	Unit	256	Medical	Medical	Failure to rescue	1.00	0.99; 1.02
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	Failure to rescue	1.90	1.29; 2.79
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	Failure to rescue	0.98	0.95; 1.01
Cho ³⁸	Administrative	Patient	232	Combined	Combined	Falls	1.08	0.99; 1.18
Needleman ²⁸	Administrative	Hospital	4,156	Medical	Medical	Falls	1.00	0.99; 1.02
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	Pressure ulcers	0.99	0.97; 1.02
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	Pressure ulcers	0.99	0.97; 1.01
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Pressure ulcers	1.02	1.00; 1.04
Needleman ²⁸	Administrative	Unit	256	Medical	Medical	Pressure ulcers	1.02	0.99; 1.05
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	Pressure ulcers	0.82	0.64; 1.05
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	Pressure ulcers	0.64	0.46; 0.88
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	SWI	1.00	0.99; 1.02
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	SWI	1.01	0.99; 1.03
Cho ³⁸	Administrative	Patient	232	Combined	Surgical	SWI	1.00	0.95; 1.06
Needleman ²⁸	Administrative	Hospital	4,156	Medical	Medical	DVT	1.00	0.98; 1.02
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	DVT	1.02	1.00; 1.05
Needleman ²⁸	Administrative	Hospital	3,357	Medical	Medical	DVT	1.00	0.99; 1.02
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	DVT	1.01	0.99; 1.04
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	DVT	1.00	0.97; 1.02
Needleman ²⁸	Administrative	Unit	256	Medical	Medical	DVT	1.02	0.98; 1.06
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	DVT	1.06	1.02; 1.10
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	DVT	1.09	1.03; 1.15
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	Complications	1.03	1.01; 1.06
Needleman ²⁸	Administrative	Hospital	3,357	Medical	Medical	Complications	1.25	1.05; 1.50
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	Complications	1.03	1.00; 1.06

Table G13. Relative risk of patient outcomes corresponding to an increase by 1 nurse hour/patient day as reported by authors (continued)

Author	Data	Analytic unit	Hospitals	Unit	Patients	Outcome	Relative Risk	95% CI
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Complications	1.02	0.99; 1.05
Needleman ²⁸	Administrative	Unit	256	Medical	Medical	Complications	1.06	1.01; 1.10
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	Complications	0.39	0.14; 1.13
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	Complications	1.10	1.03; 1.18
Needleman ²⁸	Administrative	Hospital	4,156	Medical	Medical	Sepsis	1.00	0.98; 1.01
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	Sepsis	1.00	0.98; 1.02
Needleman ²⁸	Administrative	Hospital	3,357	Medical	Medical	Sepsis	0.99	0.98; 1.01
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	Sepsis	0.99	0.97; 1.01
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Sepsis	1.01	0.99; 1.03
Needleman ²⁸	Administrative	Unit	256	Medical	Medical	Sepsis	1.01	0.98; 1.04
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	Sepsis	0.59	0.31; 1.14
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	Sepsis	1.03	0.99; 1.07
Cho ³⁸	Administrative	Patient	232	Combined	Medical	Sepsis	1.01	0.95; 1.08

DVT = Deep vein thrombosis; GIB = Gastrointestinal bleeding; SWI = Surgical wound infection; UTI = Urinary tract infection

Table G14. Patient outcomes corresponding to an increase by 1 RN hour/patient day (calculated from published results, more studies contributed to pooled analysis)

Studies	Outcomes	Measure	Effect	Significance
Simmonds ⁸²	Nosocomial infection	Rate		NS
Ritter-Teitel ⁶⁹	Pressure ulcers	Rate		NS
Ritter-Teitel ⁶⁹	Urinary tract infection	Rate		NS
Ritter-Teitel ⁶⁹	Falls	Rate		NS
Cho ³⁰	Sepsis	Rate		NS
Cho ³⁰	Pressure ulcers	Rate		NS
Cho ³⁰	Surgical wound infection	Rate		NS
Cho ³⁰	Pneumonia	Rate		NS
Cho ³⁰	Urinary tract infection	Rate		NS
Cho ³⁰	Falls	Rate		NS
Zidek ⁸⁵	Pressure ulcers	Rate		NS
Zidek ⁸⁵	Falls	Rate		NS
Tallier ⁸³	Pressure ulcers	Rate*		NS
Tallier ⁸³	Urinary tract infection	Rate*	-0.70	0.019
Cimiotti ⁸⁷	Sepsis	Rate		NS
Cimiotti ⁸⁷	Nosocomial infection	Rate		NS
Cimiotti ⁸⁷	Nosocomial infection	Relative risk		NS
Cimiotti ⁸⁷	Pneumonia	Rate		NS
Stratton ⁹¹	Nosocomial infection	Rate*	0.02	0.012
Fridkin ¹	Sepsis	Rate*		NS
Fridkin ¹	Sepsis	Relative risk	0.71	<.0001
Fridkin ¹	Nosocomial infection	Rate*		NS
Fridkin ¹	Nosocomial infection	Relative risk	0.71	<.0001
Archibald ⁵⁷	Nosocomial infection	Rate*		NS
Blegen ⁵⁸	Falls	Rate*		NS
Blegen ⁵⁸	CPR	Rate*	0.03	0.042
Kovner ²²	Pulmonary failure	Rate		NS
Kovner ²²	Pneumonia	Rate		NS
Blegen ⁷³	Falls	Rate*	0.04	0.010
Bolton ²⁶	Pressure ulcers	Rate*		NS
Bolton ²⁶	Falls	Rate*		NS
Sovie ⁷¹	Pressure ulcers	Rate	0.32	0.032
Sovie ⁷¹	Urinary tract infection	Rate		NS
Sovie ⁷¹	Falls	Rate		NS
Kovner ³⁵	Deep vein thrombosis	Rate	-0.11	<.0001
Kovner ³⁵	Pulmonary failure	Rate		NS
Kovner ³⁵	Pneumonia	Rate		NS
Kovner ³⁵	Urinary tract infection	Rate		NS
Kovner ³⁵	Urinary tract infection	Relative risk		NS
Cho ³⁸	Sepsis	Relative risk		NS
Cho ³⁸	Surgical wound infection	Relative risk		NS
Cho ³⁸	Pulmonary failure	Relative risk		NS
Cho ³⁸	Pneumonia	Rate	-0.16	<.0001
Cho ³⁸	Pneumonia	Relative risk		NS
Cho ³⁸	Urinary tract infection	Relative risk		NS

Table G14. Patient outcomes corresponding to an increase by 1 RN hour/patient day (calculated from published results, more studies contributed to pooled analysis) (continued)

Studies	Outcomes	Measure	Effect	Significance
Cho ³⁸	Falls	Relative risk		NS
Potter ⁴⁰	Falls	Rate*		NS
Langemo ⁴¹	Pressure ulcers	Rate		NS
Mark ⁸⁹	Pneumonia	Relative risk		NS
Mark ⁸⁹	Urinary tract infection	Relative risk		NS
Seago ⁹³	Falls	Rate*		NS
Donaldson ⁹	Pressure ulcers	Rate*		NS
Donaldson ⁹	Falls	Rate*		NS
Needleman ²⁸	Sepsis	Rate		NS
Needleman ²⁸	Shock	Rate		NS
Needleman ²⁸	Gastrointestinal bleeding	Rate		NS
Needleman ²⁸	Pressure ulcers	Rate		NS
Needleman ²⁸	Surgical wound infection	Rate		NS
Needleman ²⁸	Surgical wound infection	Relative risk		NS
Needleman ²⁸	Deep vein thrombosis	Rate		NS
Needleman ²⁸	Pulmonary failure	Rate		NS
Needleman ²⁸	Pneumonia	Rate		NS
Needleman ²⁸	Urinary tract infection	Rate		NS
Needleman ²⁸	Failure to rescue	Rate		NS

NS = Not significant

* Rate per 100 patient days

Table G15. Relative risk of patient outcomes corresponding to an increase by 1 RN hour/patient day as reported by authors

Author	Data	Analytic Unit	Hospitals	Units	Patients	Outcomes	Relative Risk	95% CI
Berney ⁸⁴	Administrative	Hospital	161	Medical	Medical	UTI	0.99	0.98; 1.01
Berney ⁸⁴	Administrative	Hospital	161	Surgical	Surgical	UTI	0.98	0.96; 1.00
Needleman ²⁸	Administrative	Hospital	4,156	Medical	Medical	UTI	0.99	0.98; 0.99
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	UTI	1.00	0.98; 1.02
Needleman ²⁸	Administrative	Hospital	3,,357	Medical	Medical	UTI	0.99	0.99; 1.00
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	UTI	0.99	0.98; 1.00
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	UTI	0.99	0.97; 1.00
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	UTI	0.98	0.96; 1.00
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	UTI	0.87	0.77; 0.99
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	UTI	0.77	0.59; 0.99
Cho ³⁸	Administrative	Hospital	232	Combined	Medical	UTI	1.01	0.93; 1.08
Needleman ²⁸	Administrative	Hospital	799	Combined	Surgical	UTI	1.00	0.98; 1.02
Needleman ²⁸	Administrative	Hospital	799	Combined	Medical	UTI	0.99	0.98; 1.00
Berney ⁸⁴	Administrative	Hospital	161	Surgical	Surgical	GIB	0.95	0.92; 0.99
Needleman ²⁸	Administrative	Hospital	4,156	Medical	Medical	GIB	0.98	0.97; 0.99
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	GIB	0.98	0.96; 1.01
Needleman ²⁸	Administrative	Hospital	3,357	Medical	Medical	GIB	0.99	0.99; 1.00
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	GIB	0.98	0.98; 0.99
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	GIB	0.98	0.96; 1.00
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	GIB	0.98	0.95; 1.01
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	GIB	1.01	0.98; 1.05
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	GIB	1.03	0.98; 1.08
Needleman ²⁹	Administrative	Hospital	799	Combined	Medical	GIB	0.98	0.97; 0.99
Needleman ²⁸	Administrative	Hospital	4,156	Medical	Medical	Pneumonia	0.99	0.98; 1.00
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	Pneumonia	1.00	0.98; 1.03
Needleman ²⁸	Administrative	Hospital	3,357	Medical	Medical	Pneumonia	1.00	0.99; 1.00
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	Pneumonia	0.99	0.98; 1.00
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Pneumonia	0.99	0.97; 1.01

Table G15. Relative risk of patient outcomes corresponding to an increase by 1 RN hour/patient day as reported by authors (continued)

Author	Data	Analytic Unit	Hospitals	Units	Patients	Outcomes	Relative Risk	95% CI
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Pneumonia	0.98	0.96; 1.00
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	Pneumonia	1.02	0.99; 1.04
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	Pneumonia	1.02	0.98; 1.07
Cho ³⁸	Administrative	Hospital	232	Combined	Medical	Pneumonia	0.91	0.85; 0.97
Needleman ²⁹	Administrative	Hospital	799	Combined	Medical	Pneumonia	0.99	0.98; 1.00
Needleman ²⁸	Administrative	Hospital	4,156	Medical	Medical	Shock	0.98	0.96; 1.00
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	Shock	0.99	0.96; 1.02
Needleman ²⁸	Administrative	Hospital	3,357	Medical	Medical	Shock	0.99	0.98; 1.00
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	Shock	0.99	0.98; 1.00
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Shock	0.97	0.94; 1.00
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Shock	0.97	0.92; 1.01
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	Shock	0.97	0.94; 1.00
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	Shock	1.55	1.12; 2.15
Needleman ²⁹	Administrative	Hospital	799	Combined	Medical	Shock	0.98	0.96; 1.01
Berney ⁸⁴	Administrative	Hospital	161	Medical	Medical	Failure to rescue	0.98	0.97; 0.99
Berney ⁸⁴	Administrative	Hospital	161	Surgical	Surgical	Failure to rescue	0.98	0.97; 0.99
Needleman ²⁸	Administrative	Hospital	4,156	Medical	Medical	Failure to rescue	1.00	0.99; 1.01
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	Failure to rescue	0.98	0.96; 0.99
Needleman ²⁸	Administrative	Hospital	3,357	Medical	Medical	Failure to rescue	1.00	0.99; 1.00
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	Failure to rescue	0.97	0.95; 1.00
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Failure to rescue	0.99	0.98; 1.00
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Failure to rescue	0.99	0.97; 1.01
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	Failure to rescue	0.96	0.94; 0.99
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	Failure to rescue	0.96	0.92; 0.99
Needleman ²⁹	Administrative	Hospital	799	Combined	Surgical	Failure to rescue	0.98	0.96; 0.99
Needleman ²⁹	Administrative	Hospital	799	Combined	Medical	Failure to rescue	1.00	0.99; 1.01
Cho ³⁸	Administrative	Hospital	232	Combined	Medical	Falls	1.07	0.96; 1.19
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	Pulmonary failure	1.00	0.98; 1.02
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	Pulmonary failure	1.00	0.99; 1.00
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	Pulmonary failure	0.99	0.96; 1.02

Table G15. Relative risk of patient outcomes corresponding to an increase by 1 RN hour/patient day as reported by authors (continued)

Author	Data	Analytic Unit	Hospitals	Units	Patients	Outcomes	Relative Risk	95% CI
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	Pulmonary failure	0.99	0.94; 1.04
Cho ³⁸	Administrative	Hospital	232	Combined	Combined	Pulmonary failure	1.11	0.97; 1.27
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	Pressure ulcers	0.99	0.97; 1.00
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Pressure ulcers	0.98	0.96; 1.01
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Pressure ulcers	0.99	0.98; 1.00
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	Pressure ulcers	0.98	0.98; 0.99
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	Pressure ulcers	0.99	0.97; 1.02
Cho ³⁸	Administrative	Hospital	232	Combined	Medical	Pressure ulcers	1.00	0.96; 1.03
Kovner ³⁵	Administrative	Hospital	5,708	Surgical	Surgical	Pressure ulcers	0.87	0.75; 1.02
Needleman ²⁹	Administrative	Hospital	799	Combined	Surgical	Pressure ulcers	1.04	0.99; 1.10
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	SWI	1.00	0.99; 1.02
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	SWI	1.02	1.01; 1.03
Cho ³⁸	Administrative	Hospital	232	Combined	Surgical	SWI	0.97	0.91; 1.04
Needleman ²⁸	Administrative	Hospital	4,156	Medical	Medical	DVT	1.01	0.99; 1.03
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	DVT	1.03	1.00; 1.06
Needleman ²⁸	Administrative	Hospital	3,357	Medical	Medical	DVT	1.00	0.99; 1.01
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	DVT	1.00	0.99; 1.01
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	DVT	1.00	0.98; 1.03
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	DVT	1.02	0.98; 1.06
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	DVT	1.07	1.03; 1.11
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	DVT	1.11	1.05; 1.17
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	Complications	0.96	0.68; 1.35
Needleman ²⁸	Administrative	Hospital	3,357	Medical	Medical	Complications	1.01	1.00; 1.02
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	Complications	1.10	1.03; 1.19
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Complications	1.02	0.98; 1.05
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Complications	1.05	1.00; 1.10
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	Complications	1.04	0.98; 1.10
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	Complications	1.10	1.02; 1.19
Berney ⁸⁴	Administrative	Hospital	161	Medical	Medical	Sepsis	0.96	0.94; 0.98
Berney ⁸⁴	Administrative	Hospital	161	Surgical	Surgical	Sepsis	0.97	0.95; 0.99

Table G15. Relative risk of patient outcomes corresponding to an increase by 1 RN hour/patient day as reported by authors (continued)

Author	Data	Analytic Unit	Hospitals	Units	Patients	Outcomes	Relative Risk	95% CI
Needleman ²⁸	Administrative	Hospital	4,156	Medical	Medical	Sepsis	1.04	1.01; 1.08
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	Sepsis	1.01	0.98; 1.03
Needleman ²⁸	Administrative	Hospital	3,357	Medical	Medical	Sepsis	1.00	0.99; 1.01
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	Sepsis	0.99	0.98; 0.99
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Sepsis	1.01	0.99; 1.04
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Sepsis	1.02	0.98; 1.05
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	Sepsis	1.01	0.98; 1.04
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	Sepsis	1.03	0.98; 1.08
Cho ³⁸	Administrative	Hospital	232	Combined	Medical	Sepsis	1.02	0.95; 1.09

DVT = Deep vein thrombosis; GIB = Gastrointestinal bleeding; SWI = Surgical wound infection; UTI = Urinary tract infection

Table G16. Patient outcomes corresponding to an increase by 1 LPN hour/patient day (effects reported by authors and calculated from published results, more studies contributed to pooled analysis)

Studies	Outcomes	Measure	Effect	Significance
Zidek ⁸⁵	Pressure ulcers	Rate		NS
Zidek ⁸⁵	Falls	Rate		NS
Tallier ⁸³	Pressure ulcers	Rate*		NS
Tallier ⁸³	Urinary tract infection	Rate*		NS
Stratton ⁹¹	Nosocomial Infection	Rate*		NS
Bolton ²⁶	Pressure ulcers	Rate*		NS
Bolton ²⁶	Falls	Rate*		NS
Kovner ³⁵	Deep vein thrombosis	Rate	-0.31	0.003
Kovner ³⁵	Pulmonary failure	Rate	-1.23	0.002
Kovner ³⁵	Pneumonia	Rate	-1.69	0.002
Kovner ³⁵	Urinary tract infection	Rate		NS
Langemo ⁴¹	Pressure ulcers	Rate		NS
Mark ⁸⁹	Pneumonia	Relative risk	0.13	0.004
Mark ⁸⁹	Urinary tract infection	Relative risk		NS
Needleman ²⁸	Sepsis	Rate		NS
Needleman ²⁸	Gastrointestinal bleeding	Rate		NS
Needleman ²⁸	Pressure ulcers	Rate		NS
Needleman ²⁸	Surgical wound infection	Rate		NS
Needleman ²⁸	Surgical wound infection	Relative risk		NS
Needleman ²⁸	Deep vein thrombosis	Rate		NS
Needleman ²⁸	Pulmonary failure	Rate		NS
Needleman ²⁸	Pneumonia	Rate	1.07	0.015
Needleman ²⁸	Urinary tract infection	Rate		NS
Needleman ²⁸	Failure to rescue	Rate		NS

NS = Not significant

* Rate per 100 patient days

Table G17. Patient outcomes corresponding to an increase by 1 unlicensed assistive personnel hour/patient day (effects reported by authors and calculated from published results, more studies contributed to pooled analysis)

Studies	Outcomes	Measure	Effect	Significance
Needleman ²⁸	Shock	Rate		NS
Needleman ²⁸	Gastrointestinal bleeding	Rate		NS
Ritter-Teitel ⁶⁹	Pressure ulcers	Rate		NS
Zidek ⁸⁵	Pressure ulcers	Rate		NS
Tallier ⁸³	Pressure ulcers	Rate*		NS
Sovie ⁷¹	Pressure ulcers	Rate		NS
Needleman ²⁸	Pressure ulcers	Rate		NS
Needleman ²⁸	Surgical wound infection	Rate		NS
Needleman ²⁸	Surgical wound infection	Relative risk		NS
Cimiotti ⁸⁷	Nosocomial infection	rate		NS
Stratton ⁹¹	Nosocomial infection	Rate*		NS
Needleman ²⁸	Deep vein thrombosis	Rate		NS
Needleman ²⁸	Pulmonary failure	Rate		NS
Needleman ²⁸	Pneumonia	Rate		NS
Cimiotti ⁸⁷	Pneumonia	Rate		NS
Ritter-Teitel ⁶⁹	Urinary tract infection	Rate	1.58	0.0001
Tallier ⁸³	Urinary tract infection	Rate*		NS
Sovie ⁷¹	Urinary tract infection	Rate		NS
Needleman ²⁸	Urinary tract infection	Rate		NS
Needleman ²⁸	Failure to rescue	Rate		NS
Ritter-Teitel ⁶⁹	Falls	Rate		NS
Zidek ⁸⁵	Falls	Rate		NS
Sovie ⁷¹	Falls	Rate		NS

NS = Not significant

* Rate per 100 patient days

Table G18. Evidence of the association between nurse education and experience and patient outcomes

Author, Definition of Patient Outcomes, Definition of Nurse Education and Experience	Number of hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Education and Experience Categories	Patient Outcomes
Aiken ³⁹ Failure to rescue: deaths within 30 days of admission among patients who experienced complications, Complications: the secondary diagnosis distinguished from preexisting co morbidities, Highest credential in nursing: a hospital school diploma, an associate degree, a bachelor's degree, a master's degree, or another degree; the mean number of years of experience working as an RN for nurses from each hospital	Hospitals 168		Falls, rate %
	Unit ICU	60% of hospital workforce with BSN or higher, 8 patients/day	8.47
	Patients Surgical	40% of hospital workforce with BSN or higher, 4 patient/nurse	7.84
		20% of hospital workforce with BSN or higher, 4 patients/nurse	8.54
		60% of hospital workforce with BSN or higher, 6 patients/nurse	7.80
		40% of hospital workforce with BSN or higher, 6 patients/nurse	8.50
		20% of hospital workforce with BSN or higher, 6 patients/nurse	9.26
		60% of hospital workforce with BSN or higher, 4 patients/nurse	7.18
		20-29% of hospital workforce with BSN or higher, experience 14.4 years	9.40
		<20% of hospital workforce with BSN or higher, 14.9 years	10.20
		20% of hospital workforce with BSN or higher, 8 patients/nurse	10.02
		>50% of hospital workforce with BSN or higher, experience 12.5 years	6.90
		40-49% of hospital workforce with BSN or higher, experience 14.3 years	8.60
		30-39% of hospital workforce with BSN or higher, experience 14.0 years	8.00
		40% of hospital workforce with BSN or higher	9.22
		20-29% of hospital workforce with BSN or higher, experience 14.4 years	Complications 22.90
		<20% of hospital workforce with BSN or higher, 14.9 years	22.90
	>50% of hospital workforce with BSN or higher, experience 12.5 years	25.20	
	40-49% of hospital workforce with BSN or higher, experience 14.3 years	22.00	
	30-39% of hospital workforce with BSN or	22.80	

Table G18. Evidence of the association between nurse education and experience and patient outcomes (continued)

Author, Definition of Patient Outcomes, Definition of Nurse Education and Experience	Number of hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Education and Experience Categories	Patient Outcomes
		higher, experience 14.0 years Increase by 1 year in nurse experience 10% increase in nurses with BSN degree	Failure to rescue 1.01 0.96 1.03 0.95 0.91 0.99
Blegen ⁷³ The number of patient falls on the unit in quarter/1,000patient days, The proportion of RNs on the unit with BSN education, the proportion of RNs on the unit with more than 5 years experience or the average years of nursing experience of RNs on the unit	Hospitals 11 Unit Combined Patients Combined	Increase by 1 year in RN experience in unit Increase by 1% in proportion of RN with BSN Increase by 1% in proportion of RN with BSN Increase by 1% in proportion of RN with experience >5 years Nurse hours RN hours % BSN 10.7 7.704 47.00	Falls, rate per 100 patien days -0.04 0.01 -0.01 -0.01 0.27 ± 0.28
Langemo ³³ Any lesion which is caused by unrelieved pressure that results in damage to underlying tissues, unplanned descent to the floor recorded in incidence reports	Hospitals 6 Unit ICU Patients Medical Age 61.9 Sex 41	Nurse hours RN hours % BSN Experience 10.9 5.42 59.5 11.0	Pressure ulcers, rate % 8.6
Marcin ³ Extubation – displacement of the endotracheal tube from the trachea by either the patient (self-extubation) or unplanned by medical personnel (e.g., when positioning a patient for a radiograph or procedure), The number of years of clinical experience in the PICU calculated from the time of starting work in the PICU to the middle of the study period	Hospitals 1 Unit ICU Patients Combined Age 3.3	1:2 nurse/patient ratio, experience 7.8 years 1:1 nurse/patient ratio, experience 7.0 years 7.8 years of nurse experience in ICU 7 years of nurse experience in ICU	Relative risk 4.24 1.00 19.10 1.00 1.00 1.00 1.02 0.96 1.08 1.00 1.00 1.00
Mark ⁸⁰ Number of incidents per 1,000 acuity-adjusted patient days; average highest educational level attained by nurses on the unit; the average years of experience in nursing for nurses on the unit	Hospitals 64 Unit Combined Patients Medical	% RN % BSN 58 21.00	Falls, rate % ± SD 0.75 ± 0.09

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Table G18. Evidence of the association between nurse education and experience and patient outcomes (continued)

Author, Definition of Patient Outcomes, Definition of Nurse Education and Experience	Number of hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Education and Experience Categories		Patient Outcomes	
Sovie ⁷¹ Nosocomial urinary tract infection (not present at admission or within 72 hours after); the number of infections / number of patients discharged * 100 at hospital level; any fall or slip in which a patient came to rest unintentionally on the floor; the ratio of the number of falls in a unit (or area) to the number of patient days * 1,000; % of nurses with BSN; nursing experience in years	Hospitals 29	BS	Years	UTI, rate % ± SD	
	Unit Combined	1997	53.00	10.9	2.64 ± 1.67
	Patients Combined	1998	52.70	11.2	2.02 ± 1.43
	Medical units	1997	53.00	10.9	2.17 ± 2.49
	Medical units	1998	52.70	11.2	2.61 ± 2.56
	Surgical units	1997	53.00	10.9	1.87 ± 2.29
	Surgical units	1998	52.70	11.2	2.45 ± 2.24
			BS	Years	Falls, rate % ± SD
	Medical units	1997	53.00	10.9	2.88 ± 1.20
	Medical units	1998	52.70	11.2	2.95 ± 0.91
	Surgical units	1997	53.00	10.9	3.97 ± 2.10
	Surgical units	1998	52.70	11.2	4.11 ± 1.68
			53.00	10.9	2.42 ± 1.41
			52.70	11.2	2.69 ± 1.19
			BS	Years	Pressure ulcers, rate % ± SD
		1997	53.00	10.9	3.53 ± 1.82
	1998	52.70	11.2	3.14 ± 2.63	
Medical units	1997	53.00	10.9	2.61 ± 2.56	
Medical units	1998	52.70	11.2	2.23 ± 1.94	
Surgical units	1997	53.00	10.9	2.68 ± 2.22	
Surgical units	1998	52.70	11.2	1.88 ± 1.33	

BSN = Bachelor of Science in Nursing; ICU = Intensive Care Unit; PICU = Pediatric Intensive Care Unit; RN = Registered Nurse; SD = Standard Deviation

Table G19. The association between nurse characteristics and patient outcomes

Author, Definition of Nurse Characteristics and Patient Outcomes	Unit, Number of Nurses, % of Whites, % of Females	Nurse Categories		Patient Outcomes		
Aiken ⁴ Patient survey; patients satisfaction with nurse care in unit, nurses survey; burnout scale not reported on the article, nurses autonomy subscale		% of reported Burnout 26.73 21.48 21.9	Adequate autonomy 70.8 75.45 84.8	Patient satisfaction with nursing care Scores ± SD 60.06 ± 8.09 64.41 ± 8.18 67.85 ± 9.08		
Dugan ¹⁷ Incident reports; the number of reported patient falls occurred monthly during the study period; nurses survey to measure stress: a manifestation, evidences by behavioral, physical, and personal changes that were perceived by staff nurses and measured by the Stress Continuum Scale (10 max stress) and Stress Survey Scores (max 268)	Unit Combined Nurses 293	% reported stress 20 45.5 53 58 63 68 85.5		Falls, rate % 0.6 1 1.1 1.6 1.8 2.1 2.2		
Estabrooks ⁵⁰ Hospital Inpatient Database, Alberta Health Care Insurance Plan Registry (AHCIPR) was linked to identify persons who died within 30 days of admission. Survey of RN (Alberta Association of Registered Nurses registry) working in acute care hospitals. Responses for the Q "On the whole, how satisfied are you with your job?": 1. very dissatisfied; 2. a little dissatisfied; 3. moderately satisfied; 4. very satisfied); Q." Freedom to make important patient care and work decisions". Responses: 1. Strongly disagree; 2. Somewhat disagree; 3. Somewhat agree; 4. strongly agree	Unit Nurses Combined 4,799	% satisfied 60.125 77.5	% adequate autonomy 55.375 69.25	Relative risk of death, 95% CI 1 1 1 0.85 0.47 1.55 1 1 1 0.79 0.37 1.66		

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Table G19. The association between nurse characteristics and patient outcomes (continued)

Author, Definition of Nurse Characteristics and Patient Outcomes	Unit, Number of Nurses, % of Whites, % of Females	Nurse Categories			Patient Outcomes
Halm ⁵¹ The hospital's data warehouse with patient's discharges; deaths within 30 days of admission, death following complications within 30 days). Survey of 140 staff nurses (42% response rate); Maslach Burnout Inventory Manual (max 6 scores) with 3 subscales of burnout: emotional exhaustion; depersonalization; personal accomplishment (feelings of competence and successful achievement in one's work), overall rating on a simple 4-point Likert scale, ranging from 1 (very dissatisfied) to 4 (very satisfied) and the likelihood to leave current position within the next 12 months, the 22-item Human Services Survey from the Maslach Burnout Inventory Manual to measure emotional exhaustion	Unit Surgical Nurses 140 % females 96.4	% Burnout 25	% Satisfied 70	% Stress 25	Death rate % 1.2

Table G19. The association between nurse characteristics and patient outcomes (continued)

Author, Definition of Nurse Characteristics and Patient Outcomes	Unit, Number of Nurses, % of Whites, % of Females		Nurse Categories			Patient Outcomes
<p>Mark⁸⁰ The hospital's incident reporting system and patient survey; total patient days divided by the number of discharges. Patients' satisfaction with nursing care; perceptions of the courtesy of the nursing staff; the ability of the doctors, nurses, and other staff to work together; their satisfaction with pain relief; and their level of comfort sharing concerns with nurses. Number of falls per 1,000 acuity-adjusted patient days. Administrative hospital data, nursing survey. Turnover as a ratio of the number of nurses who left during the period divided by the number of nurses employed at the end of the year; global satisfaction in the job (alpha = .84, a single factor explained 68% of the variance). Adequacy - the extent to which nurses on the unit felt free to engage in activities such as consulting with others about complex care problems, influencing standards of care, and acting on their own decisions related to caregiving. Availability of support services was evaluated with a 27-item, 3-point checklist 24 in which staff nurses (n = 1,682) indicated whether a variety of support services was available, not available, or inconsistently available (alpha =.85)</p>	Unit Nurses	Medical 1,682	Turnover 17	Satisfaction 54.25	Adequacy 47	Length of stay, days ± SD 5.31 ± 1.47 % if satisfied with nurse care ± SD 78.33 ± 7.5 Falls, rate/100 patient days ± SD 0.12 ± 0.09
			Support 50	Coordination 50.33	Autonomy 73.2	

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Table G19. The association between nurse characteristics and patient outcomes (continued)

Author, Definition of Nurse Characteristics and Patient Outcomes	Unit, Number of Nurses, % of Whites, % of Females	Nurse Categories	Patient Outcomes
Minnick ¹⁹ Patient survey with interviews within 26 days of hospital discharge using the Computer-Assisted Telephone Interview (CATI) system, reports about assistance with pain management. Unit labor quantity data and nurses survey: Manager's Ability to Involve Staff in Practice Self-Governance. This variable is the average of the unit's RNs' rating (on a 5 point scale with 5 as most favorable) of the manager's ability to involve staff in setting patient care standards; the pay (score range 6-42), professional status (score 7-49), and task requirement attitude (score 6-42) scales (Stamps and Piedmonte) and the benefit (3 score 3-21) and schedule (score 4-28) scales (Minnick and Roberts); Central Hospital Support Systems Adequacy-the average of a RNs' ratings (on a 1 to 5 scale with 1 as least favorable) of hospital-wide support systems		Increase in nurse job satisfaction by 10 scores	Patient satisfaction with pain management Relative risk 1.22
Ridge ²⁵ Patient survey 2 weeks after discharge with computerized phone interview system; length of stay in hospital; patient satisfaction measured with Likert-type 5 points scale from strongly disagree to agree for overall nursing care, pain management, overall hospital care. Hospital administrative database, finance reports, HCIA database, unit nurse manager reports; turnover - number of individual staff hired annually/total number of staff; staffing adequacy - RN worked hours/RN target hours	Unit Surgical Nurses 22 % Females 92	% Turnover 23.2 % Turnover 23.2 % Vacancy 9 % Turnover 23.2 % Vacancy 9	Length of stay, days ± SD 4.1 ± 3.9 % satisfied with nurse care 88 87.2 % satisfied with pain management 83.6 ± 16.6 83.2 ± 3.828

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Table G19. The association between nurse characteristics and patient outcomes (continued)

Author, Definition of Nurse Characteristics and Patient Outcomes	Unit, Number of Nurses, % of Whites, % of Females	Nurse Categories			Patient Outcomes		
Seago ⁸ Hospital incidence reports database at three time periods: time 1-third quarter fiscal year 1996 (FY96); time 2-second quarter fiscal year 1997 (FY97); and time 3-third quarter fiscal year 1997 (FY97) in three different cross-sections of patients, Patient satisfaction measured with Likert scale; the proportion of pressure ulcers per patient day; the proportion of falls per patient day. The nursing staffing system (ANSOS) and nursing survey at three time periods: time 1-third quarter fiscal year 1996 (FY96); time 2-second quarter fiscal year 1997 (FY97); and time 3-third quarter fiscal year 1997 (FY97).		% satisfied 71 69 59	Coordination 62.13 62.13	Autonomy 94.40 93.60 92.20	Relative risk of pressure ulcer Not significant		
Sochalski ⁴⁵ MedPAR dataset of hospital discharges; reported by RN frequency of medication errors and patients falls from "never in the past year" (score 1) to "occur frequently" (score 10). survey of RNs, the survey question "In general, how would you describe the quality of nursing care delivered to patients your unit on your last shift?," and for which a 4-category response was available (poor, fair, good, excellent)	Unit Nurses Combined 8,670	Perceived quality of care, % satisfied 10 20 30 40	Perceived quality of care, % satisfied		Adverse events Relative risk, 95% 1.00 1.00 1.00 0.92 0.91 0.92 0.88 0.87 0.88 0.84 0.84 0.85		
		% satisfied 71 69 59	Coordination 62.13 62.13	Autonomy 94.40 93.60 92.20	Falls 0.29 0.27 0.23	Pressure ulcer 0.24 0.18 0.29	

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Table G19. The association between nurse characteristics and patient outcomes (continued)

Author, Definition of Nurse Characteristics and Patient Outcomes	Unit, Number of Nurses, % of Whites, % of Females					Nurse Categories			Patient Outcomes			
Sovie ⁷¹ Incident reports, patient survey 4 years after restructuring and reengineering in hospitals. The Picker Institute Patient Satisfaction Survey; the Press, Ganey Patient Satisfaction Survey. Dimensions: Pain management; Education; Attention to needs; Nursing care; Preparation for discharge. Nosocomial (not present at admission or within 72 hours after); the number of infections / number of patients discharged * 100 at hospital level; any fall or slip in which a patient came to rest unintentionally on the floor; the ratio of the number of falls in a unit (or area) to the number of patient days * 1,000. the MECON-PEERx Operations Benchmarking Database Reports; the office of the chief nurse executives; nursing survey; achieving quality patient outcomes; ranged from 1 = strongly disagree to 5 = strongly agree	Unit	Nurses	Age	Sex	Race	Management	Quality	Autonomy	% satisfied with nurse care ± SD			
	Medical	347	36.9	92.8	79.6	66.8	74.4	47	83.6 ± 5.89			
	Medical	298	36.7	92.3	82.4	66.8	72	47.25	83.32 ± 5.67			
	Surgical	289	36.9	92.8	79.6	65.6	74	49	82.82 ± 6.54			
	Surgical	239	36.7	92.3	82.4	65.6	72.2	49.25	84.9 ± 6.99			
							Management	Quality	Autonomy	% satisfied with pain management ± SD		
							66.8	74.4	47	83.04 ± 9.92		
							66.8	72	47.25	83.31 ± 7.82		
							65.6	74	49	85.55 ± 6.77		
							65.6	72.2	49.25	85.92 ± 4.63		
Vahey ⁴⁴ Conducted cross-sectional surveys of patients (621) satisfaction with nursing care using the La Monica-Oberst Patient Satisfaction Scale (LOPSS), 4 points scale. Conducted cross-sectional surveys of nurses (N=820) with the Maslach Burnout Inventory (MBI);7 point scales, staffing adequacy , administrative support, 4 scores, emotional exhaustion, 7 point scales	Unit	Specialized				Burnout	Support	Stress	Patient satisfaction, relative risk			
	Nurses	621					80	20	20	Reference		
	Age	34.6					Support	80	1.49 1.06 2.09			
	Sex	7.4					Burnout	20	2.37 1.37 4.12			
	Race	48.8					Stress	80	0.51 0.3 0.87			

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Table G19. The association between nurse characteristics and patient outcomes (continued)

Author, Definition of Nurse Characteristics and Patient Outcomes	Unit, Number of Nurses, % of Whites, % of Females		Nurse Categories	Patient Outcomes	
Zidek ⁸⁵ Patient records and chart audits, individuals length of stay in the hospital, new incidence of skin breakdown acquired over the course of the hospital stay, number of reported unplanned descent to the floor during the course of the hospital stay, administrative records, quarterly turnover rate in %	Unit Nurses	Combined 1,759	Turnover % 10.67 12.04 13.16	Rate, %	Falls Pressure ulcers 2.79 0.68 1.58 0.67 2.95 0.72

CI = Confidence Interval; RN = Registered Nurse; SD = Standard Deviation

Table G20. The evidence of the association between nurse staffing and patient satisfaction

Author, Measure of Patient Satisfaction	Sample Size, Unit, Patients	Nurse Categories	Patient Satisfaction
Aiken ⁵ Twenty-one item scale based in part on the LaMonica/Oberst Patient Satisfaction Scale (LOPSS)	Size 1,205 Unit Combined Patients Medical	Increase by 1 RN Nurse control over practice setting Dedicated AIDS units AIDS hosp-scattered bed units Conventional scattered bed units	Relative risk of being satisfied 3.0 0.0 343.8 1.4 1.4 2.5 3.6 0.3 41.3 0.1 0.0 2.0 1.0 1.0 1.0
Aiken ⁴ Patients satisfaction with nurse care in unit	Size 1,205 Unit Spec Patients Medical	Conventional general medical unit, Non-magnet hospital Specialized AIDS unit, non-magnet hospital General medical unit, magnet hospital	% satisfied Scores ± SD 74% 7.42 ± 2.3 83% 8.29 ± 1.7 85% 8.53 ± 1.9
Barkell ⁷⁷ Patient satisfaction: the patient's perception of pain, and the frequency of documentation of pain scores measured by scores on the Parkside Patient Satisfaction Survey	Size 96 Unit Surgical Patients Surgical	Team nursing model with UAP assisting RNs in delivery of patient care (lower proportion of RN = 65.7%) Total patient care model (higher proportion of RNs = 78.5%)	% Satisfied ± SD 83.4 ± 13 84.6 ± 13
Blegen ⁵⁹ The number of patient complaints standardized as a rate per 1,000 patient days.	Size 42 Unit Combined Patients Combined	Increase by 1% in proportion of RNs Proportion of RNs >87.5% Increase by 1 hour in total nursing hours 10.74 nurse hours/patient day	Rate of complains/100 patient days ± SD 0.46 ± 1.85 0.04 ± 0.07 0.02 ± 0.60 0.22
Bolton ⁴² The standardized Picker Institute inpatient questionnaire including respect patients' values and preferences, coordination of care; information and education; pain management; emotional support, and transition and continuity to the home or community	Size 113 Unit Combined Patients Combined	Nurse hours/patient day 7.9 hours RN hours/patient day 4.4 hours % RN 56%	% Satisfied with nurse care ± SD 86 ± 5%

Table G20. The evidence of the association between nurse staffing and patient satisfaction (continued)

Author, Measure of Patient Satisfaction	Sample Size, Unit, Patients	Nurse Categories	Patient Satisfaction
Langemo ³³ Patient's satisfaction with nursing care and opinions of overall hospital care, pain management, and education from 42-item Patient Opinions of Nursing Care Survey	Size 942 Unit ICU Patients Medical	Nurse Hours/patient day 10.9 RN hours/patient day 5.42 % BSN 59.5	Score for satisfaction with pain management 0.913
Mark ⁸⁰ Patients' satisfaction with nursing care; perceptions of the courtesy of the nursing staff; ability of the doctors, nurses, and other staff to work together; their satisfaction with pain relief; and their level of comfort sharing concerns with nurses	Size 1,326 Unit Combined Patients Medical	% RN 58 % BSN 21.00	% Satisfied with care 78.33% Score of satisfaction with nurse care ± SD 4.7 ± 0.45
Minnick ¹⁹ Reports about assistance with pain management; patient teaching was defined as reports of instruction that patients received about signs and symptoms that needed attention after hospital discharge	Size 2,051 Unit Medical Patients Medical	Patient satisfaction in units with >54% of RN with BSN vs. lower % of RN with BSN	Relative risk of being satisfied with care – 1.48 Relative risk of being satisfied with pain management - Not significant
Potter ⁴⁰ Eight Visual Analog Scale and post discharge (48 hour) satisfaction with seven satisfaction measures including communication, respect, coordination of care, nursing care, discharge process, advocating, and patient compassionate care (5 point Likert scale)	Size 32 Unit ICU Patients Medical	Nurse hours/patient day % RN 3.1 53.8 2.9 55.4 3 56.2 3.1 57.1	% Satisfied with nurse care 75.4 74.2 77.3 75.6

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Table G20. The evidence of the association between nurse staffing and patient satisfaction (continued)

Author, Measure of Patient Satisfaction	Sample Size, Unit, Patients	Nurse Categories	Patient Satisfaction																																
Ridge ²⁵ Likert-type 5-point scale from strongly disagree to agree for overall nursing care, pain management, and overall hospital care	Size 1,076 Unit Surgical Patients Surgical	<table border="0"> <tr> <td>% BSN</td> <td>Experience</td> </tr> <tr> <td>44</td> <td>8.70</td> </tr> <tr> <td>Nurse hours/patient day</td> <td>% RN</td> </tr> <tr> <td>6.9</td> <td>67</td> </tr> <tr> <td>Increase by 1 hour in LPN hours</td> <td></td> </tr> <tr> <td>Increase by 1% in RN</td> <td></td> </tr> <tr> <td>% BSN</td> <td>Experience</td> </tr> <tr> <td>44</td> <td>8.70</td> </tr> <tr> <td>Nurse hours/patient day</td> <td>% RN</td> </tr> <tr> <td>6.9</td> <td>67</td> </tr> <tr> <td>% BSN</td> <td>Experience</td> </tr> <tr> <td>44</td> <td>8.70</td> </tr> <tr> <td>Nurse hours/patient day</td> <td>% RN</td> </tr> <tr> <td>6.9</td> <td>67</td> </tr> </table>	% BSN	Experience	44	8.70	Nurse hours/patient day	% RN	6.9	67	Increase by 1 hour in LPN hours		Increase by 1% in RN		% BSN	Experience	44	8.70	Nurse hours/patient day	% RN	6.9	67	% BSN	Experience	44	8.70	Nurse hours/patient day	% RN	6.9	67	Satisfaction with nurse care ± SD 4.3 ± 0.76 4.29 ± 0.14 0.65 0.893 % satisfied 88% 87.2% % satisfied with pain management 84 ± 7 83 ± 3.8				
% BSN	Experience																																		
44	8.70																																		
Nurse hours/patient day	% RN																																		
6.9	67																																		
Increase by 1 hour in LPN hours																																			
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% BSN	Experience																																		
44	8.70																																		
Nurse hours/patient day	% RN																																		
6.9	67																																		
Ritter-Teitel ⁶⁹ satisfaction with nursing care and pain management during hospital stay (max 100 scores)	Size 56 Unit Combined Patients Combined	<table border="0"> <tr> <td>Nurse hours/patient day</td> <td>% RN</td> </tr> <tr> <td>9.3</td> <td>56.15</td> </tr> <tr> <td>9.58</td> <td>56.4</td> </tr> <tr> <td>9.19</td> <td>56.79</td> </tr> <tr> <td>9.79</td> <td>56.77</td> </tr> <tr> <td>9.41</td> <td>56.79</td> </tr> <tr> <td>9.36</td> <td>56.77</td> </tr> <tr> <td>Increase by 1 hour in RN hours</td> <td></td> </tr> <tr> <td>Nurse hours/patient day</td> <td>% RN</td> </tr> <tr> <td>9.3</td> <td>56.15</td> </tr> <tr> <td>9.58</td> <td>56.4</td> </tr> <tr> <td>9.19</td> <td>56.79</td> </tr> <tr> <td>9.79</td> <td>56.77</td> </tr> <tr> <td>9.41</td> <td>56.79</td> </tr> <tr> <td>9.36</td> <td>56.77</td> </tr> <tr> <td>Increase by 1 hour in RN hours</td> <td></td> </tr> </table>	Nurse hours/patient day	% RN	9.3	56.15	9.58	56.4	9.19	56.79	9.79	56.77	9.41	56.79	9.36	56.77	Increase by 1 hour in RN hours		Nurse hours/patient day	% RN	9.3	56.15	9.58	56.4	9.19	56.79	9.79	56.77	9.41	56.79	9.36	56.77	Increase by 1 hour in RN hours		% satisfied with nurse care ± SD 82.68 ± 6.08% 84.38 ± 6.31% 83.29 ± 6.08% 83.82 ± 5.67% 82.08 ± 6.31% 84.9 ± 6.99% 1.18 ± 4.17% % satisfied with pain management 84.1 ± 8.73% 84.6 ± 6.46% 83.1 ± 10.2% 83.3 ± 7.82% 85.3 ± 6.87% 85.9 ± 4.63% 1.50 ± 4.08%
Nurse hours/patient day	% RN																																		
9.3	56.15																																		
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9.19	56.79																																		
9.79	56.77																																		
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9.79	56.77																																		
9.41	56.79																																		
9.36	56.77																																		
Increase by 1 hour in RN hours																																			
Seago ⁸ Patient satisfaction measured with Likert scale	Size 89,256 Unit Combined Patients Medical	<table border="0"> <tr> <td>Patient focused care</td> <td>% RN</td> </tr> <tr> <td>Before</td> <td>63</td> </tr> <tr> <td>After</td> <td>61.5</td> </tr> <tr> <td>After</td> <td>62</td> </tr> </table>	Patient focused care	% RN	Before	63	After	61.5	After	62	Relative risk of being satisfied with nurse care Not significant Not significant Not significant																								
Patient focused care	% RN																																		
Before	63																																		
After	61.5																																		
After	62																																		

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Table G20. The evidence of the association between nurse staffing and patient satisfaction (continued)

Author, Measure of Patient Satisfaction	Sample Size, Unit, Patients	Nurse Categories	Patient Satisfaction
Seago ⁹³ Patient satisfaction measured with Likert scale	Size 1,012 Unit Combined Patients Medical	Nurse hour %RN 8.1 75 8.3 96 7.49 72 Increase by 1 nurse hour Increase by 1% in RN Increase by 1 RN hour	% satisfied with pain management ± SD 84.2 ± 3.5% 89.3 ± 6.4% 80.5 ± 6.7% 2.44 ± 0.62 13.6 ± 3.6 2 ± 2
Sovie ⁷¹ The Picker Institute Patient Satisfaction Survey; the Press, Ganey Patient Satisfaction Survey. Dimensions: pain management, education, Attention to needs, nursing care, preparation for discharge	Size 29 Unit Combined Patients Medical	Nurse hour UAP hour % BSN 9.14 2.39 53.00 9.79 2.7 52.70 9.34 2.22 53.00 9.36 2.56 52.70 Increase by 1 RN hour Nurse hour UAP hour % BSN 9.14 2.39 53.00 9.79 2.7 52.70 9.34 2.22 53.00 9.36 2.56 52.70 Medical Surgical Increase by 1 nurse hour Increase by 1 nurse hour	% satisfied with nurse care ± SD 84 ± 5.9% 84 ± 5.7% 83 ± 6.5% 85 ± 7% 2.87 % satisfied with pain management 83.04 ± 9.962 83.31 ± 7.862 85.55 ± 6.862 85.92 ± 4.662 -2.3 ± 1 -1.4 ± 0.3
Tallier ⁸³ Patient opinion of care in hospital measured with Patient Satisfaction Survey (max 27 scores)	Size 2,897 Unit Combined Patients Medical	Nurse hours % RN 5.8 57 5.7 60 Nurse hours RN hours 6.2 5.9 5.8 5.9 5.8 5.5 5.7 6.9 5.3 6.6 6.1 6.8	% satisfied 72% 72% 72% 72% 77% 77% 77%

RN = registered nurse; UAP = unlicensed assistive personnel; BSN = Bachelor of Science in Nursing; SD = Standard deviation

Table G21. Research studies related to staffing ratios/hours/skill mix in acute care hospitals (not included in questions 1, 2, and 4)

Author, Year, Publication Type	Aim of the Study	Sample	Study Design and Method	Variables	Results
Systematic reviews					
Lankshear ⁹⁶	Assesses the evidence for a relationship between the nursing workforce and patient outcomes in acute hospitals through a systematic review of the literature	22 international studies between 1990 and 2004	Systematic review of literature	Nurse staffing Patient outcomes	22 studies relating nurse staffing to mortality, failure to rescue, and 7 common complications. Concluded that there is support that higher nurse staffing and RN skill mix are associated with improved patient outcomes. Noted that the effect size could not be estimated reliably. The association between nurse staffing and patient outcomes appears to show diminishing marginal returns.
Lang ⁹⁷	Determine if peer-reviewed literature supports minimum nurse-patient ratios for acute care hospitals and whether nurse staffing is associated with patient, nurse employee, and hospital outcomes	43 studies between 1980 and 2003	Systematic review of literature	Nurse staffing Patient, nurse employee, and hospital outcomes	43 studies relating nurse staffing to in-hospital adverse events (failure to rescue, inpatient mortality, pneumonia, urinary tract infection, pressure ulcers, shock); nurse outcomes (needle stick injuries, nurse burnout, nurse documentation, nurse satisfaction, absenteeism, assaults, and nurse professionalism), hospital outcomes (length of stay, financial outcomes, staffing models). Concluded there is probable relationships between nurse staffing and failure to rescue among surgical patients, inpatient mortality; limited evidence between nurse staffing and burnout, needle stick injuries, nurse documentation, hospital financial outcomes; statistically and clinically significant relationship between nurse staffing and length of stay. No support in the literature for specific, minimum nurse-patient ratios, especially in the absence of adjustments for skill and patient mix.

Table G21. Research studies related to staffing ratios/hours/skill mix in acute care hospitals (not included in questions 1, 2, and 4) (continued)

Author, Year, Publication Type	Aim of the Study	Sample	Study Design and Method	Variables	Results
<i>Externally imposed staffing policies (mandated patient ratios)</i>					
Seago ⁹⁸	Examine the relationship between nurse staffing and owner type or specific corporate entity	Short-term general hospitals that reported in the California Office of Statewide Health Planning and Development's (OSHPD) Hospital Disclosure report from 1997-1999	Descriptive cross-sectional design. Secondary data analysis using data from the California OSHPD Hospital Disclosure report (1997-1998).	RN hours/patient day, RN-to-patient ratio, RN skill mix. LVN, aide, and total hours/patient day, patient days, discharges, RN/LPN/NA wages, percent Medicaid, Medicare case mix, length of stay, technology index, rural/urban location, proprietary status for hospital and system	For profit hospitals and system had fewer RN productive hours for medical-surgical nursing, but when distinguished by rural or urban location, the relationship is no longer significant. The lower use of RNs in for profit systems is likely driven by one health system. More RN productive hours is predicted by more patient days, higher case mix index and higher technology scores.
Donaldson ⁹	Examine the impact of mandated nurse-to-patient ratios on unit-level nurse staffing, the incidence and patient outcomes	California hospitals participating in the California Nursing Outcomes Coalition (CalNOC) N = 68 hospitals and 268 patient care units	Descriptive, pre-post design CalNOC data collected at the point of service in real time by hospitals using current staffing data as well as the three patient outcomes. Pre-ratio baseline: first 6 months (2 quarters) of 2002 Post-ratio period: first 6 months (2 quarters) of 2004 following implementation of the licensed nurse-to-patient ratios	Nursing-care hours (RN, LVN, unlicensed productive hours); RN nursing care hours; LVN nursing care hours; non-RN and LVN caregiver care hours; contracted hours; skill mix; total patient days; patient falls incidence; hospital acquired pressure ulcer prevalence.	Mean total RN hours of care per patient day increased by 20.85 on medical-surgical units after implementation of mandated staffing ratios; total nursing hours increased by 7.4%. Number of patients per licensed nurse decreased post-implementation by 16% and the number of patients per RN decreased by 17.5%. No changes noted to step-down units; no changes in use of contract nurses. Changes were consistent across hospital size and hospital systems. There was no statistically significant change in the incidence of falls or the prevalence of hospital acquired pressure ulcers following implementation of the nurse-patient mandated ratios.

Table G21. Research studies related to staffing ratios/hours/skill mix in acute care hospitals (not included in questions 1, 2, and 4) (continued)

Author, Year, Publication Type	Aim of the Study	Sample	Study Design and Method	Variables	Results
Hodge ⁹⁹	Develop baseline data on the characteristics, number, and distribution of licensed caregivers in specific units of acute care hospitals in California and determine how staffing varies across different types of acute care hospitals.	Stratified random sample of general acute care hospitals in California. N = 80 hospitals; 2,298 nurses	Cross-sectional descriptive design. Investigator developed survey instrument which was administered by RN surveyors. Data collected from hospital administrators, nurse managers, direct care staff nurses.	Unit-related data: Duration of shifts, type of shifts, number of patients, nurses, unlicensed staff, admissions, discharges, patient care assignments, services provided by licensed nurses; experience, education, employment status and patient load of each nurse on duty on day of survey; staffing and skill mix data for all shift.	Diverse nursing staffs are present in California hospitals (e.g. education, experience, employment status). 50% of RNs on day shift have a baccalaureate degree. The proportion of RNs varied by type of unit ranging from 30% (subacute) to 84% (postpartum/delivery). Per diem and agency staff comprise more than 20% of the day shift staff for emergency departments and post-partum units. Nurses in academic medical centers and rural hospitals generally had fewer patients than did nurses in other hospital types.
<i>Studies with implications for staffing policies that were ineligible for meta-analysis</i>					
McGillis Hall ¹⁰⁰	Evaluate the impact of different nurse staffing models selected patient outcomes.	19 teaching hospitals in Ontario, Canada using adult medical-surgical and obstetric inpatients. N at admission: = 2,046 N at discharge = 1,811 N at 6 weeks post discharge = 1,483	Repeated measure design Data collected from patients using a variety of instruments and data also collected by data collectors. Staffing data provided by nurse managers. Patient data collected at admission, discharge, and 6 weeks after discharge.	Functional health outcomes (Functional Independence Measure; SF-36); Pain (Brief Pain Inventory Short Form); Patient perception of nursing care (Patient Judgment of Hospital Quality Questionnaire); Mix of staff on patient care units Continuity of patient care assignments	A higher proportion of regulated nursing staff (Canadian term for RN) was associated with better FIM scores and better social function scores at hospital discharge. Nursing staff mix (higher proportion of RN/RPNs) was a significant predictor of functional independence, pain, social functioning, and patient satisfaction with obstetric care, after other potential determinants of health outcomes were controlled.

Table G21. Research studies related to staffing ratios/hours/skill mix in acute care hospitals (not included in questions 1, 2, and 4) (continued)

Author, Year, Publication Type	Aim of the Study	Sample	Study Design and Method	Variables	Results
McGillis Hall ¹⁰¹	Determine if nurse staffing models and nursing demographic variables explain variation in quality outcomes. Determine if the influence of the nurse staffing model on the quality outcomes varies by type of care delivery model.	77 adult medical, surgical and obstetrical patient care units in 19 urban teaching hospitals in Ontario, Canada. 1,116 nurses	Descriptive correlational design Nurse staffing data collected through questionnaires to unit managers; Surveys distributed to RNs	Nurse staff mix; Nursing care delivery models (total patient care, team nursing, primary nursing); Nurses' perceptions of quality of care; Unit communication and coordination.	There was a significant positive relationship between all nursing staff models with an all-RN staff and nurses' perceptions of quality of care. A staff mix of RNs and RPNs had a statistically significant negative influence on the use of individualized approaches for the coordination of care and overall unit communication, whereas the opposite was true for staff models that had both regulated and unregulated workers (RNs, RPNs, and URWs).
McGillis Hall ¹⁰¹	Examine the effect of different nurse staffing models on costs and patient outcomes.	77 adult medical, surgical and obstetrical patient care units in 19 urban teaching hospitals in Ontario, Canada.	Descriptive correlational design	Four types of nursing staff mix (RN and RPN; all RN; proportion of URW to regulated workers (RNs and RPNs); RN/RPN//URW staff mix. Patient safety outcomes (patient falls, medication errors, wound infections, urinary tract infections); Case nursing hours (measure of nursing resource use); Patient complexity.	Lower proportions of professional nursing staff (RNs/RPNs) was related to higher number of medication errors and wound infections.

FIM = Functional independence measure; RN = Registered Nurse; RPN = Registered Practical Nurse; URW = unregulated workers

Table G22. Research studies related to shift work of nurses (types of shifts; length of shifts)

Author, Year, Publication Type	Aim of the Study	Sample	Study Design and Method	Variables	Results
Skipper ¹⁰²	Examine the relationship between the physical health and mental depression of nurse shift workers and relevant social and work related variables	482 RNs working shifts in five hospitals in the southeastern region of the U.S.	Descriptive survey Distributed questionnaires through the nurses' hospital	Physical health scale (e.g. quantity and quality of sleep; physical related problems); Depression measured by the CES-D scale; Family relation; Informal social participation (e.g. frequency visiting friends, relatives); Job performance measured by the Six-Dimension Scale of Nursing Performance; Job related stress scale. Covariates: age, marital status, number of children under age 6, education, work experiences, shift preferences, etc.	When controlling for the background variables, there was no relationship between difficulty in family relations and shift work or informal social participation and shift work. Shift work was associated with voluntary organization participation (most prevalent in the day shift nurses), hours spent in solitary activities (most prevalent in the evening shift nurses), and job performance (lowest perception of job performance by nurses working rotating shifts). Job related stress and shift work were significantly related (nurses working rotating shifts experienced the highest stress). No association was found between shift work and physical health or depression. There was an association with shift type and quality and quantity of sleep. Night shift nurses received the least amount of sleep and had the most trouble sleeping.
Gold ¹⁰³	Examine the impact of work schedule on the sleep schedule, sleepiness, and accident rates of female nurses in a Massachusetts hospital based on a self-administered questionnaire administered in 1986.	687 RNs and LPNs employed in one hospital	Cross-sectional Self-administered questionnaire in which nurses kept records for two weeks regarding their work schedules and sleep patterns	Nurses' record of shifts worked for two weeks and sleep and wake times for the same two weeks. Nurses' self-assessments of quality of sleep, sleepiness, automobile accidents or other injuries, medication, and procedural errors.	Night nurses and nurses that rotated shifts (rotators) had the highest odds of poorer quality of sleep and using sleeping medications. The odds of reporting any accidents or errors were higher for rotators than nurses working days or evenings.

Table G22. Research studies related to shift work of nurses (types of shifts; length of shifts) (continued)

Author, Year, Publication Type	Aim of the Study	Sample	Study Design and Method	Variables	Results
Ruggiero ¹⁰⁴	To determine variables contributing to chronic fatigue in critical care nurses and to determine if there are differences between critical care nurses working day and night shifts in regards to fatigue, depression anxiety, and quality of sleep.	Subjects were members of the American Association of Critical Care Nurses. 67 worked the day shift and 75 worked the night shift.	Descriptive, survey; two-group comparison Mailed survey	Chronic shift worker fatigue measured by the <i>Standard Shiftwork Index Chronic Fatigue Scale</i> ; Global sleep quality measured by the <i>Pittsburgh Sleep Quality Index</i> ; Depression measured with the <i>Beck Depression Inventory-II</i> ; Anxiety measured with the <i>Beck Anxiety Inventory</i> . Demographic data obtained regarding age, gender, shift, and schedule details.	Permanent night nurses had significantly more depression and poorer global sleep quality; no significant differences between day and night shift nurses in chronic fatigue or anxiety. 46% of the variance in chronic fatigue was explained by depression and global sleep quality.
Rogers ¹⁰⁵	To examine the work patterns of hospital staff nurses and determine if there is a relationship between hours worked and frequency of errors.	393 RNs who were members of the American Nurses Association. Unit of analysis was number of shifts worked (5,317) over a 28-day reporting period.	Descriptive; survey Mailed log book	Nurse-reported data regarding hours worked (scheduled and actual), time of day worked, overtime, days off, sleep/wake patterns, mood, caffeine intake, errors and near errors.	Participants worked, on average, 55 minutes longer than scheduled each day. Almost 2/3 of the nurses worked overtime 10 or more times during the 28-day period. One quarter of the respondents worked more than 50 hours per week for two or more weeks of the 2-day period. More than 25% of nurses reported working mandatory overtime at least once during the 28 days. There were 199 reported errors and 213 reported near errors. More than half of the errors and near errors were medication related. The likelihood of making an error increased with longer work hours and was three times higher when nurses worked shifts lasting 12.5 hours or more (OR = 3.29). Working overtime increased the odds of making at least one error, regardless of how long the shift was originally scheduled (OR = 2.06). The risk of making errors increases when nurses work overtime after longer shifts. Age, hospital size, or type of unit did not have an effect on errors or near errors.

Table G22. Research studies related to shift work of nurses (types of shifts; length of shifts) (continued)

Author, Year, Publication Type	Aim of the Study	Sample	Study Design and Method	Variables	Results
Trinkoff ¹⁰⁶	To describe the nature and prevalence of extended work schedules of nurses	2,273 randomly selected RNs who participated in the NIOSH Nurses Worklife and Health Study	Cross-sectional survey Mailed survey	Work-schedule variables derived from the <i>Standard Shiftwork Index</i> hours worked per day and week; weekends worked/month; days worked in a row; work more than one job; how off shifts are organized). Mandatory overtime requirement. Demographic characteristics.	When compared to the entire sample, hospital staff nurses were most likely to work 12 or more hours/day, but half as likely to work 6-7 days/week. They were more likely to work off-shifts. Similarly, nurses with more than one job worked more hours per week as well as more consecutive days. Nurses 50 years old and older were less likely to work long days and were the group that tended to work days only. 17% of the sample were required to work mandatory overtime. On call requirements were more prevalent among hospital staff nurses.
Havlovic ¹⁰⁷	Examine the impact of work schedule congruence on personal life interference and service to patients; examine the combined effects of the rotating shift and the compressed work week	520 randomly selected nurses in British Columbia that returned the mailed survey. Nurses were members of the nurses' union.	Descriptive correlational Mailed survey	Subscales from the Comprehensive Work-Schedule Survey (CWSS): Current Schedule Interference with Activities with Family & Friends; General Affect Toward Current Schedule; Service to External Constituents; Interference with Rest and Sleep. Nurse characteristics included full/part time status, shift and schedule currently working and preferred.	Over 40% of nurses worked a rotating compressed work week schedule and 47% were working both their preferred shift and work week. Nurses that worked their preferred shift, but not their preferred week reported lower interference with family and friends, a positive general affect toward their schedule and less interference with sleep and rest. Work week congruence was not significant for any of the dependent variables. Nurses with a rotating compressed work week schedule experienced more interference with their personal lives, including rest patterns as well as family and social activities, and most were dissatisfied with their schedules and reported lower quality service to their patients. Nurses who worked in larger hospitals (hospital factor) experienced greater interference of their work schedules with rest and sleep. Nurses that worked a longer time in a hospital (nurse factors) were less likely to report negative consequences of their work schedule.

Table G22. Research studies related to shift work of nurses (types of shifts; length of shifts) (continued)

Author, Year, Publication Type	Aim of the Study	Sample	Study Design and Method	Variables	Results
Hoffman ¹⁰⁸	Examine the variation in role stress and career satisfaction among hospital-based RNs by work shift length	Probability sample of 208 nurses who were members of the Michigan Nurses Association (50.4% response rate). N = 99 working predominantly 8-hour shift pattern; N = 105 working 12 hours shifts or a combination of 8, 10, and 12 hour shifts.	Descriptive comparative study Mailed questionnaires	Role stress (Nursing Stress Scale) Career satisfaction (Index of Work Satisfaction)	No significant demographic differences between groups. RNs working 12 hour shifts experienced significantly higher levels of stress than those working 8-hour shifts; however, when controlling for nursing experience, similar levels of stress were found in both groups. Both groups were similar in regards to work satisfaction and the only differences in career satisfaction was that 8-hour RNs were significantly more satisfied with their current salary and 12-hour RNs derived more satisfaction from professional status.

Table G23. Research studies related to use of agency/contract nursing staff in hospitals

Author, Year, Publication Type	Aim of the Study	Sample	Study Design and Method	Variables	Results
Hughes ¹⁰⁹	Examine differences between agency and hospital nurses as related to recruitment, retention, and compensation.	6,895 staff nurses responding to a survey sent by a state's Board of Nursing. Primary employer a staffing agency: n=3,360 Primary employer a hospital: n=3,535 (randomly selected)	Descriptive; survey Survey sent out with nurses' renewal of their license.	Items from the survey regarding nurses' non-salary compensation package; issues related to recruitment and retention; conditions for willingness or need to increase current work hours.	Hospital nurses were more likely to receive pension plans, health and dental insurance, reimbursement for continuing education and tuition; child care services, and parking. Agency nurses received significantly higher hourly wages. Agency nurses were more likely to indicate that improved benefits would be an incentive to change jobs whereas hospital nurses were more likely to change jobs for increased autonomy. There was no difference between the groups in terms of changing jobs for improved scheduling, specialty practice, or salary. Half of all nurses in the study indicated they would leave their job for increased salary, but there was no difference between agency and hospital nurses. While most nurses were willing to increase their work hours for incentives such as salary increases, child care services, improve relations at work, improved scheduling, promotion opportunities, and improved patient care, hospital nurses were more likely to increase their workload for those incentives.

Table G23. Research studies related to use of agency/contract nursing staff in hospitals (continued)

Author, Year, Publication Type	Aim of the Study	Sample	Study Design and Method	Variables	Results
Hughes ¹¹⁰	Examine the sociodemographic characteristics of agency and hospital staff nurses and determine if there are differences in their work schedules and clinical practice.	6,895 staff nurses responding to a survey sent by a state's Board of Nursing. Primary employer a staffing agency: n=3,360 Primary employer a hospital: n=3,535 (randomly selected)	Descriptive; survey Survey sent out with nurses' renewal of their license.	Items from the survey regarding nurses' work schedules, practice activities/use of clinical skills, and perception of nurses regarding opportunities in their jobs to use the clinical skills.	Agency nurses were more likely to be male, unmarried, and members of minority groups, and have a master's degree, whereas hospital nurses were more likely to be enrolled in an education program at least part time. Agency nurses were more likely to work evening and night shifts as well as weekend shifts and fewer hours per week than hospital employed nurses. There were significant differences in the clinical practice of both groups. Hospital nurses reported performing more physical and psychological examinations on a greater percentage of their patients. Agency nurses evaluated clinical outcomes, developed nursing diagnoses and therapeutic plans for more patients. Agency nurses differed significantly from hospital nurses in regard to reporting they had a very or fairly good chance to use their skills; whereas hospital nurses felt they had little or no chance. Agency nurses used computers to a significantly lesser extent than hospital nurses.

Table G23. Research studies related to use of agency/contract nursing staff in hospitals (continued)

Author, Year, Publication Type	Aim of the Study	Sample	Study Design and Method	Variables	Results
Warren ¹¹¹	To examine nurse managers' use, perceptions of costs, benefits and quality of care of supplemental nursing staff.	89 nurses in management positions in two urban and two rural hospitals randomly selected from 32 hospitals in a southeastern state.	Descriptive; survey Mailed questionnaire	Investigator developed questionnaire that queried the use of supplemental staffing and perceptions of the quality of care provided by supplemental staff nurses. Supplemental staff could be either agency-based or hospital-pool.	While the majority of nurse managers believed that the use of supplemental nurses would increase in the future, they did not believe it was a cost effective practice. 59 of the 89 respondents had used supplemental staffing. The primary reason for non-use was perception of poor quality care. Those that had used supplemental staff indicated that it resulted in reduction of overtime and workload for nursing staff as well as covering for weekends, night shifts, absenteeism, and vacations. Managers' perceptions of quality care of supplemental staff did not differ for hospital pool supplemental staff versus agency staff.
Strzalka ¹¹²	To compare float pool nurses (FPN), agency nurses (AN), and unit-hired nurses (UHN) on selected clinical indicators.	Over the course of 8 months, medical records associated with nurses on one nursing unit from each of the three groups were reviewed. 150 records were reviewed—50 from each group. Study was conducted in a large teaching hospital in the southeastern U.S.	Descriptive comparative design	Two clinical aspects of care were monitored: patient safety measures to prevent falls and assessment and management of bowel function. Patient flow sheets in the patients' medical records were reviewed.	Float pool nurses had the highest rate of documentation, followed by agency nurses and then unit-hired nurses. There were statistically significant differences between FPNs and UHNs for 3 of 5 indicators to prevent falls and a statistically significant difference between ANs and FPNs on 1 of 3 indicators for bowel management and between UHNs and ANs and FPNs on 1 of 3 indicators for bowel management.

Table G23. Research studies related to use of agency/contract nursing staff in hospitals (continued)

Author, Year, Publication Type	Aim of the Study	Sample	Study Design and Method	Variables	Results
Bloom ¹⁸	Assess the effect of four nurse staffing patterns on the efficiency of patient care delivery: RNs from temporary agencies; part-time career RNs; RN rich skill mix; and organizationally experienced RNs	Random sample of 1,222 hospitals selected; 583 hospitals in sample	Descriptive correlational	Nursing Personnel Survey which includes information about full and part time staff, use of agency staff, RN mix and experience. Merged data from the American Hospital Association's annual survey of hospitals and the Area Resource File. Hospital efficiency was the dependent variable and measured as personnel costs per adjusted admission and total non-personnel operating costs per adjusted hospital admission. Control variables: hospital size, ownership/control; teaching status; occupancy rate; length of stay; geographic region; urban/rural status; regulatory intensity by state; local economic climate; hospital wage rates; hospital competition within a service area; supply of nursing labor within the community.	Use of part-time staff was related to lower personnel and hospital costs; skill mix was unrelated to personnel and hospital costs; use of temporary RNs was not related to personnel costs but was related to higher hospital operating costs.

Table G24. Research studies related to full- and part-time nursing staff

Author, Year, Publication Type	Aim of the Study	Sample	Study Design and Method	Variables	Results
Jolma ¹¹³	Examine the relationship between nursing workload and turnover.	Randomly selected sample of medical-surgical staff nurses employed in Arizona (n=270). 123 respondents with usable questionnaires.	Descriptive correlational Mailed questionnaire	Nursing workload was measured by the <i>Role Overload</i> subscale and intent to turnover was measured by the <i>Intention to Turnover</i> subscale, both part of the <i>Michigan Organizational Assessment Questionnaire</i> . Demographic questionnaire including information on full- and part-time status.	Full-time status, large hospital size, and large unit size were associated with higher role overload and turnover intent.
Wetzel ¹¹⁴	Comparison of personal and job characteristics and work-related attitudes of full-time and part-time registered nurses.	Full and part time RNs employed in three large urban hospitals in a Canadian province. Stratified sampling technique to ensure representation of full- and part-time RNs. Questionnaire sent to 930 nurses with 634 responding. Eliminated nurses with less than a year of employment resulting in a final sample of 595.	Descriptive comparative design Mailed questionnaires	Job characteristics and work related attitude measures: organizational commitment; professionalism; job involvement; extrinsic and intrinsic job satisfaction, satisfaction with supervisor; difficulty leaving job; influence on decision making. No description provided of the questionnaire, reliability and validity.	Part-time nurses were older, married, had greater tenure in the organization, and more experience. Statistically significant difference in job involvement between full- and part-time nurses. Full-time nurses were significantly more job involved. There was no difference between full- and part-time nurses on the other work-related attitude items.
Porter ¹¹⁵	Determine if there were self-image differences between beginning and expert nurses, caregivers and non-caregivers, educational levels of nursing and full-time and part-time staff.	363 nurses in a midwestern hospital responding to a survey.	Descriptive; comparative Method for distributing questionnaires not provided.	Self image measured by <i>Porter Nursing Image Scale</i> (3 factors: interpersonal power; interpersonal relations; interpersonal ability) and demographic questionnaire	More positive scores on the three factors were found for full-time versus part-time nurses; there was a statistically significant difference for the interpersonal power factor (e.g. leader; functioning in an independent manner).

Table G24. Research studies related to full- and part-time nursing staff (continued)

Author, Year, Publication Type	Aim of the Study	Sample	Study Design and Method	Variables	Results
Bloom ¹⁸	Assess the effect of four nurse staffing patterns on the efficiency of patient care delivery: RNs from temporary agencies; part-time career RNs; RN rich skill mix; and organizationally experience RNs	Random sample of 1,222 hospitals selected; 583 hospitals in sample	Descriptive correlational Secondary data	Nursing Personnel Survey which includes information about full- and part-time staff, use of agency staff, RN mix and experience. Merged data from the American Hospital Association's annual survey of hospitals and the Area Resource File. Hospital efficiency was the dependent variable and measured as personnel costs per adjusted admission and total non-personnel operating costs per adjusted hospital admission. Control variables: hospital size, ownership/control; teaching status; occupancy rate; length of stay; geographic region; urban/rural status; regulatory intensity by state; local economic climate; hospital wage rates; hospital competition within a service area; supply of nursing labor within the community.	Use of part-time staff was related to lower personnel and hospital costs; skill mix was unrelated to personnel and hospital costs; use of temporary RNs was not related to personnel costs but was related to higher hospital operating costs.

Table G24. Research studies related to full- and part-time nursing staff (continued)

Author, Year, Publication Type	Aim of the Study	Sample	Study Design and Method	Variables	Results
Burke ¹¹⁶	Examine the effects of hospital restructuring and downsizing on full- and part-time nursing staff.	Randomly selected nurses employed in Ontario hospitals and members of a nurses union. N=1,362 Part time: 700 Full time: 645	Descriptive, correlational Mailed questionnaire	Personnel and situational characteristics which included whether the respondent worked full or part time. Restructuring and downsizing measures (extent of restructuring; workload; staff bumping; impact of generic workers). Threats to security (e.g. layoff, change of employment status to part time). Impact on staff and institutions (job insecurity feelings; impact of restructuring on hospital functioning; impact on hospital facilities). Implementation and management measures (fairness, communication, vision, staff participation, revitalization). Organizational support. Work outcomes (job satisfaction, intent to quit and absenteeism). Psychological well-being indicators (emotional exhaustion, cynicism, professional efficacy, psychosomatic symptoms, physical health, medication use, lifestyle habits)	Full- and part-time nurses differed significantly on the majority of demographic and situational characteristics (e.g. full-time nurses more experience in nursing, worked more hours per week, older, higher levels of education, less likely to be married). They responded to the effects of downsizing and restructuring quite similarly, but full-time nurses reported significantly heavier workloads. They were also similar in regards to job satisfaction, but full-time nurses were more likely to be absent and less likely to quit. Full-time nurses reported significantly higher levels of exhaustion, cynicism, and professional efficacy (psychological burnout). They were also more likely to report poorer physical health, greater medication use, and poorer lifestyles (physical wellbeing).

Table G24. Research studies related to full- and part-time nursing staff (continued)

Author, Year, Publication Type	Aim of the Study	Sample	Study Design and Method	Variables	Results
Havlovic ¹⁰⁷	Examine the impact of work schedule congruence on personal life interference and service to patients; examine the combined effects of the rotating shift and the compressed work week.	520 randomly selected nurses in British Columbia that returned the mailed survey. Nurses were members of the nurses' union.	Descriptive correlational Mailed survey	Subscales from the Comprehensive Work-Schedule Survey (CWSS): Current schedule Interference with activities with family & friends; general affect toward current schedule; Service to external constituents; interference with rest and sleep. Nurse characteristics including full- and part-time status, shift and schedule currently working and preferred	Specific to full- and part-time status of nurses, nurse who worked part-time reported providing higher quality service to patients, liked their present work schedules more, and experienced less interference between their work and non-work activities. Nurses who worked part time on a contingent basis did not have these positive experiences.

Table G25. Research studies related to internationally educated nurses (IEN)

Author, Year, Publication Type	Aim of the Study	Sample	Study Design and Method	Variables	Results
Crawford ¹¹⁷	Compare processes of U.S. and IEN nurses' experience to acquire licensure, and compare practice settings of U.S. nurses and IENs.	Stratified random sample of 1,000 RNs educated in the U.S. and 1,000 RNs educated in targeted foreign countries (10% Philippines, 20% India, 10% Canada, 10% South Korea, 10% Nigeria, 10% England, 10% USSR, and 10% China) and who had successfully completed the NCLEX-RN examination. U.S. response rate = 570 (58.7%) IEN response rate = 401 (45.5%)	Descriptive survey Potential responders were selected from the nurses who had successfully completed the NCLEX-RN examination between September 1 and November 30, 2002. A 4-stage mailing process was used to engage participants. Selected potential responders were sent the Practice and Professional Issues Survey (PPI) which is routinely used by the National Council of State Boards of Nurses to collect information from entry-level nurses of practice activities.	Demographic data; description of process experienced by nurses to complete the application for U.S. RN licensure and secure a job; work settings, geographic locations.	35% of IENs worked with a recruiter when completing the steps for U.S. nursing licensure. The average amount of time to complete the process to receive a U.S. RN licensed for IENs was 23 months, but 19 months for those using a recruiter. 34% of IEN RNs secured a nursing position in the U.S. before moving to the U.S. from their home country. U.S. nurses were more likely to report working in critical care (29.8 %) and medical surgical units (42.7%). IENs were more likely to work in medical surgical units (41.4%) and nursing homes (21.6%).
DiCicco-Bloom ¹¹⁸	To describe the experiences of a group of immigrant women nurses regarding their life and work in a culture other than their own.	Snowball sample initiated with the South Asian Nurses Association in New York state. 10 participants educated in India between the ages of 40-50, married, and lived in either Pennsylvania (n=3) or New Jersey (n=7). All were educated in India.	Descriptive, qualitative design. Semi structured interviews with open-ended questions were used to evaluate for themes of life and work as reported by the female immigrants from India.	Descriptive experiences of nurses educated in India and living and working in the U.S. as RNs	The themes emerging from the interviews were related to the challenges of living between two cultures and countries, racism experienced by the participants and their experience of marginalization as female nurses of color.

Table G25. Research studies related to internationally educated nurses (IEN) (continued)

Author, Year, Publication Type	Aim of the Study	Sample	Study Design and Method	Variables	Results
Flynn ¹¹⁹	Examine differences, between cultures of the U.S. and international nurses regarding core values of nursing (autonomy, control over practice, and relationship with physicians); job satisfaction; and levels of burnout	820 nurses who worked at least 16 hours per week on one of the 40 study units. N=252 international in origin N=547 U.S. in origin	Comparative descriptive study using secondary data collected in 1991 from 40 inpatient care units in 20 hospitals located in 11 U.S. cities with a high incidence of AIDS.	Country of origin (IV); values related to the professional nursing practice environment (Nursing Work Index-6 subscales); emotional exhaustion (Maslach Burnout Inventory)	124 of the international nurses received their nursing education outside of the U.S. No differences were found between country of origin and three of the subscales of the Nursing Work Index (control over practice, relationships with physicians, and importance of hierarchy). Significant differences were found for three of the subscales (autonomy, ambiguity reduction, and collectivism). The absence of a professional practice environment was a significant predictor of emotional exhaustions among both U.S. and international nurses.
Pizer ¹²⁰	Compare job satisfaction and demographics for U.S. and IEN in six New York City public hospitals.	857 direct care nurses from six public hospitals in New York City. N=857 IEN nurses N=535 U.S. nurses	Comparative study design. A two-part survey was developed for study by the Institute for Health Policy distributed to nurses.	Demographics (e.g. education, shift worked, overtime, age, experience, unit type). Job satisfaction (Nurse Job Satisfaction Survey)	Internationally educated nurses were younger and held a baccalaureate degree. They were more likely to be male, have less children, work off shifts and more overtime, work in specialty units, and had less experience as an RN than U.S. nurses. No differences between the two groups were found in job satisfaction for time to do the job and satisfaction with quality of care they were able to provide. There was a small significant difference for enjoyment of job with U.S. nurses reporting slightly more job enjoyment. This difference disappeared however when nurses who had positions that required both administrative responsibilities and direct care were omitted. Being a IEN did not provide any explanation of variance for the three subscales of the NJSS.

Table G25. Research studies related to internationally educated nurses (IEN) (continued)

Author, Year, Publication Type	Aim of the Study	Sample	Study Design and Method	Variables	Results
Xu ¹²¹	Describe the demographic, educational, and employment characteristics of Internationally Educated Nurses (IENs) with comparison to U.S. trained nurses.	35,579 nurses from the 2000 National Sample Survey of Registered Nurses; 3.7% of sample (1,300) were IENs.	Descriptive study using secondary data from the 2000 National Sample Survey of Registered Nurses (NSSRN),	Age, gender, education, employment (full time vs. part time; work hours) work setting and unit; position; income; job satisfaction, reasons for not working.	IENs were generally younger than U.S. nurses. Most were from the Philippines (38.9%), followed by Canada (17.5%), India (10.9%) and the UK (8.9%). IENs are more likely to be baccalaureate prepared over USNs (38.3% and 30% respectively) and more likely to work full time (73.7% vs. 59.1%). Many of the IENs were on contract to work full time and thus did not have an option to work part time. There was no difference in job satisfaction between the two groups. The rate of IENs who left nursing was only half that of U.S. nurses (2.3% vs. 4.6%).
Yi ¹²²	Investigate how Korean nurses adjust to the U.S. hospital settings, the processes by which they adjust, and how their cultural background affects their adjustment process.	Purposive sample of 12 Korean nurses working in the U.S.	Exploratory study using a grounded theory method using semi-structured, indepth interviews.	Experience of Korean nurses' adjustment to U.S. hospitals.	Adjustment to U.S. hospitals involves two stages. Initial stage of adjustment is 2-3 years involving three stages: 1) relieving psychological stresses; 2) overcoming the language barriers; 3) accepting U.S. nursing practice. 5-10 years for two later stages: 1) adopting U.S. styles of problem-solving strategies; 2) adopting styles of U.S. interpersonal relationships.

USNs = U.S. trained nurses

Table G26. Research related to nursing staff overtime

Author, Year, Publication Type	Aim of the Study	Sample	Study Design and Method	Variables	Results
Shader ¹²³	Examine the relations between work satisfaction, stress, age, cohesion, work schedule, and anticipated turnover	Staff nurses and nurse managers from 12 units in a 908-bed university hospital in the southeastern U.S. N = 241	Descriptive study using a cross-sectional survey design. Questionnaire distributed directly to nurses during work hours.	Nurse work satisfaction (Index of Work Satisfaction) Job stress (modified version of the Job Stress Scale). Group cohesion (Bryne Group Cohesion Scale). Anticipated turnover (Anticipated Turnover Scale). Actual turnover (calculated as a ratio of the number of people who resigned to the average number of staff working for one year) Unit demographics (e.g., size of the unit, turnover data, patient satisfaction scores, overtime, acuity, ADC, staffing mix, and reallocation). Nurse demographics (e.g., age, gender, position, years of experience, tenure, education, shift worked).	Specific to overtime, work satisfaction, weekend overtime, job stress, and group cohesion predicted anticipated turnover rate and explained 31% of the variance

Table G26. Research related to nursing staff overtime (continued)

Author, Year, Publication Type	Aim of the Study	Sample	Study Design and Method	Variables	Results
Berney ¹²⁴	To determine factors that influence overtime use among various hospitals and within the same hospitals from year to year	General acute care hospitals in New York state that filed Institutional Cost Reports (ICR) 1995 to 2000. Over the five years, hospitals included in analysis ranged from 167 to 174 hospitals. Observations represented hospital years and varied from 1,008 to 1,028.	Secondary data from cost reports	Straight time and overtime hours; proportion of RN hours for acute inpatients that were overtime hours; ownership; location; teaching; unionization.	RNs, on average, worked 4.5% of their total hours as overtime (under 2 hours/week; range 0 to 8 hours/week. Multivariate analysis results found that within hospitals, an increase of 1 hour of RN straight time per patient day was associated with a 10% decrease in overtime. Occupancy, average hourly wage and hours in the average work week were not associated with RN overtime within hospitals. When controlling for year to year variations in overtime for each hospital, higher RN straight hours were significantly associated with higher RN overtime. Each 1 hour increase in straight time was associated with an 8.7% increase in overtime. Government hospitals used 44% less overtime than did for-profit and nonprofit hospitals. Having unionized RNs was associated with a 22% higher rate of overtime use.

Table G26. Research related to nursing staff overtime (continued)

Author, Year, Publication Type	Aim of the Study	Sample	Study Design and Method	Variables	Results
Rogers ¹⁰⁵	To examine the work patterns of hospital staff nurses and determine if there is a relationship between hours worked and frequency of errors.	393 RNs who were members of the American Nurses Association. Unit of analysis was number of shifts worked (5,317) over a 28 day reporting period.	Descriptive; survey Mailed log book	Nurse-reported data regarding hours worked (scheduled and actual), time of day worked, overtime, days off, sleep/wake patterns, mood, caffeine intake, errors and near errors.	Participants worked, on average, 55 minutes longer than scheduled each day. Almost 2/3 of the nurses worked overtime 10 or more times during the 28-day period. One quarter of the respondents worked more than 50 hours per week for two or more weeks of the 28-day period. More than 25% of nurses reported working mandatory overtime at least once during the 28 days. There were 199 reported errors and 213 reported near errors. More than half of the errors and near errors were medication related. The likelihood of making an error increased with longer work hours and was three times higher when nurses worked shifts lasting 12.5 hours or more (OR=3.29). Working overtime increased the odds of making at least one error, regardless of how long the shift was originally scheduled (OR=2.06). The risk of making errors increases when nurse work overtime after longer shifts. Age, hospital size or type of unit did not have an effect on errors or near errors.

Table G26. Research related to nursing staff overtime (continued)

Author, Year, Publication Type	Aim of the Study	Sample	Study Design and Method	Variables	Results
Trinkoff ¹⁰⁶	To describe the nature and prevalence of extended work schedules of nurses.	2,273 randomly-selected RNs who participated in the NIOSH Nurses Worklife and Health Study.	Cross-sectional survey Mailed survey	Work-schedule variables derived from the <i>Standard Shiftwork Index</i> hours worked per day and week; weekends worked/month; days worked in a row; work more than one job; how off shifts are organized). Mandatory overtime requirement. Demographic characteristics.	When compared to the entire sample, hospital staff nurses were most likely to work 12 or more hours/day, but half as likely to work 6-7 days/week and off-shifts. Similarly, nurses with more than one job worked more hours per week as well as more consecutive days. Nurses 50 and older were less likely to work long days and were the group that tended to work days only. 17% of the sample was required to work mandatory overtime and 2/3 were required to do so with less than a 2 hour notice. There were no differences in the prevalence of mandatory overtime among hospital staff RNs compared with the overall sample, those working more than one job and those 50 years and older. Single parents were more likely to work jobs with mandatory overtime. Those whose jobs included mandatory overtime worked significantly longer hours. On call requirements were more prevalent among hospital staff nurses.

Table G26. Research related to nursing staff overtime (continued)

Author, Year, Publication Type	Aim of the Study	Sample	Study Design and Method	Variables	Results
O'Brien-Pallas ¹²⁵	Determine factors contributing to high RN injury claim rates in Canadian hospitals.	127 hospitals in Ontario, Canada N = 8,044 RNs	Cross-sectional study Secondary data (1998-99)	Workload and staffing data (mandatory annual Ontario Ministry of Health and Long Term Care hospital submissions; Nursing lost-time injury claims data (Ontario Workplace Safety and Insurance Board database); Organizational (job dissatisfaction), nurse characteristics (age, health, missed shifts, emotional exhaustion, autonomy in practice, control over practice, nurse-physician relationships).	High hospital RN lost-time claim rates were increased by 70% for each quartile increase in the percentage of RNs reporting more than one hour of overtime per week.
Berney ¹²⁶	Examine trends in the use of overtime by hospitals to determine whether overtime has been increasing more rapidly in some kinds of hospitals than in others.	150 hospitals in New York State	Secondary data from cost reports	Straight time and overtime hours; proportion of RN hours for acute inpatients that were overtime hours; ownership; location; teaching; unionization.	Overtime increased 51% from 1995-2002. Overtime increased more in nongovernment, unionized hospitals and non teaching hospitals.

Table G27. Evidence of the association between nurse skill mix (proportion of registered nurses) and patient outcomes

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes Source to Measure Nurse Skill Mix, Definition of Nurse Skill Mix	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
ANA ⁵⁶ An average hospital rate of nosocomial pneumonia, urinary tract infections, postoperative infections as secondary diagnoses in surgical patients; % RN Hours/total nursing hours	Hospitals 131 Unit Combined Patients Combined	Increase by 1% in RNs in New York, 1992 Increase by 1% in RNs in New York, 1994 Increase by 1% in RNs in California, 1992 Increase by 1% in RNs in California, 1994 Increase by 1% in RNs in New York, 1992 Increase by 1% in RNs in New York, 1994 Increase by 1% in RNs in California, 1992 Increase by 1% in RNs in California, 1994 Increase by 1% in RNs in New York, 1992 Increase by 1% in RNs in New York, 1994 Increase by 1% in RNs in California, 1992 Increase by 1% in RNs in California, 1994	Relative risk Urinary tract infection 1.00 0.99 0.99 0.99 Pneumonia Rate, % Relative risk 0.00 1.00 0.00 1.00 -0.56 0.99 -0.39 1.00 Pressure ulcers Rate, % Relative risk -1.77 0.98 -1.23 0.99 -0.79 0.99 -1.23 0.99 Nosocomial infections Rate, % Relative risk 0.00 1.00 0.00 1.00 -0.53 0.99 -0.47 1.00

Table G27. Evidence of the association between nurse skill mix (proportion of registered nurses) and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes Source to Measure Nurse Skill Mix, Definition of Nurse Skill Mix	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
Barkell ⁷⁷ The incidence of urinary tract infection: a) presence of white blood cells >100/high-powered field (HPF) on urinalysis, b) bacteria 3+/ high-powered field F or 4+/ high-powered field on urinalysis, and c) urine culture showing >100,000 colonies of one or two (not three or more) organisms; the incidence of pneumonia; proportion of RN/ total nursing staff.	Hospitals 1 Unit Surgical Patients Surgical Race 88.1 Sex 40.7	Team nursing model with patient care associate assisting RNs in delivery of patient care (lower proportion of RN: 65.8%) Total patient care model, higher proportion of RN: 78.6%)	Pneumonia, rate % 5.1 0
Berney ⁸⁴ Actual number of urinary tract infections, gastrointestinal bleeding, and sepsis events identified as secondary DRG; RN acute hours/(RN + LPN acute hours)	Hospitals 161	1% increase in RN hours/total licensed hours, medical patients 1% increase in RN hours/total licensed hours, surgical patients 1% increase in RN hours/total licensed hours, medical patients 1% increase in RN hours/total licensed hours, surgical patients 1% increase in RN hours/total licensed hours, medical patients 1% increase in RN hours/total licensed hours, surgical patients	Relative risk Urinary tract infection 1.00 0.99 1.00 1.00 0.99 1.00 Gastrointestinal bleeding 1.00 1.00 1.01 1.01 1.00 1.01 Sepsis 1.01 1.00 1.01 1.01 1.00 1.01
Blegen ⁵⁸ The number of patient falls on the unit in quarter/1,000 patient days; the number of CPR on the unit in quarte/1,000 patient days; RN hours per patient day divided by all hours per patient day	Hospitals 11 Unit Combined Patients Combined	Increase by 1% in proportion of RN Increase by 1% in proportion of RN	Rate per 100 patient days ± SD Falls -0.05 ± 1.63 CPR -0.01 ± 0.55

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Table G27. Evidence of the association between nurse skill mix (proportion of registered nurses) and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes Source to Measure Nurse Skill Mix, Definition of Nurse Skill Mix	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
Blegen ⁷³ The number of patient falls on the unit in quarter/1,000patient days; RN hours per patient day divided by all hours per patient day		Proportion of BSN 73% 72%	Rate/100 patient days ± SD Falls 0.22 ± 0.18 0.27 ± 0.28
Blegen ⁵⁹ New incidences of skin breakdown secondary to pressure or exposure to urine or feces; suddenly and involuntarily leaving a position and coming to rest on the floor or some object. All reported falls were included whether or not injuries resulted. RN hours per patient day divided by all hours per patient day	Hospitals 1 Unit Combined Patients Combined	Increase by 1% in proportion of RN nurses Proportion of RN >87.5% Increase by 1% in proportion of RN nurses Proportion of RN >87.5% Increase by 1% in proportion of RN nurses Proportion of RN >87.5%	Rate/100 patient days ± SD Decubitus ulcer -1.06 ± 3.36 0.25 ± 0.12 Falls 0.04 ± 3.01 -0.22 ± 0.10 Nosocomial infection -1.26 ± 6.15 0.13 ± 0.22
Bolton ²⁶ Hospital-acquired pressure ulcers; the monthly rate per 1,000 patient days for each nursing unit and each hospital. Data are collected at the patient level and aggregated by CalNOC staff to the unit level. Unplanned descent to the floor in adult patients; the monthly fall rate per 1,000 patient days for each nursing unit and each hospital; % of RN hours/total nursing hours.	Hospitals 38	% RN Medical-surgical units 59 Critical care units 91	Rate/100 patient days Falls Pressure ulcers 3.70 8.00 0.10 13.00

Table G27. Evidence of the association between nurse skill mix (proportion of registered nurses) and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes Source to Measure Nurse Skill Mix, Definition of Nurse Skill Mix	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
Cheung ³² Pressure ulcers, patient falls coded as secondary diagnosis, primary bloodstream infections after admitting the unit, ratio of RN and LPN among to unlicensed nursing personnel	Hospitals 1 Unit Combined Patients Medical	Increase by 1% of licensed nurses	Relative risk of decubitus ulcers, failure to rescue, and nosocomial infection Not significant
Cho ³⁸ ICD-9-CM for urinary tract infections ICD-9-CM for pressure ulcers ICD-9-CM for falls and injury ICD-9-CM for surgical wound infection ICD-9-CM for sepsis ICD-9-CM for adverse drug event. RN Hours divided by all hours	Unit Combined Patients Combined Hospitals 48 48 79 79 48 48 48 48 48 79 12 12 12 79 12 12 48 48 48 232	% RN 70 50 60 90 60 60 80 90 50 70 50 80 50 60 70 80 90 80 90 70 100% increase in RN hours 100% increase in RN hours 100% increase in RN hours	Pneumonia, rate % 1.67 2.03 1.72 1.28 1.96 1.84 1.51 1.37 2.16 1.56 2.08 1.42 1.90 1.89 1.71 1.55 1.41 1.61 1.46 1.78 Relative risk, 95% CI Urinary tract infection 0.92 0.31 2.64 Pneumonia 0.37 0.15 0.91 Falls 0.96 0.21 4.49 Pulmonary failure

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Table G27. Evidence of the association between nurse skill mix (proportion of registered nurses) and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes Source to Measure Nurse Skill Mix, Definition of Nurse Skill Mix	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes																																																																																																																							
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Cho ³⁰ The same study	<table border="0"> <tr> <td>Unit</td> <td>Combined</td> <td>% RN</td> <td>Rate, % ± SD</td> </tr> <tr> <td>Patients</td> <td>Combined</td> <td>76.5</td> <td>2.50 ± 1.30</td> </tr> <tr> <td>Age</td> <td>67.9</td> <td>68.1</td> <td>1.60 ± 1.40</td> </tr> <tr> <td>Race</td> <td>79.3</td> <td>72.4</td> <td>2.00 ± 1.00</td> </tr> <tr> <td>Sex</td> <td>48.9</td> <td>72.7</td> <td>2.10 ± 1.80</td> </tr> <tr> <td>Severity</td> <td>49.7</td> <td></td> <td>Pneumonia</td> </tr> <tr> <td></td> <td></td> <td>76.5</td> <td>3.10 ± 1.90</td> </tr> <tr> <td></td> <td></td> <td>68.1</td> <td>2.70 ± 2.20</td> </tr> <tr> <td></td> <td></td> <td>72.4</td> <td>2.80 ± 1.30</td> </tr> <tr> <td></td> <td></td> <td>72.7</td> <td>2.80 ± 2.00</td> </tr> <tr> <td></td> <td></td> <td></td> <td>Falls</td> </tr> <tr> <td></td> <td></td> <td>76.5</td> <td>0.20 ± 0.20</td> </tr> <tr> <td></td> <td></td> <td>68.1</td> <td>0.20 ± 0.30</td> </tr> <tr> <td></td> <td></td> <td>72.4</td> <td>0.20 ± 0.20</td> </tr> <tr> <td></td> <td></td> <td>72.7</td> <td>0.10 ± 0.20</td> </tr> <tr> <td></td> <td></td> <td></td> <td>Pressure ulcers</td> </tr> <tr> <td></td> <td></td> <td>76.5</td> <td>0.10 ± 0.30</td> </tr> <tr> <td></td> <td></td> <td>68.1</td> <td>0.30 ± 0.60</td> </tr> <tr> <td></td> <td></td> <td>72.4</td> <td>0.30 ± 0.50</td> </tr> <tr> <td></td> <td></td> <td>72.7</td> <td>0.20 ± 0.40</td> </tr> <tr> <td></td> <td></td> <td></td> <td>Surgical wound infection</td> </tr> <tr> <td></td> <td></td> <td>76.5</td> <td>1.60 ± 1.00</td> </tr> <tr> <td></td> <td></td> <td>68.1</td> <td>1.10 ± 1.10</td> </tr> <tr> <td></td> <td></td> <td>72.4</td> <td>1.50 ± 0.70</td> </tr> <tr> <td></td> <td></td> <td>72.7</td> <td>1.10 ± 1.00</td> </tr> <tr> <td></td> <td></td> <td></td> <td>Sepsis</td> </tr> <tr> <td></td> <td></td> <td>76.5</td> <td>1.20 ± 0.70</td> </tr> <tr> <td></td> <td></td> <td>68.1</td> <td>0.80 ± 0.80</td> </tr> <tr> <td></td> <td></td> <td>72.4</td> <td>1.10 ± 0.60</td> </tr> <tr> <td></td> <td></td> <td>72.7</td> <td>1.00 ± 1.10</td> </tr> </table>	Unit	Combined	% RN	Rate, % ± SD	Patients	Combined	76.5	2.50 ± 1.30	Age	67.9	68.1	1.60 ± 1.40	Race	79.3	72.4	2.00 ± 1.00	Sex	48.9	72.7	2.10 ± 1.80	Severity	49.7		Pneumonia			76.5	3.10 ± 1.90			68.1	2.70 ± 2.20			72.4	2.80 ± 1.30			72.7	2.80 ± 2.00				Falls			76.5	0.20 ± 0.20			68.1	0.20 ± 0.30			72.4	0.20 ± 0.20			72.7	0.10 ± 0.20				Pressure ulcers			76.5	0.10 ± 0.30			68.1	0.30 ± 0.60			72.4	0.30 ± 0.50			72.7	0.20 ± 0.40				Surgical wound infection			76.5	1.60 ± 1.00			68.1	1.10 ± 1.10			72.4	1.50 ± 0.70			72.7	1.10 ± 1.00				Sepsis			76.5	1.20 ± 0.70			68.1	0.80 ± 0.80			72.4	1.10 ± 0.60			72.7	1.00 ± 1.10	
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Table G27. Evidence of the association between nurse skill mix (proportion of registered nurses) and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes Source to Measure Nurse Skill Mix, Definition of Nurse Skill Mix	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories		Patient Outcomes
Cimiotti ⁸⁷ Infections occurring in an infant 48 hours or longer after admission to the Neonatal Intensive Care Unit including bloodstream infections, device associated pneumonia, Central nervous System and skin infections, conjunctivitis. % of RN hours among total nursing hours adjusted for nursing intensity weights	Hospitals 1 Unit Neonatal Patients Medical	% RN 100 96 100 96		Rate, % Pneumonia Nosocomial infection 0.50 18.30 0.90 15.10 Sepsis 10.50 5.50
Donaldson ⁹ Total number of patients with Stage I-IV pressure ulcers regardless of whether ulcer was acquired during hospitalization or present on admission; %/total number of surveyed patients; unplanned descent to the floor; rate/1,000 patient days; % of RN hours/total nursing care hours; % of licensed hours/total nursing care hours.	Hospitals 68 Patients Medical Unit Combined ICU ICU	% RN % licensed nurses 59.2 67.52 66.67 74.29 68.79 72.99 72.19 75.54 59.2 67.52 66.67 74.29 68.79 72.99 72.19 75.54		Rate/100 patient days ± SD Falls 0.31 ± 0.20 0.32 ± 0.17 0.30 ± 0.22 0.26 ± 0.16 Pressure ulcers 14.07 ± 11.07 14.48 ± 10.39 13.52 ± 10.78 16.29 ± 10.27
Donaldson ^{9b} Patients' unplanned descent to the hospital floor; were analyzed as 7 day aggregate per unit; also actually number per unit; the number of falls/1,000 patient days, the % of RN hours / total care hours per day, per unit.	Hospitals 25 Unit Combined Patients Medical	Increase by 1% in RN hours of care Increase by 1% licensed hours of care		Rate/100 patient days ± SD Falls -0.0020 ± 0.00 -0.0010 ± 0.01

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Table G27. Evidence of the association between nurse skill mix (proportion of registered nurses) and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes Source to Measure Nurse Skill Mix, Definition of Nurse Skill Mix	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
Flood ⁵³ infections including urinary tract infection and gangrene; Complications: congestive heart failure and arrhythmias, gastrointestinal bleeding	Hospitals 1 Unit Combined Patients Medical Sex 60	% RN Understaffed unit 60.45 Normally staffed unit 42.32 Understaffed unit 60.45 Normally staffed unit 42.32	Rate, % Nosocomial infections 0.16 0.19 Complications 64 71
Grillo-Peck ¹⁰ The number of reported monthly incidents in the unit, total number of infected patients per month of the entire unit census. Decrease in % of RNs in the unit within new partnership model with increase patient care technicians and service associates. RN spent more time on direct patient care.	Hospitals 1 Unit Specialty Patients Medical Sex 43.7	% RN 80 60 80 60	Rate, % ± SD Falls 8.69 ± 3.93 3.53 ± 1.66 Nosocomial infection 16.48 ± 32.87 10.39 ± 32.92
Halm ⁵¹ Failure to rescue: death following complications within 30 days	Hospitals 1 Unit Surgical Patients Surgical Age 55.6 Sex 37.4 Severity 22.7	Increase by 1 unit in RN/patient ratio	Failure to rescue, relative risk NS
Hope ⁸⁶ Incidence rate of urinary tract infection, ventilator associated pneumonia, surgical site infections, and infections that occurred after 72 hours of hospitalization; incidence rate of positive culture with known pathogen or two or more positive cultures with pathogens (one can be considered as contaminant); proportion of RN hours/total	Hospitals 1 Sex 44.99 Units Surgical Surgical Surgical Surgical Medical Medical Medical Medical Medical	% RN 83.65 84.26 81.73 85.09 98.81 77.28 76.48 89.7 98.6 80.4 78.12	Rate/100 patient days Nosocomial Infection 3.08 20.00 4.62 10.77 0.00 6.15 1.54 1.54 0.00 0.00 3.08

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Table G27. Evidence of the association between nurse skill mix (proportion of registered nurses) and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes Source to Measure Nurse Skill Mix, Definition of Nurse Skill Mix	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
nursing hours/patient day 4-10 days before the event occurred	Medical	76.23	10.77
	Medical	98.75	0.00
	Specialty	94.48	33.85
	ICU	99.56	1.54
	ICU	99.11	3.08
	Surgical	92.11	0.00
	Neonatal		Sepsis
		83.65	7.54
	Surgical	84.26	11.80
	Surgical	81.73	0.33
	Surgical	85.09	4.59
	Surgical	98.81	0.00
	Medical	77.28	7.21
	Medical	76.48	2.95
	Medical	89.7	1.31
	Medical	80.4	7.87
	Medical	78.12	8.20
	Medical	76.23	6.56
	Medical	98.75	1.97
	Spec	94.48	23.28
	ICU	99.56	9.51
	ICU	99.11	4.59
	Surgical	92.11	2.30
	Neonatal		Relative risk, 95% CI
		Increase by 1% in proportion of RN	Urinary tract infection
		1.01 1.00 1.01	
	Increase by 1% in proportion of RN	Pneumonia	
		1.06 0.93 1.21	
	Increase by 1% in proportion of RN	Nosocomial infection	
		1.06 1.03 1.09	
	Increase by 1% in proportion of RN	Surgical wound infection	
		1.03 0.99 1.08	
	Increase by 1% in proportion of RN	Sepsis	
		1.05 1.04 1.07	

Table G27. Evidence of the association between nurse skill mix (proportion of registered nurses) and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes Source to Measure Nurse Skill Mix, Definition of Nurse Skill Mix	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
Houser ⁴⁹ Failure to rescue: death/1,000 patients who developed complications of care during hospitalization; cases of decubitus ulcer/1,000 discharges identified as secondary diagnosis; cases of acute respiratory failure/1,000 surgical discharges; cases of deep vein thrombosis or pulmonary embolism/1,000 surgical discharges. Reported by hospitals ratio reported RN FTE/RN+LPN	Unit Combined Patients Medical Age 55.08 Race 51 Sex 42		Rate, % ± SD
	Hospitals 170 172 174 171 39 14 8	% RN 79 86 87 88 88 88 88 86 79 86 87 88 88 88 88 79 86 87 88 88 88 86	Failure to rescue 11.61 ± 8.41 13.82 ± 5.80 12.40 ± 9.11 10.51 ± 6.82 9.01 ± 6.26 9.42 ± 10.16 5.43 ± 8.89 Decubitus ulcer 2.21 ± 1.78 2.57 ± 1.62 2.14 ± 1.45 1.90 ± 1.70 1.70 ± 1.39 1.44 ± 1.48 2.24 ± 4.21 Pulmonary failure 0.26 ± 0.65 0.33 ± 0.37 0.32 ± 0.37 0.19 ± 0.42 0.15 ± 0.36 0.34 ± 0.79 0.00 Deep vein thrombosis 0.52 ± 0.71 0.75 ± 0.63 0.68 ± 0.65 0.44 ± 0.78 0.38 ± 1.06 0.52 ± 1.28 0.06 ± 0.13

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Table G27. Evidence of the association between nurse skill mix (proportion of registered nurses) and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes Source to Measure Nurse Skill Mix, Definition of Nurse Skill Mix	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes																																																																																								
Langemo ⁴¹ % of patients who had a pressure ulcer on a given day to all patients assessed for a pressure ulcer, pressure ulcers that occurred post admission were documented as hospital-acquired. Number of productive hours worked by RN divided by total staff hours.	Hospitals 1	<table border="0"> <tr> <td></td> <td style="text-align: right;">% RN</td> </tr> <tr> <td>Medical-surgical units in hospitals with <100 beds</td> <td style="text-align: right;">53.4</td> </tr> <tr> <td>ICU in hospitals with 200-299 beds</td> <td style="text-align: right;">99.4</td> </tr> <tr> <td>ICU units in hospitals <100 beds</td> <td style="text-align: right;">60.6</td> </tr> <tr> <td>Medical-surgical units in hospitals with 200-299 beds</td> <td style="text-align: right;">61.5</td> </tr> </table>		% RN	Medical-surgical units in hospitals with <100 beds	53.4	ICU in hospitals with 200-299 beds	99.4	ICU units in hospitals <100 beds	60.6	Medical-surgical units in hospitals with 200-299 beds	61.5	<table border="0"> <tr> <td>Rate, %</td> </tr> <tr> <td>4.10</td> </tr> <tr> <td>0.00</td> </tr> <tr> <td>13.10</td> </tr> <tr> <td>0.00</td> </tr> </table>	Rate, %	4.10	0.00	13.10	0.00																																																																									
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Lichtig ⁶³ Likely adverse patient outcomes of the hospital stay, secondary diagnoses of urinary tract infection, pneumonia, pressure ulcers, infection in surgical patients. RN hours as a percentage of total nursing hours per nursing intensity weight-adjusted patient day	<table border="0"> <tr> <td>Hospitals</td> <td>Unit</td> </tr> <tr> <td>352</td> <td>Surgical</td> </tr> <tr> <td>295</td> <td>Surgical</td> </tr> <tr> <td>126</td> <td>Surgical</td> </tr> <tr> <td>131</td> <td>Surgical</td> </tr> </table>	Hospitals	Unit	352	Surgical	295	Surgical	126	Surgical	131	Surgical	<p>Increase by 1% in proportion of RNs:</p> <table border="0"> <tr> <td>California, 1992</td> <td></td> </tr> <tr> <td>California, 1994</td> <td></td> </tr> <tr> <td>New York, 1992</td> <td></td> </tr> <tr> <td>New York, 1994</td> <td></td> </tr> <tr> <td>California, 1992</td> <td></td> </tr> <tr> <td>California, 1994</td> <td></td> </tr> <tr> <td>California, 1992</td> <td></td> </tr> <tr> <td>California, 1994</td> <td></td> </tr> <tr> <td>New York, 1992</td> <td></td> </tr> <tr> <td>New York, 1994</td> <td></td> </tr> </table>	California, 1992		California, 1994		New York, 1992		New York, 1994		California, 1992		California, 1994		California, 1992		California, 1994		New York, 1992		New York, 1994		<table border="0"> <tr> <td>Rate, %</td> </tr> <tr> <td>Pressure ulcers</td> </tr> <tr> <td>-0.79</td> </tr> <tr> <td>-1.23</td> </tr> <tr> <td>-1.77</td> </tr> <tr> <td>-1.23</td> </tr> <tr> <td>Pneumonia</td> </tr> <tr> <td>-0.56</td> </tr> <tr> <td>-0.39</td> </tr> <tr> <td>Surgical wound infections</td> </tr> <tr> <td>-0.53</td> </tr> <tr> <td>-0.47</td> </tr> <tr> <td>Relative risk of UTI, pneumonia, pressure ulcers, and SWI: Not significant</td> </tr> </table>	Rate, %	Pressure ulcers	-0.79	-1.23	-1.77	-1.23	Pneumonia	-0.56	-0.39	Surgical wound infections	-0.53	-0.47	Relative risk of UTI, pneumonia, pressure ulcers, and SWI: Not significant																																													
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Table G27. Evidence of the association between nurse skill mix (proportion of registered nurses) and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes Source to Measure Nurse Skill Mix, Definition of Nurse Skill Mix	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions		Nurse Staffing Categories	Patient Outcomes		
pneumonia, hypostatic pneumonia, bacterial	256	Medical	level analysis, California hospitals Increase by 1% in RN hours/total nursing hours, unit level	0.50	0.30	0.84
pneumonia, bronchopneumonia coded in discharge abstract as secondary diagnosis; cardiac	256	Medical	analysis, California hospitals Increase by 1% of RN hours/licensed hours, unit level	0.60	0.41	0.87
arrest; shock without mention of trauma; cardiogenic shock;	256	Medical	analysis, California hospitals Increase by 1% in RN hours/total nursing hours, hospital	0.82	0.47	1.44
respiratory arrest, nonmechanical methods of resuscitation, cardiopulmonary	256	Surgical	level analysis, California hospitals Increase by 1% in RN hours/licensed hours, hospital level	0.64	0.30	1.37
resuscitation, failure to rescue: death in patients with sepsis,	256	Surgical	analysis, California hospitals Increase by 1% in RN hours/total nursing hours, California	0.09	0.01	0.91
pneumonia, gastrointestinal bleeding, shock or deep vein	256	Surgical	hospitals Increase by 1% in RN hours/licensed hours, unit level	0.05	0.00	1.54
thrombosis coded in discharge abstract as secondary	799	Medical	analysis, California hospitals 1% increase in RN hours/total licensed hours	0.49	0.37	0.61
diagnosis; pressure ulcers, posttraumatic surgical wound	799	Surgical	1% increase in RN hours/total licensed hours	0.88	0.71	1.04
infection and postoperative surgical wound infection; % of	799	Surgical	1% increase in RN hours/total licensed hours	0.68	0.40	0.95
RN hours/total nursing hours; % of licensed hours/total	799	Surgical	1% increase in RN hours/total licensed hours	0.59	0.36	0.82
nursing hours	799	Medical	1% increase in RN hours/total licensed hours	0.76	0.67	0.85
	799	Medical	1% increase in RN hours/total licensed hours	0.54	0.41	0.66
	799	Medical	1% increase in RN hours/total licensed hours	0.48	0.38	0.61
	799	Surgical	1% increase in proportion of RN/total nursing personnel	0.67	0.46	0.98
	4156	Medical	Increase by 1% in RN/total nursing hours	0.52	0.35	0.77
	4156	Surgical	Increase by 1% in RN/total nursing hours	0.41	0.19	0.86
	4156	Medical	increase by 1% of RN hours/total licensed hours	0.59	0.44	0.80
	4156	Surgical	Increase by 1% in RN hours/total licensed hours	0.56	0.31	1.01
	3,357	Medical	Increase by 1% in RN hours/total licensed hours	0.83	0.71	0.98
	3,357	Medical	Increase by 1% in RN hours/total nurse hours	0.49	0.32	0.76
	3357	Surgical	Increase by 1% in RN hours/licensed hours	0.94	0.76	1.16
	3357	Surgical	Increase by 1% in RN hours/total nursing hours	0.23	0.10	0.53
	256	Medical	Increase by 1% in RN hours/total nursing, hospital level	0.44	0.22	0.86
	256	Medical	analysis, California hospitals Increase by 1% of RN hours/total licensed hours, hospital	0.52	0.32	0.87
	256	Medical	level analysis, California hospitals Increase by 1% in RN hours/total nursing hours, unit level	1.02	0.72	1.44
	256	Medical	analysis, California hospitals Increase by 1% of RN h/licensed hours, unit level analysis,	0.69	0.47	1.03
	256	Medical	California hospitals			

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Table G27. Evidence of the association between nurse skill mix (proportion of registered nurses) and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes Source to Measure Nurse Skill Mix, Definition of Nurse Skill Mix	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions		Nurse Staffing Categories	Patient Outcomes		
	256	Surgical	Increase by 1% in RN h/total nursing hours, hospital level analysis, California hospitals	0.61	0.30	1.23
	256	Surgical	Increase by 1% in RN hours/licensed hours, hospital level analysis, California hospitals	0.66	0.26	1.69
	256	Surgical	Increase by 1% in RN hours/total nursing hours, California hospitals	0.78	0.40	1.52
	256	Surgical	Increase by 1% in RN hours/licensed hours, unit level analysis, California hospitals	0.79	0.37	1.71
	799	Medical	1% increase in RN hours/total licensed hours	0.61	0.42	0.79
	799	Surgical	1% increase in RN hours/total licensed hours	0.94	0.74	1.13
	799	Surgical	1% increase in RN hours/total licensed hours	0.36	0.12	0.59
	799	Surgical	1% increase in RN hours/total licensed hours	0.52	0.20	0.84
	799	Medical	1% increase in RN hours/total licensed hours	0.83	0.70	0.96
	799	Medical	1% increase in RN hours/total licensed hours	0.59	0.39	0.78
	799	Medical	1% increase in RN hours/total licensed hours	0.59	0.44	0.80
	4156	Medical	Increase by 1% in RN/total nursing hours	0.52	0.35	0.77
	4156	Surgical	Increase by 1% in RN/total nursing hours	0.41	0.19	0.86
	4156	Medical	increase by 1% of RN hours/total licensed hours	0.59	0.44	0.80
	4156	Surgical	Increase by 1% in RN hours/total licensed hours	0.56	0.31	1.01
	3,357	Medical	Increase by 1% in RN hours/total licensed hours	0.83	0.71	0.98
	3,357	Medical	Increase by 1% in RN hours/total nurse hours	0.49	0.32	0.76
	3357	Surgical	Increase by 1% in RN hours/licensed hours	0.94	0.76	1.16
	3357	Surgical	Increase by 1% in RN hours/total nursing hours	0.23	0.10	0.53
	256	Medical	Increase by 1% in RN hours/total nursing, hospital level analysis, California hospitals	0.44	0.22	0.86
	256	Medical	Increase by 1% of RN h/total licensed hours, hospital level analysis, California hospitals	0.52	0.32	0.87
	256	Medical	Increase by 1% in RN hours/total nursing hours, unit level analysis, California hospitals	1.02	0.72	1.44
	256	Medical	Increase by 1% of RN hours/licensed hours, unit level analysis, California hospitals	0.69	0.47	1.03
	256	Medical	Increase by 1% in RN h/total nursing hours, hospital level analysis, California hospitals	0.61	0.30	1.23
	256	Surgical	Increase by 1% in RN hours/licensed hours, hospital level analysis, California hospitals	0.66	0.26	1.69
	256	Surgical	Increase by 1% in RN hours/total nursing hours, California hospitals	0.78	0.40	1.52

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Table G27. Evidence of the association between nurse skill mix (proportion of registered nurses) and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes Source to Measure Nurse Skill Mix, Definition of Nurse Skill Mix	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes			
	256	Surgical	Increase by 1% in RN hours/licensed hours, unit level analysis, California hospitals	0.79	0.37	1.71
	799	Medical	1% increase in RN hours/total licensed hours	0.94	0.74	1.13
	799	Surgical	1% increase in RN hours/total licensed hours	0.36	0.12	0.59
	799	Surgical	1% increase in RN hours/total licensed hours	0.52	0.20	0.84
	799	Surgical	1% increase in RN hours/total licensed hours	0.83	0.70	0.96
	799	Medical	1% increase in RN hours/total licensed hours	1.00	0.99	1.01
	799	Medical	1% increase in RN hours/total licensed hours	0.59	0.39	0.78
	799	Medical	1% increase in RN hours/total licensed hours	0.59	0.44	0.80
			Shock			
	4156	Medical	Increase by 1% in RN/total nursing hours	0.84	0.71	0.99
	4156	Surgical	Increase by 1% in RN/total nursing hours	1.08	0.60	1.96
	4156	Medical	increase by 1% of RN hours/total licensed hours	0.46	0.27	0.81
	4156	Surgical	Increase by 1% in RN hours/total licensed hours	0.54	0.28	1.04
	3,357	Medical	Increase by 1% in RN hours/total licensed hours	0.66	0.50	0.87
	3,357	Medical	Increase by 1% in RN hours/total nurse hours	0.52	0.31	0.89
	3357	Surgical	Increase by 1% in RN hours/licensed hours	0.59	0.44	0.78
	3357	Surgical	Increase by 1% in RN hours/total nursing hours	0.36	0.14	0.93
			Increase by 1% in RN hours/total nursing, hospital level analysis, California hospitals	0.30	0.12	0.72
	256	Medical	Increase by 1% of RN hours/total licensed hours, hospital level analysis, California hospitals	0.20	0.08	0.53
	256	Medical	Increase by 1% in RN hours/total nursing hours, unit level analysis, California hospitals	0.34	0.16	0.75
	256	Medical	Increase by 1% of RN hours/licensed hours, unit level analysis, California hospitals	0.40	0.19	0.86
	256	Medical	Increase by 1% in RN hours/total nursing hours, hospital level analysis, California hospitals	0.14	0.05	0.43
	256	Surgical	Increase by 1% in RN hours/licensed hours, hospital level analysis, California hospitals	0.22	0.09	0.57
	256	Surgical	Increase by 1% in RN hours/total nursing hours, California hospitals	0.17	0.06	0.47
	256	Surgical	Increase by 1% in RN hours/licensed hours, unit level analysis, California hospitals	0.27	0.12	0.61
	256	Surgical	1% increase in RN hours/total licensed hours	0.59	0.42	0.76
	799	Medical	1% increase in RN hours/total licensed hours	0.42	0.10	0.74
	799	Surgical	1% increase in RN hours/total licensed hours	0.60	0.19	1.00
	799	Surgical	1% increase in RN hours/total licensed hours	0.66	0.48	0.85

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Table G27. Evidence of the association between nurse skill mix (proportion of registered nurses) and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes Source to Measure Nurse Skill Mix, Definition of Nurse Skill Mix	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions		Nurse Staffing Categories	Patient Outcomes		
	799	Medical	1% increase in RN hours/total licensed hours	1.00	0.97	1.02
	799	Medical	1% increase in RN hours/total licensed hours	0.40	0.18	0.63
	799	Medical	1% increase in RN hours/total licensed hours	0.46	0.27	0.81
				Failure to rescue		
	4156	Medical	Increase by 1% in RN/total nursing hours	0.85	0.70	1.03
	4156	Surgical	Increase by 1% in RN/total nursing hours	0.64	0.44	0.92
	4156	Medical	increase by 1% of RN hours/total licensed hours	0.81	0.66	1.00
	4156	Surgical	Increase by 1% in RN hours/total licensed hours	0.73	0.49	1.09
	3,357	Medical	Increase by 1% in RN hours/total licensed hours	0.90	0.80	1.01
	3,357	Medical	Increase by 1% in RN hours/total nurse hours	0.85	0.70	1.04
	3357	Surgical	Increase by 1% in RN hours/licensed hours	0.82	0.70	0.96
	3357	Surgical	Increase by 1% in RN hours/total nursing hours	0.69	0.45	1.06
			Increase by 1% in RN hours/total nursing , hospital level analysis, California hospitals	0.63	0.47	0.84
	256	Medical	Increase by 1% of RN hours/total licensed hours, hospital level analysis, California hospitals	0.58	0.40	0.86
	256	Medical	Increase by 1% in RN hours/total nursing hours, unit level analysis, California hospitals	0.70	0.54	0.90
	256	Medical	Increase by 1% of RN hours/licensed hours, unit level analysis, California hospitals	0.69	0.50	0.95
	256	Medical	Increase by 1% in RN hours/total nursing hours, hospital level analysis, California hospitals	0.36	0.14	0.89
	256	Surgical	Increase by 1% in RN hours/licensed hours, hospital level analysis, California hospitals	0.45	0.22	0.92
	256	Surgical	Increase by 1% in RN hours/total nursing hours, California hospitals	0.44	0.20	0.96
	256	Surgical	Increase by 1% in RN hours/licensed hours, unit level analysis, California hospitals	0.54	0.30	0.99
	799	Medical	1% increase in RN hours/total licensed hours	0.80	0.64	0.97
	799	Surgical	1% increase in RN hours/total licensed hours	0.81	0.68	0.94
	799	Surgical	1% increase in RN hours/total licensed hours	0.70	0.37	1.03
	799	Surgical	1% increase in RN hours/total licensed hours	0.72	0.42	1.01
	799	Medical	1% increase in RN hours/total licensed hours	0.90	0.80	1.00
	799	Medical	1% increase in RN hours/total licensed hours	1.00	1.00	1.01
	799	Medical	1% increase in RN hours/total licensed hours	0.81	0.64	0.99
	799	Surgical	1% increase in proportion of RN/total nursing personnel	0.81	0.66	1.00

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Table G27. Evidence of the association between nurse skill mix (proportion of registered nurses) and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes Source to Measure Nurse Skill Mix, Definition of Nurse Skill Mix	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
Potter ⁴⁰ (Number of falls on a unit/number of patient days) * 1,000	Hospitals 1 Unit ICU Patients Medical	% RN 53.8 55.4 56.2 57.1	Falls, rate/100 patient days 0.30 0.29 0.30 0.23
Ritter-Teitel ⁶⁹ Hospital Incidence reports; % of patients with urinary tract infection not presented at admission among total discharged or sampled patients; % of patients with pressure ulcers, number of events/1,000 patient days, % of RNs among total nursing personnel	Hospitals 28	% RN 56.15 56.4 56.79 56.77 56.79 56.77 Increase by 1 hour in RN hours % RN 56.15 56.4 56.79 56.77 56.79 56.77 Increase by 1 hour in RN hours % RN 56.15 56.4 56.79 56.77 56.79 56.77 Increase by 1 hour in RN hours Increase by 1 hour in RN hours in medical units Increase by 1 hour in RN hours in surgical units	Rate %, ± SD 2.09 ± 2.25 2.53 ± 2.29 2.25 ± 2.36 2.61 ± 2.46 1.93 ± 2.18 2.45 ± 2.16 -0.18 ± 1.24 Pressure ulcers 2.42 ± 2.10 2.06 ± 1.66 2.33 ± 2.12 2.23 ± 1.94 2.50 ± 2.11 1.88 ± 1.33 -0.24 ± 1.18 Falls 0.32 ± 0.20 0.34 ± 0.16 0.40 ± 0.21 0.41 ± 0.17 0.24 ± 0.14 0.27 ± 0.12 -0.42 ± 0.90 -0.49 ± 0.87 -0.15 ± 0.96
Seago ⁸ The proportion of pressure ulcers per patient day; the proportion of falls per patient day; RN hours/total hours.	Hospitals 1 Unit Combined Patients Medical	% RN 63 61.5 62	Rate, % Falls Pressure ulcers 0.29 0.24 0.27 0.18 0.23 0.29

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Table G27. Evidence of the association between nurse skill mix (proportion of registered nurses) and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes Source to Measure Nurse Skill Mix, Definition of Nurse Skill Mix	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
Seago ⁹³ The proportion of pressure ulcers per patient day, the proportion of falls per patient day, RN hours/total hours	Hospitals 1 Unit Combined Patients Medical	% RN 75 96 72 75 96 72	Rate/100patient days ± SD Decubitus ulcers 0.78 ± 0.09 0.02 ± 0.05 0.05 ± 0.08 Falls 0.35 ± 0.20 0.19 ± 0.19 0.45 ± 0.25
Simmonds ⁸² % of patients with positive colonization of vancomycin-resistant enterococci 48 hours after admission to the hospital and after surgery; 100% of nursing care provided by a licensed practical nurse	Hospitals 1 Unit Specialty Patients Medical Age 68.75 Sex 55.8	% RN 76.83 75.51 74.19 72.87 76.83 75.51 74.19 72.87	Rate, % Nosocomial infection 1.61 3.29 4.97 6.65 2.87 3.73 4.59 1.79
Stratton ⁹¹ Rate/1,000 patient days of respiratory, gastrointestinal, bloodstream and central line infections in hospitalized patients not present at time of admission; rate/1,000 patient days of bloodstream and central line infections in hospitalized patients not present at time of admission. average % of RN productive hours/total nursing hours/patient day	Hospitals 7 Unit Patients Combined Combined Combined Combined Combined Combined Spec Surgical Spec Surgical Spec Surgical Spec Surgical ICU Medical ICU Medical ICU Medical ICU Medical Combined Medical Combined Medical Combined Medical Combined Medical Combined Medical	% RN 73.41 72.06 72.41 74 83.2 79 79.6 80.2 89 88.17 87.5 88.5 80.35 78.76 78.79 80.03 Increase by 1 hour in total nursing hours	Rate/100 patient days ± SD Nosocomial infections 0.75 ± 0.69 0.53 ± 0.67 0.71 ± 0.77 0.64 ± 0.43 0.65 ± 0.23 0.62 ± 0.39 0.71 ± 0.59 0.85 ± 0.50 0.73 ± 0.56 1.03 ± 0.96 0.80 ± 0.69 0.95 ± 0.71 0.51 ± 0.08 0.79 ± 0.17 0.66 ± 0.12 0.56 ± 0.17 0.01 ± 0.03

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Table G27. Evidence of the association between nurse skill mix (proportion of registered nurses) and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes Source to Measure Nurse Skill Mix, Definition of Nurse Skill Mix	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions		Nurse Staffing Categories	Patient Outcomes
	Combined Combined Combined	Medical Medical Medical	Increase by 1% in RN hours increase by 1% in overtime RN hours Increase by 1% in temporary nurses	0.00 ± 0.01 -0.01 ± 0.02 0.00 ± 0.01
Tallier ⁸³ Incidence rate/1,000 patient days of pressure ulcers developed 72 hours after admission, % of productive hours in direct patient care worked by RN	Hospitals Unit Patients	1 Combined Medical	% RN 57 60	Rate/100 patient days Pressure ulcers 0.17 0.29
Unruh ⁸¹ Yearly number of occurrences of pneumonia, falls, and decubitus ulcers per hospital	Hospitals Unit Patients	1477 Combined Medical	1% increase in proportion of licensed nurses/total nursing personnel 1% increase in proportion of licensed nurses/total nursing personnel 1% increase in proportion of licensed nurses/total nursing personnel	Relative risk Pneumonia 0.99 Decubitus ulcers 0.98 Falls 1.03
Unruh ⁶⁶ Nosocomial urinary tract infection as secondary diagnosis when primary diagnosis is not disorders of kidneys, urinary and reproductive tracts and systems; hospital acquired pneumonia as secondary diagnosis when primary diagnosis is not respiratory disorders and adult atelectasis; secondary diagnosis of decubitus ulcer in patients not transferred from another hospital; falls in hospital when a primary diagnosis was not fracture or injury; adult	Hospitals Unit Patients Race Sex	211 Combined Combined 45.37 42.43	% RN 68.5 69.2 70.2 71.2 71.5 71.4 71.8 70 63 70 63 Increase by 1% in RN proportion Increase by 1% in RN proportion in small hospitals Increase by 1% in RN proportion in medium hospitals Increase by 1% in RN proportion in large hospitals 68.5	Decubitus ulcer, rate % 0.55 0.49 0.53 0.69 0.67 0.73 0.73 0.68 0.78 0.69 0.75 -0.00090 -0.00070 -0.00120 0.00010 Surgical wound infections 0.29

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Table G27. Evidence of the association between nurse skill mix (proportion of registered nurses) and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes Source to Measure Nurse Skill Mix, Definition of Nurse Skill Mix	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
atelectasis as secondary diagnosis when primary diagnosis is not respiratory disorders, secondary diagnosis of post surgical infections; cardiac arrest as secondary diagnosis when primary diagnosis is not circulatory disorder, % of RN FTE/total nurses FTE		69.2	0.26
		70.2	0.24
		71.2	0.28
		71.5	0.28
		71.4	0.31
		71.8	0.30
		70	0.27
		63	0.28
		70	0.30
		63	0.31
		Increase by 1% in RN proportion	0.00
		Increase by 1% in RN proportion in small hospitals	0.00
		Increase by 1% in RN proportion in medium hospitals	0.00
		Increase by 1% in RN proportion in large hospitals	0.00
		68.5	Pneumonia 0.98
		69.2	0.91
		70.2	0.96
		71.2	1.54
		71.5	1.55
		71.4	1.63
		71.8	1.64
		Increase by 1% in RN proportion	-0.00090
		Increase by 1% in RN proportion in small hospitals	-0.00220
		Increase by 1% in RN proportion in medium hospitals	-0.00050
		Increase by 1% in RN proportion in large hospitals	-0.00030
		68.5	Falls 0.04
		69.2	0.04
		70.2	0.16
		71.2	0.91
		71.5	0.86
		71.4	0.74
		71.8	0.72
Increase by 1% in RN proportion	0.00010		
Increase by 1% in RN proportion in small hospitals	0.00050		
Increase by 1% in RN proportion in medium hospitals	-0.00030		
Increase by 1% in RN proportion in large hospitals	0.00010		

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Table G27. Evidence of the association between nurse skill mix (proportion of registered nurses) and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes Source to Measure Nurse Skill Mix, Definition of Nurse Skill Mix	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
		68.5 69.2 70.2 71.2 71.5 71.4 71.8 Increase by 1% in RN proportion Increase by 1% in RN proportion in small hospitals Increase by 1% in RN proportion in medium hospitals Increase by 1% in RN proportion in large hospitals 68.5 69.2 70.2 71.2 71.5 71.4 71.8 Increase by 1% in RN proportion Increase by 1% in RN proportion in small hospitals Increase by 1% in RN proportion in medium hospitals Increase by 1% in RN proportion in large hospitals Increase by 1% in RN proportion Increase by 1% in RN proportion in small hospitals Increase by 1% in RN proportion in medium hospitals Increase by 1% in RN proportion in large hospitals	Pulmonary failure 0.52 0.46 0.47 0.63 0.68 0.70 0.69 -0.00030 0.00010 -0.00060 0.00070 CPR 0.54 0.48 0.50 0.61 0.64 0.63 0.60 0.00 0.00 0.00 0.00 Pressure ulcers -0.00010 -0.00020 0.00001 -0.00010
Wan ⁵² Incidence/1,000 patient days of falls adjusted for severity of incident, RN hours/total nursing hours	Hospitals 45 Unit Combined Patients Combined	Increase by 1% of RNs/total nursing hours 52% of RNs	Falls, rate/100 patient days -0.05 0.31 ± 0.05

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Table G27. Evidence of the association between nurse skill mix (proportion of registered nurses) and patient outcomes (continued)

Author, Source to Measure Patient Outcomes, Definition of Patient Outcomes Source to Measure Nurse Skill Mix, Definition of Nurse Skill Mix	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
Zidek ⁸⁵ New incidence of skin breakdown acquired over the course of the hospital stay; number of reported unplanned descents to the floor during the course of the hospital stay. % of RN FTE/total nursing FTE	Hospitals 1 Unit Combined Patients Medical-surgical	% RN 31 31 28 32 30 30 31 33 32 31 33 30	Rate, % Falls Pressure ulcer 0.59 0.18 0.45 0.05 0.83 0.26 0.52 0.09 0.28 0.00 0.25 0.06 0.23 0.17 0.63 0.37 0.61 0.09 0.62 0.24 0.66 0.18 0.66 0.11

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BSN = Bachelor of Science in Nursing; CPR = Cardio Pulmonary Resuscitation; DRG = Diagnosis Related Group; HPF = high-powered field; ICU = Intensive Care Unit; LPN = Licensed Practical Nurse; NS = Not Significant; RN = Registered Nurse; SD = Standard Deviation; SWI = Surgical Wound Infection; UTI = Urinary Tract Infection

Table G28. Relative risk of patient outcomes corresponding to an increase by 1% of RNs in nurse skill mix as reported by authors

Author	Data	Analytic Unit	Hospitals	Unit	Patients	Outcomes	Relative Risk	95% CI
Needleman ²⁸	Administrative	Hospital	4,156	Medical	Medical	Urinary tract infection	0.40	0.29; 0.55
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	Urinary tract infection	0.58	0.36; 0.96
Needleman ²⁸	Administrative	Hospital	3,357	Medical	Medical	Urinary tract infection	0.46	0.34; 0.63
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	Urinary tract infection	1.02	0.73; 1.44
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Urinary tract infection	0.33	0.18; 0.61
Needleman ²⁸	Administrative	Unit	256	Medical	Medical	Urinary tract infection	0.50	0.30; 0.84
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	Urinary tract infection	0.82	0.47; 1.44
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	Urinary tract infection	0.09	0.01; 0.91
Needleman ²⁹	Administrative	Hospital	799	Combined	Surgical	Urinary tract infection	0.67	0.46; 0.98
Hope ⁸⁶	Administrative	Patient	1	Combined	Medical	Urinary tract infection	1.01	1.00; 1.01
Needleman ²⁸	Administrative	Hospital	4,156	Medical	Medical	Gastrointestinal bleeding	0.60	0.36; 0.97
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	Gastrointestinal bleeding	0.45	0.18; 1.11
Needleman ²⁸	Administrative	Hospital	3,357	Medical	Medical	Gastrointestinal bleeding	0.81	0.58; 1.12
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	Gastrointestinal bleeding	0.27	0.09; 0.78
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Gastrointestinal bleeding	0.89	0.52; 1.53
Needleman ²⁸	Administrative	Unit	256	Medical	Medical	Gastrointestinal bleeding	0.93	0.56; 1.55
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	Gastrointestinal bleeding	0.02	0.00; 0.51
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	Gastrointestinal bleeding	0.04	0.00; 0.64
Needleman ²⁸	Administrative	Hospital	4,156	Medical	Medical	Pneumonia	0.52	0.35; 0.77
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	Pneumonia	0.41	0.19; 0.86
Needleman ²⁸	Administrative	Hospital	3,357	Medical	Medical	Pneumonia	0.49	0.32; 0.76
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	Pneumonia	0.23	0.10; 0.53
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Pneumonia	0.44	0.22; 0.86
Needleman ²⁸	Administrative	Unit	256	Medical	Medical	Pneumonia	1.02	0.72; 1.44
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	Pneumonia	0.61	0.30; 1.23
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	Pneumonia	0.78	0.40; 1.52
Hope ⁸⁶	Administrative	Patient	1	Combined	Medical	Pneumonia	1.06	0.93; 1.21
Needleman ²⁸	Administrative	Hospital	4,156	Medical	Medical	Shock	0.84	0.71; 0.99
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	Shock	1.08	0.60; 1.96
Needleman ²⁸	Administrative	Hospital	3,357	Medical	Medical	Shock	0.52	0.31; 0.89
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	Shock	0.36	0.14; 0.93
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Shock	0.30	0.12; 0.72
Needleman ²⁸	Administrative	Unit	256	Medical	Medical	Shock	0.34	0.16; 0.75
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	Shock	0.14	0.05; 0.43
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	Shock	0.17	0.06; 0.47
Needleman ²⁸	Administrative	Hospital	4,156	Medical	Medical	Failure to rescue	0.85	0.70; 1.03
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	Failure to rescue	0.64	0.44; 0.92
Needleman ²⁸	Administrative	Hospital	3,357	Medical	Medical	Failure to rescue	0.85	0.70; 1.04
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	Failure to rescue	0.69	0.45; 1.06

Table G28. Relative risk of patient outcomes corresponding to an increase by 1% of RNs in nurse skill mix as reported by authors (continued)

Author	Data	Analytic Unit	Hospitals	Unit	Patients	Outcomes	Relative Risk	95% CI
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Failure to rescue	0.63	0.47; 0.84
Needleman ²⁸	Administrative	Unit	256	Medical	Medical	Failure to rescue	0.70	0.54; 0.90
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	Failure to rescue	0.36	0.14; 0.89
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	Failure to rescue	0.44	0.20; 0.96
Needleman ²⁹	Administrative	Hospital	799	Combined	Surgical	Failure to rescue	0.73	0.49; 1.09
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	Pulmonary failure	0.94	0.56; 1.56
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	Pulmonary failure	0.76	0.43; 1.34
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	Pulmonary failure	0.81	0.41; 1.60
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	Pulmonary failure	0.86	0.46; 1.59
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	Pressure ulcers	0.44	0.23; 0.86
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Pressure ulcers	0.27	0.09; 0.83
Needleman ²⁸	Administrative	Unit	256	Medical	Medical	Pressure ulcers	0.65	0.36; 1.17
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	Pressure ulcers	0.01	0.00; 0.29
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	Pressure ulcers	0.00	0.00; 0.11
Hope ⁸⁶	Administrative	Patient	1	Combined	Combined	Nosocomial infections	1.06	1.03; 1.09
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	Surgical wound infection	1.03	0.66; 1.60
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	Surgical wound infection	1.31	0.73; 2.38
Hope ⁸⁶	Administrative	Patient	1	Combined	Surgical	Surgical wound infection	1.03	0.99; 1.08
Needleman ²⁸	Administrative	Hospital	3,357	Medical	Medical	Deep vein thrombosis	1.05	0.64; 1.71
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	Deep vein thrombosis	1.39	0.66; 2.91
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Deep vein thrombosis	0.78	0.39; 1.57
Needleman ²⁸	Administrative	Unit	256	Medical	Medical	Deep vein thrombosis	0.75	0.40; 1.40
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	Deep vein thrombosis	1.55	0.51; 4.76
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	Deep vein thrombosis	1.87	0.69; 5.04
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	Complications	3.06	0.94; 10.03
Needleman ²⁸	Administrative	Hospital	3,357	Medical	Medical	Complications	18.55	1.22; 281.24
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	Complications	1.68	0.66; 4.27
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Complications	0.68	0.29; 1.58
Needleman ²⁸	Administrative	Unit	256	Medical	Medical	Complications	0.74	0.32; 1.68
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	Complications	0.57	0.17; 1.91
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	Complications	0.71	0.20; 2.48
Needleman ²⁸	Administrative	Hospital	4,156	Medical	Medical	Sepsis	1.55	0.93; 2.61
Needleman ²⁸	Administrative	Hospital	4,156	Surgical	Surgical	Sepsis	1.15	0.72; 1.84
Needleman ²⁸	Administrative	Hospital	3,357	Medical	Medical	Sepsis	0.83	0.56; 1.22
Needleman ²⁸	Administrative	Hospital	3,357	Surgical	Surgical	Sepsis	0.74	0.43; 1.28
Needleman ²⁸	Administrative	Hospital	256	Medical	Medical	Sepsis	1.08	0.61; 1.91
Needleman ²⁸	Administrative	Unit	256	Medical	Medical	Sepsis	1.03	0.61; 1.75
Needleman ²⁸	Administrative	Hospital	256	Surgical	Surgical	Sepsis	0.00	0.00; 0.85
Needleman ²⁸	Administrative	Unit	256	Surgical	Surgical	Sepsis	0.99	0.51; 1.92
Hope ⁸⁶	Administrative	Patient	1	Combined	Medical	Sepsis	1.05	1.04; 1.07

Table G29. Evidence of the association between nurse strategies (overtime hours, temporary nurse hours, full-time hours) and patient outcomes

Author, Definition of Patient Outcomes, Definition of Nurse Strategies	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
Alonso-Echanove ⁷⁹ Bloodstream infections as secondary diagnosis after CVC, duration of CVC, number of days from the placement date to the day when bloodstream infection occurred or to the day of CVC removal, % of temporary nurses/float nurses in unit each day; float nurse = a nurse not permanently assigned to the participating ICU, agency nurses, and nurses from other units or hospital areas who had been working in the participating ICU less than a year	Hospitals 6 Unit ICU Patients Medical Race 61 Sex 54	Patients cared for by float nurse, days >60% Patients cared by float nurse, days >60% Patients cared for by float nurse, days <60%	Relative risk Nosocomial infection 2.75 1.45 5.22 2.61 1.21 5.59 1.00 1.00 1.00
Berney ⁸⁴ Actual number of events identified as secondary DRG: urinary tract infection, gastrointestinal bleeding, pneumonia, shock, failure to rescue, sepsis	Hospitals 161 Unit Surgical Surgical Surgical Medical Medical Medical Medical Medical Medical Surgical Surgical Surgical Surgical Surgical Surgical Medical Medical Medical Medical Medical Medical Surgical Surgical Surgical Surgical Surgical Surgical Medical Medical Medical Medical Medical Medical Surgical Surgical Surgical Surgical Surgical Surgical Medical Medical	1% increase in RN overtime hours 1st (low overtime) quartile 1.6% 4th (high overtime) quartile 7.4% 1% increase in RN overtime hours .00% 1st (low overtime) quartile 1.6% 4th (high overtime) quartile 7.4% 1% increase in RN overtime hours 1st (low overtime) quartile 1.6% 4th (high overtime) quartile 7.4% 1% increase in RN overtime hours 1st (low overtime) quartile 1.6% 4th (high overtime) quartile 7.4% 1% increase in RN overtime hours 1st (low overtime) quartile 1.6% 4th (high overtime) quartile 7.4%	Relative risk Urinary tract infection 1.01 0.99 1.02 1.00 0.99 1.01 1.00 1.00 1.00 1.01 1.00 1.02 1.01 0.99 1.02 1.00 1.00 1.00 Gastrointestinal bleeding 1.02 0.99 1.05 0.98 0.96 1.01 1.00 1.00 1.00 1.01 0.98 1.03 1.00 0.96 1.03 1.00 1.00 1.00 Pneumonia 1.02 1.00 1.04 1.01 0.99 1.02 1.00 1.00 1.00 1.01 1.00 1.02 1.01 0.99 1.04 1.00 1.00 1.00 Shock 1.01 0.98 1.03 1.01 0.99 1.03

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Table G29. Evidence of the association between nurse strategies (overtime hours, temporary nurse hours, full-time hours) and patient outcomes (continued)

Author, Definition of Patient Outcomes, Definition of Nurse Strategies	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes	
	Medical	Medical	4th (high overtime) quartile 7.4%	1.00 1.00 1.00
	Medical	Medical	1% increase in RN overtime hours .00%	1.02 1.00 1.04
	Surgical	Surgical	1st (low overtime) quartile 1.6%	1.00 0.98 1.02
	Surgical	Surgical	4th (high overtime) quartile 7.4%	1.00 1.00 1.00
				Failure to rescue
	Surgical	Surgical	1% increase in RN overtime hours	1.00 0.99 1.01
	Medical	Medical	1st (low overtime) quartile 1.6%	1.00 0.99 1.00
	Medical	Medical	4th (high overtime) quartile 7.4%	1.00 1.00 1.00
	Medical	Medical	1% increase in RN overtime hours .00%	1.00 1.00 1.01
	Surgical	Surgical	1st (low overtime) quartile 1.6%	1.00 0.99 1.01
	Surgical	Surgical	4th (high overtime) quartile 7.4%	1.00 1.00 1.00
				Sepsis
	Surgical	Surgical	1% increase in RN overtime hours	1.02 1.00 1.04
	Medical	Medical	1st (low overtime) quartile 1.6%	1.01 0.99 1.02
	Medical	Medical	4th (high overtime) quartile 7.4%	1.00 1.00 1.00
	Medical	Medical	1% increase in RN overtime hours .00%	1.03 1.01 1.04
	Surgical	Surgical	1st (low overtime) quartile 1.6%	1.02 1.00 1.03
	Surgical	Surgical	4th (high overtime) quartile 7.4%	1.00 1.00 1.00

Table G29. Evidence of the association between nurse strategies (overtime hours, temporary nurse hours, full-time hours) and patient outcomes (continued)

Author, Definition of Patient Outcomes, Definition of Nurse Strategies	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
Cho ³⁰ ICD-9-CM for urinary tract infection, pressure ulcers, falls and injury, surgical wound infection, and sepsis; Contracted hours = productive nursing hours (direct care to patient) worked by nursing personnel contracted on a temporary basis. Contract hours * % of RN	Unit	% Contract hours	Rate, % ± SD
	Patients	% of RN	Urinary tract infection
	Age	3.60	2.50 ± 1.30
	Race	3.30	1.60 ± 1.40
	Sex	3.20	2.00 ± 1.00
	Severity	5.00	2.10 ± 1.80
	Combined	3.60	Pneumonia
	Combined	3.30	3.10 ± 1.90
	67.9	3.20	2.70 ± 2.20
	79.3	5.00	2.80 ± 1.30
	48.9	3.60	2.80 ± 2.00
	49.7	3.30	Falls
		3.20	0.20 ± 0.20
		5.00	0.20 ± 0.30
		3.60	0.20 ± 0.20
		3.30	0.10 ± 0.20
		3.20	Pressure ulcers
		5.00	0.10 ± 0.30
		3.60	0.30 ± 0.60
		3.30	0.30 ± 0.50
	3.20	0.20 ± 0.40	
	5.00	Surgical wound infections	
	3.60	1.60 ± 1.00	
	3.30	1.10 ± 1.10	
	3.20	1.50 ± 0.70	
	5.00	1.10 ± 1.00	
	3.60	Sepsis	
	3.30	1.20 ± 0.70	
	3.20	0.80 ± 0.80	
	5.00	1.10 ± 0.60	
	3.60	1.00 ± 1.10	
	3.30		
	3.20		
	5.00		

Table G29. Evidence of the association between nurse strategies (overtime hours, temporary nurse hours, full-time hours) and patient outcomes (continued)

Author, Definition of Patient Outcomes, Definition of Nurse Strategies	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories	Patient Outcomes
Cimiotti ⁸⁷ Infections occurring in an infant 48 hours or longer after admission to the NICU including bloodstream infections, device associated pneumonia, CNS and skin infections, conjunctivitis; hours/patient day worked by float pool and agency RN not regularly assigned to the NICU	Hospitals 1 Unit Neonatal Patients Medical	0.19% of float nurses 24.07% of float nurse 0.19% of float nurses 24.07% of float nurse Mean staffing levels 12.13% Low % of pooled nurses 14.19% High % of pooled nurses 12.13% Mean staffing levels 12.13% Low % of pooled nurses 14.19% High % of pooled nurses 12.13%	Rate, % Pneumonia Nosocomial infection 0.50 18.30 0.90 15.10 Sepsis 10.50 5.50 Relative risk Nosocomial infection Reference 1.30 1.30 Sepsis rate% 1.00 2.01 2.06
Donaldson ⁹ Total number of patients with Stage I-IV pressure ulcers regardless of whether ulcer was acquired during hospitalization or present on admission; % total number of surveyed patients; unplanned descent to the floor; rate/1,000 patient days, total number of productive hours worked only by those with direct patient care responsibilities who are contract staff (registry, travelers). It does not include internal float staff	Hospitals 68	% contract hours % RN 8.43 59.2 8.04 66.67 9.22 68.79 10.74 72.19	Rate/100 patient days ± SD 0.31 ± 0.20 0.32 ± 0.17 0.30 ± 0.22 0.26 ± 0.16
Donaldson ⁹⁵ Hospital acquired pressure related skin injury controlling for date of admission, % of all patients on the day of prevalence study, patient's unplanned descent to the hospital floor; were analyzed as 7 day aggregate per unit; also actually number per unit; the number of falls/1,000 patient days, percent of contacted or agency staff.	Hospitals 25 Unit Combined Patients Medical	Increase by 1% contracted hours of care	Rate/100 patient days ± SD Falls -0.001 ± 0.01

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Table G29. Evidence of the association between nurse strategies (overtime hours, temporary nurse hours, full-time hours) and patient outcomes (continued)

Author, Definition of Patient Outcomes, Definition of Nurse Strategies	Number of Hospitals, Units, Patient Age, % of Whites, % of Males, % of Emergency Admissions	Nurse Staffing Categories			Patient Outcomes
Potter ⁴⁰ (Number of falls on a unit/number of patient days) * 1,000, an average % of float nurses in day shift provided by nurses from other units or outside the hospital	Hospitals 1 Unit ICU Patients Medical	% float hours	% RN		Rate/100 patient days Falls 0.30 0.29 0.30 0.23
Robert ⁶ Primary bloodstream infections (BSIs) (CDC). Index date for cases, the day of 1 positive blood culture; for controls = (cases LOS before BSI/total cases LOS) * control total LOS, % of pool staff - not regular full-time employees of the hospital assigned to SICU.	Hospitals 1 Unit ICU Patients Surgical	% of contract hours			Nosocomial infection, rate/100 patient days 0.28 0.76 Relative risk 1.00 1.00 1.00 3.20 1.20 8.20
Stratton ⁹¹ Rate/1,000 patient days of respiratory, gastrointestinal, bloodstream and central line infections in hospitalized patients not present at time of admission, rate/1,000 patient days of bloodstream and central line infections in hospitalized patients not present at time of admission, % of total productive overtime nursing hours worked by RN, LPN, and UAP in each quarter 2002, % of RN productive hours worked by supplemental nurse staffing (total nursing overtime hours and percentages of hours from float/agency/traveler RN hours)	Hospitals 7	% hours overtime	contract	RN	Rate/100 patient days ± SD Nosocomial infection 0.75 ± 0.69 0.53 ± 0.67 0.71 ± 0.77 0.64 ± 0.43 0.65 ± 0.23 0.62 ± 0.39 0.71 ± 0.59 0.85 ± 0.50 0.73 ± 0.56 1.03 ± 0.96 0.80 ± 0.69 0.95 ± 0.71 0.51 ± 0.08 0.79 ± 0.17 0.66 ± 0.12 0.56 ± 0.17 -0.01 ± 0.02 0.00380 ± 0.01
Tourangeau ⁷⁶ 30 day mortality, % of full time nurses	Hospitals 75 Unit Combined Patients Medical	% fulltime	% RN		Rate, % 14.02 15.27 15.05

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BSI = Bloodstream infection; CNS = Central nervous system; CVC = Central venous catheter DRG = Diagnosis related group; ICU = Intensive care unit; LOS = Length of stay; NISU = Neonatal intensive care unit; RN = Registered Nurse; SD = Standard deviation; SICU = Surgical intensive care unit

Table G30. The significant effect modification by the study design of the association between nurse staffing and patient outcomes

	Outcomes Rates (N=16)	Outcomes Relative Risk (N=19)
Quality scores	% Significant interactions	% Significant interactions
Patients/RN/shift	12.5	21.1
RN FTE/patient day	12.5	15.8
Patients/LPN	31.3	5.3
Total nurse hours	6.3	0
RN hours/patient day	12.5	21.1
LPN hours	31.3	0
UAP hours	6.3	0

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