

Nurse–Patient Ratios as a Patient Safety Strategy

A Systematic Review

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A small percentage of patients die during hospitalization or shortly thereafter, and it is widely believed that more or better nursing care could prevent some of these deaths. The author systematically reviewed the evidence about nurse staffing ratios and in-hospital death through September 2012. From 550 titles, 87 articles were reviewed and 15 new studies that augmented the 2 existing reviews were selected. The strongest evidence supporting a causal relationship between higher nurse staffing levels and decreased inpatient mortality comes from a longitudinal study in a single hospital that carefully accounted for nurse staffing and patient

comorbid conditions and a meta-analysis that found a “dose-response relationship” in observational studies of nurse staffing and death. No studies reported any serious harms associated with an increase in nurse staffing. Limiting any stronger conclusions is the lack of an evaluation of an intervention to increase nurse staffing ratios. The formal costs of increasing the nurse–patient ratio cannot be calculated because there has been no evaluation of an intentional change in nurse staffing to improve patient outcomes.

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THE PROBLEM

A small percentage of hospitalized patients die during or shortly after hospitalization. Evidence suggests that some proportion of these deaths could probably be prevented with more nursing care. For example, in 1 early study of 232 342 surgical discharges from several Pennsylvania hospitals, 4535 patients (2%) died within 30 days of hospitalization; the investigators estimated that the difference between 4:1 and 8:1 patient–nurse ratios may be approximately 1000 deaths in a group of this size (1). Other studies have produced roughly similar estimates, namely approximately 1 to 5 fewer deaths per 1000 inpatient days with more nurse staffing per patient (2–4). The rationale for suggesting that increasing the ratio of registered nurses (RNs) to patients will lead to decreased illness or mortality rates rests on the belief that improved attention to patients is the critical factor. This systematic review examined the evidence on the effects of interventions aimed at increasing nurse–patient ratios on patient illness and death.

PATIENT SAFETY STRATEGIES

There has been no evaluation of an intentional change in RN staffing to improve patient outcomes; therefore, the patient safety strategy referred to in this article remains somewhat unclear. Most studies have been cross-sectional or longitudinal assessments of differences in nursing staff variables, with the most commonly assessed measure being the proportion of RN time per some measure of inpatient load and the most commonly assessed outcome being mortality. However, many other factors have been proposed as being causal with respect to the relationship between nurs-

ing care and reductions in hospital mortality, potentially in addition to or instead of a simple nurse–patient ratio. These factors include measures of nursing burnout, job satisfaction, teamwork, nurse turnover, nursing leadership in hospitals, and nurse practice environment.

Several research groups have proposed conceptual frameworks to explain why more effective nursing care may reduce inpatient mortality (5–8). Underlying all of these conceptual frameworks is the belief that surveillance is a critical factor that can be improved with more staff, better-educated staff, or a better working environment (9). A representative framework by Aiken and colleagues (8) posits that nurse–patient ratios, along with staffing skill mix, can lead to better surveillance, which, along with many other factors, can influence the process of care and lead to better patient outcomes (Figure 1).

REVIEW PROCESSES

Two existing reviews relevant to the topic were identified, by using methods described by Whitlock and colleagues (10). These reviews were supplemented by searching the Web of Science for articles published from 2009 (the end date of the search from the most recent review) to September 2012 that cited any of 4 key articles in this field, including the older of the 2 reviews, and was limited to studies published in English. For a complete description of the search strategies, literature flow diagram, and evidence tables, see the Supplement (available at www.annals.org). The update search identified 546 titles, and 4 articles came from reference mining. Titles and abstracts were reviewed and selected if they reported empirical data on the relationship between nurse staffing ratios and mortality or nursing-sensitive outcomes, such as pressure ulcers and failure to rescue. Because several cross-sectional studies have assessed this relationship, only 1 additional cross-sectional study was included for detailed review. The exception was a cross-sectional study that evaluated a quasi-intervention (11). Nine longitudinal studies were identified (12–20).

See also:

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Key Summary Points

Cross-sectional studies, mostly in intensive care unit or postsurgical settings, support a relationship between the number of nurses staffed per patient and inpatient mortality.

The strongest evidence supporting a causal relationship between higher nurse staffing levels and decreased inpatient mortality comes from a longitudinal study in a single hospital that carefully accounted for nurse staffing levels and found decreases in mortality of 2% to 7%.

Limiting any stronger conclusions is the lack of an evaluation of an intervention to increase nurse staffing ratios.

Four simulation studies reported on costs, and 1 systematic review article was included (21–25). Two frameworks were also included (6, 7). No experimental studies were identified.

The assessment of multiple systematic reviews (AMSTAR) criteria was used to assess the quality of the systematic reviews (26). Only criteria relevant to a particular review were applied; for example, 2 of the 11 AMSTAR criteria are only applicable to reviews that involve meta-analysis. In addition, the AMSTAR criteria requiring a list of all excluded studies were not applied. New studies were not formally assessed for study quality, but their strengths and limitations are discussed later.

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BENEFITS AND HARMS**Benefits**

Two recent relevant systematic reviews on this topic, a meta-analysis (27) and a narrative review (28), respectively

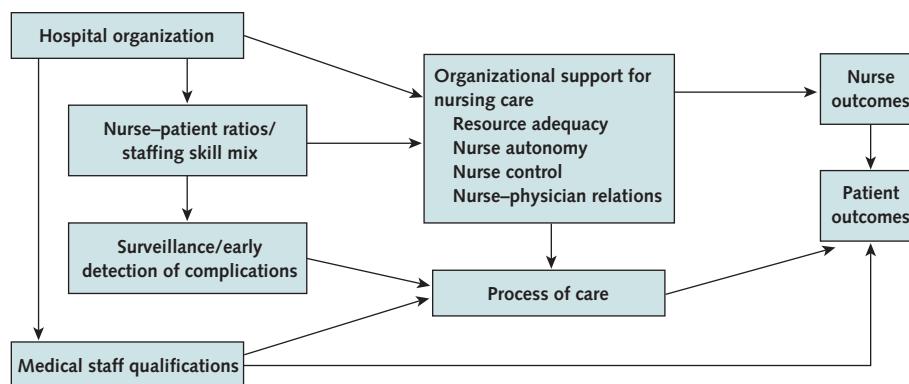
scored 10 out of 10 relevant criteria and 7 out of 9 relevant criteria according to AMSTAR.

The meta-analysis included 28 studies, of which 17 were cohort studies, 7 were cross-sectional studies, and 4 were case-control studies (no experimental studies were identified). Most were U.S. studies, and the average level of staffing was 3.0 patients per RN for the intensive care unit (ICU) setting, 4.0 patients per RN in the surgical setting, and 4.4 patients per RN for the medical setting. It found a consistent relationship between higher RN staffing and lower hospital-related mortality: An increase of 1 RN full-time equivalent (FTE) per patient day was related to a 9% reduction in the odds of death in the ICU, a 16% reduction in the surgical setting, and a 6% reduction in the medical setting. With respect to other outcomes, lower rates of hospital-acquired pneumonia, pulmonary failure, unplanned extubation, failure to rescue, and nosocomial bloodstream infections were related to higher RN staffing in pooled analyses of several studies. However, several other outcomes that were presumed to have strong sensitivity to nurse staffing levels did not show consistent relationships, including falls, pressure ulcers, and urinary tract infections.

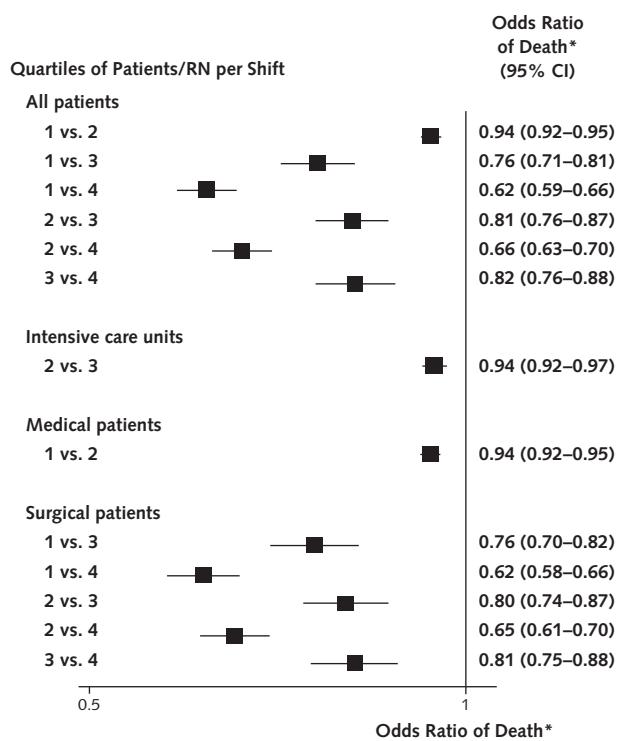
The authors also conducted an indirect analysis of the potential for a dose-response relationship. This analysis assessed the effect across studies of additional RNs per shift. In each case, comparisons of quartiles of nurse staffing levels showed the expected relationship (Figure 2). In other words, if the relationship between nurse staffing and mortality is causal, the difference in the risk for death should be greater between the first and third quartiles of nurse staffing than it is between the first and second quartiles because the difference in staffing between the first and third quartiles is greater than that between the first and second quartiles.

The authors of the meta-analysis concluded that a consistent relationship has been shown but identified several limitations in the literature with respect to establishing

Figure 1. Hospital organization, nursing organization, and patient outcomes.



From reference 8, with permission.

Figure 2. Pooled odds ratio of quartiles of nurse staffing levels.

Odds ratios are based on pooled analysis consistent across the studies (heterogeneity not significant). From reference 27, with permission. RN = registered nurse.

that this relationship is causal. The authors ultimately concluded that the arguments for a causal relationship are “mixed,” and they called for future research to address the role of nurse staffing and competence on the effectiveness of patient care, “taking greater cognizance of other relevant factors such as patient and hospital characteristics and quality of medical care” (27).

The narrative review identified literature published through 2009 and was restricted to studies that used hospital-related mortality as the outcome; the authors identified 17 studies (10 of which were not included in the first review and 7 that were published since 2007) (28). Although this review was narrative, the 2 reviews had broadly similar results: 14 of 17 studies found a statistically significant relationship between nurse staffing variables and lower mortality rates. In addition, the narrative review identified mixed findings for mortality among 5 studies assessing the characteristics of the nurse work environment and work relationships, 3 studies assessing nurses’ responses to work and the work environment (for example, burnout), and 7 studies assessing nurses’ educational preparation and experience. Only 1 study, which had a cross-sectional design, assessed nursing process-of-care variables; it found a relationship between the use of care maps and lower hospital-associated mortality, with an estimated effect size of 10 fewer deaths per 1000 acute medicine dis-

charged patients. Like the meta-analysis, the narrative review concluded that a strong relationship exists but more research is needed to understand the reasons why this relationship between higher nurse staffing and lower hospital mortality may be causal (that is, they called for a theoretical model that explains the relationship in ways that can be tested and refined).

Thus, these 2 reviews came to broadly similar conclusions. Mostly cross-sectional studies consistently report that higher RN staffing is related to lower hospital-related mortality.

However, many factors can confound the observed relationship. In cross-sectional studies, hospitals that are “better” in other ways may also be better staffed with more RNs. For example, 1 published study of electronic health record implementation showed that hospitals with electronic health records have higher nurse staffing ratios and lower patient mortality (29). If the cross-sectional relationship is confounded, then critics worry that adoption of fixed nurse–patient ratios will not necessarily lead to better health outcomes, that such a policy is “an inflexible solution that is unlikely to lead to optimal use of resources” (30).

The results of the updated search are as follows. Nine longitudinal studies and one new systematic review (12–20, 25) were identified. The systematic review included studies that assessed nurse staffing ratios and outcomes restricted to adult ICU settings (25) and reached conclusions similar to the previous reviews: a consistent relationship between increased nurse staffing and better patient outcomes in observational studies, evidence that falls short of causality. One longitudinal study narratively reported that increased nurse staffing was related to “significantly ($P \leq 0.01$) decreased rates of decubiti, pneumonia, and sepsis,” but data were not presented (20). The cross-sectional study addresses the effect of an “intervention” to change nurse staffing ratios, implemented in response to a 2004 California law requiring minimum nurse–patient ratios in acute care hospitals (11). This legislation mandated patient–nurse staffing levels of 5:1, 4:1, and 2:1 for medical or surgical units, pediatric units, and ICUs, respectively. The California legislative mandate does not require nurse staffing to be met with RNs (that is, licensed vocational [practical] nurses can also meet the mandate).

Aiken and colleagues (11) assessed the relationship between nurse staffing and mortality in 2006, 2 years after the California mandate, comparing data from California with those of 2 states without mandates, New Jersey and Pennsylvania. Data about workloads were drawn from a survey of RNs in the 3 states (22 336 nurses in total); the response rate was 35.4%. Hospital data came from the American Hospital Association, and patient and outcome data came from state hospital discharge databases.

The authors reported that their survey data showed substantial adherence to the California mandate, with 88% of medical or surgical nurses, 85% of pediatric nurses, and 85% of ICU nurses reporting that the staffing of their last

shift was within the mandated ratio. In logistic regression analyses adjusted for many patient characteristics and 3 hospital characteristics (such as bed size, teaching status, and technology use), Aiken and colleagues found statistically significant relationships between the estimation of the average number of patients per nurse and 2 outcomes: 30-day mortality and failure to rescue (11).

Although the study collected data after implementation of the California staffing mandate, it did not test the effect of that mandate *per se* because it had no comparison data from the period before the mandate went into effect. The possibility that the relationship is causal is blunted by longitudinal studies that examined measures from before and after the California mandate, which showed the expected changes in nurse staffing and proportion of licensed staff per patient but no improvement in other patient outcomes believed to be nursing-sensitive (such as falls, pressure ulcers, and failure to rescue) (16, 17, 19). In fact, an unexpected statistically significant increase in pressure ulcers was related to a greater number of hours of care for the patient (which may have been because of greater detection). These studies did not assess mortality.

Five additional longitudinal studies add further information to this picture. The first is a longitudinal assessment of nurse staffing and hospital mortality and failure to rescue in 283 California hospitals between 1996 and 2001, which had access to direct measures of nurse staffing (14). In multivariable models that included many hospital market characteristics as well as risk adjustment using the Medstat Disease Staging methodology to produce a predicted probability for complications or death, the authors found that an increase of 1 RN FTE per 1000 inpatient days was related to a statistically significant decrease in mortality of 4.3%.

The second longitudinal study assessed care at 39 Michigan hospitals between 2003 and 2006; it included adults admitted through the emergency department with acute myocardial infarction, heart failure, stroke, pneumonia, hip fracture, or gastrointestinal bleeding (15). This study simultaneously controlled for 4 factors—high hospital occupancy on hospitalization, weekend hospitalization, seasonal influenza, and nurse staffing levels—each of which had a statistically significant effect on in-hospital mortality. Each additional RN FTE per patient day was related to a 0.25% decrease in mortality.

The third longitudinal study assessed the effect of a mandate in 3 Western Australia public hospitals to implement a new staffing method, the Nursing Hours per Patient Day (12). The study assessed 3 periods: 20 months before implementation, 7 months of a “transition period,” and 2 months after implementation. The authors found that the total nursing hours and RN hours increased during the observation period. However, the percentage of total nursing hours provided by RNs decreased (from 87% to 84%). Also, the article stated that “although the nursing hours increased for all three hospitals (in the post-

implementation period), the changes were not statistically significant” (12). Mortality rates were reduced during this period. Among many other outcomes, some improved, others did not, and some changes were inconsistent across hospitals. Although the study was described as an interrupted time series, it was analyzed as a before–after study.

The fourth longitudinal study assessed changes in nurse staffing over 9 years in 124 Florida hospitals and related these to changes in Agency for Healthcare Research and Quality Patient Safety Indicators (18). The study used both initial staffing ratios and changes in staffing ratios. Results were mixed but generally favored better patient safety outcomes with higher RN staffing levels.

The methodologically strongest longitudinal study is that of Needleman and colleagues (13). The researchers used data over time from a single hospital to assess the relationship between natural differences in levels of RN staffing in the same hospital and inpatient mortality. The study is further characterized by a careful matching of nurse staffing on a shift-by-shift basis with the actual patients cared for during that shift. Knowing the actual patients cared for allowed for more sophisticated adjustments of risk for death at the patient level. The study was done at a tertiary academic hospital between 2003 and 2006 and included 197 691 hospitalizations and 176 696 nursing shifts across 43 hospital units. The patients themselves averaged 60 years of age, and approximately 50% were covered under Medicare. The variable of interest was exposure of the patient to nursing care that was below the target level (for that type of unit) for that shift (that is, the proportion of shifts below target level staffing on a per-patient basis). An additional exposure variable was a “high-turnover” shift (that is, a shift with many hospitalizations, discharges, or transfers). The authors found that exposure to each shift of below-target staffing or high turnover was related to a 2% to 7% increase in mortality, with higher levels of risk if the high-turnover or below-target shift occurred in the first 5 days after hospitalization. For patients who were not in an ICU, this risk was increased by 12% and 15% during below-target and high-turnover shifts, respectively.

The data from Needleman and colleagues contribute to the “causality” determination because the study is longitudinal in 1 hospital, thus controlling for the “hospital effect” potentially present in all cross-sectional studies, and has detailed measures of exposure and confounding variables. These results and the dose–response analysis from the meta-analysis provide the strongest evidence in support of causality.

Harms

The survey administered as part of the cross-sectional study previously described, which collected data 2 years after the California mandate for minimum nurse staffing ratios (11), found that some California nurses perceived

that they had less support from the use of licensed vocational nurses, unlicensed personnel, and nonnursing support services (such as housekeeping and unit clerks) after implementation of the mandate. For example, 25% of RNs reported that they perceived that they had decreased use of licensed vocational nurses after the mandate, whereas 10% perceived that they had increased use and 56% reported that use remained the same.

The longitudinal assessments from California (16–19) and Western Australia (12) reported an increase in pressure ulcers related to increased nurse staffing, although this development may reflect increased detection. Few other studies mentioned an explicit assessment of potential unexpected adverse outcomes.

IMPLEMENTATION CONSIDERATIONS AND COSTS

Implementation Contexts

Because no published studies of an assessment of an “implementation” were found, the contexts in which interventions have been implemented cannot be directly assessed. However, the cross-sectional and longitudinal studies that have been published and have consistently shown a relationship between staffing levels and patient outcomes have included a broad array of hospitals, often all or nearly all of the hospitals (except for very small ones) in a state. Therefore, if the relationship between increased RN staffing and inpatient mortality is a causal one, it very likely applies to most hospitals and contexts. This strategy is most likely to be implemented when mandated by state or federal policy.

As previously noted, the relationship between staffing and mortality that underpins this strategy has been seen in various hospitals and contexts. The effect, if causal, is probably relatively insensitive to the usual effects of contexts considered in other patient safety strategy reviews. Of note, the recent study by Needleman and colleagues was conducted in a tertiary medical center that has a lower-than-expected in-hospital mortality rate and a reputation for excellence. Therefore, the relationship between increased RN staffing and lower mortality, if causal, is potentially applicable even to high-performing hospitals.

Costs

Four simulation studies reported information about costs. The first used 2003 data from 28 Belgian cardiac surgery centers to assess the costs and outcomes of increasing nurse staffing. Assuming a causal relationship between this staffing increase and an outcome of 5 fewer patient deaths per 1000 elective hospitalizations, the authors concluded that the incremental cost-effectiveness ratio was €26 372 (approximately \$35 000) per avoided death and €2639 (approximately \$3500) per life-year gained (21).

The second simulation study was conducted by the University of Minnesota Evidence-based Practice Center, which produced the systematic review on nurse staffing (22). It used its own meta-analysis as the basis for estimat-

ing the potential monetary benefits of increased RN staffing. Assuming that those relationships were causal and taking a societal perspective, the authors concluded that increasing RN staffing by 1 FTE per patient day was related to positive savings–cost ratios across a broad range of clinical settings. For example, the net cost of adding 1 RN FTE per 1000 hospitalized ICU patients was an estimated \$590 000, whereas the net benefit (in terms of life-years saved and productivity) was an estimated \$1.5 million, for a benefit–cost ratio of 2.51. However, hospitals did not save money because the net cost of adding an extra RN FTE was not offset by the expected 24% decrease in length of stay.

A third simulation study (24) used data from studies by Aiken and colleagues and Needleman and colleagues to estimate benefits in mortality and length of stay, respectively, and estimated an incremental cost-effectiveness ratio between \$25 000 and \$136 000 per life saved as patient–RN staffing ratios decreased from 8:1 to 4:1. The model was most sensitive to the estimate of effect on mortality.

Lastly, 1 additional study from Portugal estimated that increasing neonatal nurse staffing to “adequate” would increase staff costs more than 30% of the current rate (23).

DISCUSSION

Nurse staffing ratios have a relationship with reductions in hospital-related mortality in most published studies. However, lack of a published evaluation of an intentional change in RN staffing from some initial value (for example, 6 patients to 1 RN on general medical wards) to some lower patient–RN staffing value (such as 5:1 or 4:1) limits conclusions on increasing nurse staffing ratios as a patient safety strategy. All longitudinal published studies to date have assessed natural variations in RN staffing. The concern also remains that mortality is not reduced by increased nurse staffing but by something the nurses do. Determining what this is and how it can best be facilitated should be the goal of an effective patient safety strategy.

Limitations of this review include those of the original articles, such as lack of rigorous evaluations of an intentional intervention, low response rates to surveys that collect explanatory variables (such as RN staffing), potentially poor matching of RN staffing to actual patients cared for and their risk for death, and lack of replication of the 1 high-quality longitudinal study that has been published; and the possibility that some relevant evidence was not found, either because it was not identified during the search or because some completed evaluations have not been unpublished.

To further advance this field, studies assessing an intentional change in nurse staffing ratios are needed. It may be impractical for such a study to be a randomized, controlled trial, but high-quality evidence could come from a time series analysis or a controlled before-and-after study, particularly if it included the necessary process variables to

serve as a test of a conceptual framework for how increased staffing can influence outcomes.

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