The relationship between nurse staffing levels and patient outcomes in acute care settings

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Abstract

Studies have not consistently shown substantial negative relationships between nurse staffing levels and hospital mortality rates. Critical care settings are well-suited for examining this link because of the high acuity and fatality rates of patients, the intense nursing care needed, and the presence of specific risk adjustment techniques.

Keywords: Community Nurses; evidence-based practice; literature review; nurses; systematic review

INTRODUCTION:

Nursing practice significantly impacts the quality of patient care in hospitals. However, it is still a difficulty to show the effect of top-notch nursing care on measurable results in order to make their importance apparent. Past study has mostly focused on negative patient outcomes associated with the level of care delivered by nurses (Flood & Diers 1988, American Nurses Association 1997, 2000). Mortality is a widely used indicator for evaluating the quality of inpatient care, although it has been criticized for its lack of sensitivity when assessed by the hospital as a whole. As inpatient acuity levels have risen, death rates may have become more responsive to the quality of care in hospitals, particularly in cases where fatality rates are elevated. Staffing levels are considered a fundamental factor influencing the quality of nursing care, directly impacting patient care. Understaffing hinders the delivery of planned care and increases the risk of human mistake, which can compromise patient safety (Beckmann et al., 1998). Previous research on the correlation between nurse staffing and patient care outcomes, namely patient mortality, has not reached a definitive conclusion despite ongoing interest. A
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The relationship between nurse staffing levels and patient outcomes in acute care settings has significantly increased during a period of significant changes in human resources and financial management within hospitals and healthcare systems. This research aims to provide a literature review and meta-analysis on the correlation between nurse staffing levels and patient mortality in critical care settings.

METHODOLOGY

Research methodology for locating studies: The literature for this study was found through computerized searches of key bibliographic databases, retrieval of references listed in existing studies, and manual searches of in-house reference libraries. The databases that were searched include Cochrane Database of Systematic Reviews (3rd Quarter, 2005), MEDLINE (1966–2005 October week 2), EMBASE (1980–2005 Week 43), the Cumulative Index of Nursing and Allied Health Literature (CINAHL) (1982–2005 October Week 2), and PsycINFO (1985 to October week 3, 2005). The initial electronic search was performed in 2002 and subsequently updated in December 2004 and October 2005.
The search terms included critical/intensive care, quality of health care, personnel staffing and scheduling, and nursing administration research.

Criteria for selection: Only papers that were published in English were included in this review. Two reviewers separately screened suitable papers for inclusion based on titles, publication years, and abstracts. The criteria for selecting studies for the review were as follows.

Study volunteers in evaluated research: The study participants were severely sick patients receiving treatment in intensive care units.

Categories of outcome measures: The main outcome measure examined was mortality, including ICU, in-patient (hospital), or 30-day mortality.

Study classifications: Randomized controlled trials, controlled trials, and observational research were incorporated.

Types of exposure related to nurse staffing: The variable being studied was the nurse staffing levels in critical care settings. The necessary staffing level should be explicitly outlined and specified using a quantitative measure like nurse-to-patient ratio (NPR) or similar metrics. The current review did not take into account disparities in nursing skill-mix. Reviewers resolved discrepancies on the inclusion of a study through discussion. The complete text of chosen publications was acquired and examined to verify the eligibility of each study. A data abstraction form was developed to establish a uniform method for data abstraction.

Data analysis and synthesis:
The candidate studies' information was structured using Reference Manager, version 10 (ISI ResearchSoft 2001), a reference management software that consolidated search results from electronic databases and manual searches. Evaluation of study inclusion reliability was conducted using the Kappa coefficient to measure agreement between reviewers. The quantitative synthesis method was used minimally since there were few qualified research that reported comparable outcome measures. A Q-test was conducted to assess heterogeneity among the identified studies. A Forest plot was used to illustrate the variation and spread of effects among studies, and parameter estimates like risk ratios were combined. Unadjusted risk ratios (RRs) were selected over odds ratios (ORs) to prevent overestimation due to the high mortality rate in one of the studies. Combined risk ratios were calculated using the DerSimonian and Laird random effects model proposed in 1986 by DerSimonian and Laird. The studies' quality was not assessed or included in the meta-analysis, although many study features were outlined in the table. The analyses were performed using Stata version 9.1 (Stata Corp 2005).
RESULTS
Selection of studies: 251 citations were found through electronic searches after eliminating duplicate items. Two reviewers evaluated the titles and abstracts and excluded 228 (90.8%) based on specific inclusion criteria. The agreement among reviewers was above 96%, with an overall kappa value of 0.78 (P < 0.0001) and a 95% confidence interval ranging from 0.66 to 0.90. The primary cause of disagreement was from insufficient detail in the abstract. Five articles with controversial decisions were removed following deliberation. Six more citations were found and included through manual searches. The study comprised participants who were hospitalized with acute myocardial infarction (AMI).

Three research were conducted in a neonatal intensive care unit (NICU) or intensive care nursery (ICN) (Hamilton et al. 2000, Tucker & The UK Neonatal Staffing Study Group 2002, Callaghan et al. 2003), whereas nine studies involved adult patients in need of intense care. NICU studies were excluded from the evaluation because of the different staffing and needs compared to adult ICUs.

Study attributes: All nine studies had an observational design and did not include any treatments. Studies were undertaken in Brazil, Scotland, Austria, and the USA. All research, except one, utilized data gathered between 1990 and 2000. The median study period was 36 months, with a range of 10 to 60 months. Eight out of nine studies were multi-centre, involving numerous hospitals with bed capacities ranging from 10 to 6668, with a median of 38 beds. 168,840 people were enrolled in the study, with the number of participants per study varying from 353 to 118,940. Three research utilized prospective data collection methods for patient outcomes (Bastos et al. 1996, Metnitz et al. 2004, Shortell et al. 1994), whereas the other studies gathered patient data retrospectively.

Nursing staff metrics: All studies, except one, utilized NPR aggregated data for each participant unit. NPR is typically represented as a ratio of 1 : x, with x representing the number of patients attended to by a nurse. Two studies utilized the ratio as a continuous variable in the analysis (Bastos et al. 1996, Shortell et al. 1994). Four studies categorized the nurse-to-patient ratio (NPR) as follows: 1 : 3 or 1 : 4 was considered 'fewer ICU nurses,' while 1 : 1 or 1 : 2 was considered 'more ICU nurses' (Amaravadi et al. 2000, Dimick et al. 2001, Pronovost et al. 2002, Pronovost et al. 2001). A study using NPR divided into quartiles (Person
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The nurse staffing measures varied according on the research question and included day shifts, night shifts, both day and night shifts, or a reduction in nurse staffing during the evening (yes or no). A research by Tarnow-Mordi et al. (2000) utilized a combined measure of 'maximum occupancy >6 or not' and 'average nurse requirement per occupied bed >1.6 or not' to represent the level of ICU staffing for each patient. One study analyzed only included information on the skill-mix of nursing personnel, namely the ratio of Registered Nurses (RNs) to Licensed Practical Nurses (LPNs) (Person et al. 2004).

Evaluation criteria: The evaluation criteria for study features can be found in Table 3. All nine research were published in peer-reviewed journals between 1994 and 2004. The studies were all observational, and one of the authors questioned if the study had sufficient statistical power to identify a difference between the two levels of nurse staffing (Bastos et al., 1996). All investigations utilized multiple regression analysis, specifically ordinary least square or logistic regression. Five out of eight multi-center studies utilized individual patients as the unit of analysis. All of these studies, with the exception of Dimick et al. 2001, utilized hierarchical modeling or generalized estimating equations (GEE) to address clustering effects. Two studies (Person et al. 2004, Tarnow-Mordi et al. 2000) reported on the examination of interaction terms and the goodness-of-fit of the selected model.

Effects of high versus low nurse staffing: Two studies showed significant differences between unadjusted and adjusted odds ratios, indicating the influence of confounding factors in the multiple regression models. Unadjusted risk ratios (RRs) comparing high nurse staffing with low nurse staffing were determined based on the reported data and displayed in the Forest plot (Figure 1). Four out of five studies demonstrated a statistically significant decrease in the risk of hospital mortality in patients with high nurse staffing levels, with an overall risk ratio of 0.65 (0.47–0.91). After controlling for several factors in multiple regression models, just one study reported a statistically significant decrease in mortality linked to increased ICU staffing levels. The statistically significant result was obtained through analysis using a sophisticated, non-binary category for the staffing level (Tarnow-Mordi et al. 2000). A recent study with a substantial sample size examined how the effect of high nurse staffing levels on mortality changes after accounting for other factors. This was done by providing odds ratios from several statistical models (Person et al., 2004).
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**DISCUSSION**

This review examined the influence of nurse staffing levels on patient mortality in critical care settings as reported in published literature. Results from nine observational studies found insufficient evidence to show a direct link between nurse staffing levels and critically ill patient death in hospitals. The unadjusted risk ratio suggested a negative correlation between nurse staffing levels and hospital mortality. However, this correlation was not observed in eight out of the nine studies after adjusting for other variables.

This review is limited by the modest number of original papers included. Furthermore, four research originated from the same geographic region in the United States, specifically Maryland. The patient group varied in two out of the four research conducted in Maryland, but all four studies shared a similar technique. The four studies had limitations such as potential coding inaccuracies in administrative databases, incomplete patient mortality risk adjustment, validity and reliability concerns regarding nurse staffing measures, and uncontrolled effects of nursing skill-mix and pre- and post-ICU care, as acknowledged by the authors. Limitations in individual research, differences in definitions of nurse staffing metrics, and variances in sets of variables utilized in the analysis hindered the numerical integration of the results.

We examined the effects of nurse staffing by concentrating on a particular healthcare...
environment, such as critical care. Variability in nurse staffing between specializations is unavoidable due to the necessity for nursing care assignments to align with the patients' expectations. It is logical to standardize the unit environment to ensure that patient groups have identical nursing care needs across and within studies. ICU patients generally require one-on-one nursing due to the severity of their illnesses, resulting in high death rates. The correlation between nurse staffing levels and fatality rates is more easily identified in patients with life-threatening diseases. Aiken et al. (2003) found that for each additional patient assigned to a nurse, there was a 7% higher chance of dying within 30 days of admission to acute care settings. The average number of patients per nurse was five, and the overall mortality rate was 2.0%. The effect of having more patients per nurse is expected to be more significant in critical care units, where both nurse-to-patient ratio and patient survival rates are notably low compared to other acute care settings.

Limiting the unit type also aids in more precise measurement of exposure levels. Nurse-staffing decisions are typically determined at the unit level. Assessing nurse staffing on a hospital-wide scale, instead than per unit, may lack precision by not differentiating between bedside nurses who directly care for patients and other nurses in the organization. Efforts to address this issue in recent research may not be entirely adaptable, and combining workforce levels from different divisions could obscure the intended relationship.

Moreover, due to increased patient acuity levels, the majority of ICUs and other critical care units are often staffed by registered nurses with minimal support from nursing assistants (Blegen & Vaughn, 1998). Restricting the study to critical care settings where Registered Nurses (RNs) are predominantly employed will help minimize the possible influence of varying nurse competence levels.

Finally, data regarding case mix adjustment are frequently accessible in these environments. Controlling the influence of case mix is critical due to its significant impact on patient prognosis and personnel demands. Utilizing standardized tools like APACHE II or III (Knaus et al. 1985, 1991), Mortality Predictive Model (MPM) (Lemeshow et al. 1987), SAPS-II (Le Gall et al. 1993), or similar instruments enables researchers to conduct patient risk adjustment during analysis.

We did not uncover a reliable negative correlation between nurse staffing levels and mortality
in critical care, despite the numerous benefits. The reasons for this discovery can be explained by the methodological difficulties inherent in this type of research. Issues with reliability and validity in assessing nurse staffing levels, limited diversity in staffing metrics, insufficient advanced statistical techniques for a specific study design, and challenging confounding variables that are hard to quantify or control may have hindered the identification of a relationship, potentially discouraging further exploration of this research topic by researchers.

There is no universally accepted practical definition for nurse staffing level. NPR was the predominant metric utilized in the studies that were examined. Yet, the ratio, typically depicted as a fixed number, may not completely reflect the changing nature of nurse staffing conditions. NPR may vary between different work shifts and days of the week. The examined studies utilized several measures of Nighttime Peripheral Resistance (NPR), such as NPR during day or night shifts, averaged across all shifts, or assessing a decrease in NPR in the evening. Studying nurse staffing at night is important due to the heightened significance of nursing care when other staffing levels are reduced. The decision to use the NPR during the day as a relevant staffing metric was made due to the relationship found between NPR during the day and hospital length of stay (LOS) (Pronovost et al. 1999). Further research is needed to determine the most effective period for measuring nurse staffing levels.

Another issue regarding the nurse staffing assessment is the way this measure was addressed in the analysis. Four research categorized the NPR into two groups, while three studies treated NPR as a continuous variable. Dichotomization may result from limited variability in the measure and/or the absence of an odds-linear or linear relationship between various exposure levels and the outcome. A research by Person et al. (2004) supported the adoption of classified nurse staffing levels based on an unfulfilled linearity assumption. Establishing a specific threshold to differentiate between 'high' and 'low' staffing levels is subjective and there is no widely recommended value for this yet (Lang et al. 2004). Combining the NPR from many original categories into a smaller number of levels assumes that there is minimal variation among the combined categories in terms of their effect on mortality. Validating this assumption using the provided data would have ensured the suitability of the selected cut-off values.

With the exception of three research, the study durations were greater than 32 months, with a maximum of 5 years. Questioning the appropriateness of using a single fixed measure of nurse staffing level in a lengthy study is valid. Using an aggregated unit-level measure on individual
patients might lead to bias, referred to as the ecological fallacy. Aggregating data masks individual variances among patients in the unit. The only study that identified a distinct relationship between ICU staffing and mortality, even after accounting for other factors, was a single-center study that allocated staffing levels to each patient individually (Tarnow-Mordi et al. 2000).

Four out of five multi-centre studies that employed the patient as the unit of analysis applied multi-level hierarchical modeling or GEE approach in their analytical methods. Patients are likely grouped together in hospitals, hence it is advisable to use these analytical methods in all multi-center research to prevent artificially reducing variance estimates.

The validity of multivariate modeling relies on how well the chosen model aligns with the data. When using statistical modeling for analysis, it is important to report the adequacy of the chosen model's fit and the appropriateness of statistical assumptions. Only two research provided findings from such inquiries.

The impact of unmeasured and/or uncontrolled confounding factors should not be underestimated. Comparability among ICUs in multi-centre research needs to be ensured, specifically in terms of nurse staffing. It is important to address crucial differences in potential confounding factors that are linked to both nurse staffing and patient mortality during the analysis. The intensity of medical staffing could be a complicating element. This component was proven to have a standalone correlation with hospital mortality in ICU patients (Pronovost et al., 2002). If the relationship between high-intensity physician staffing and nurse staffing levels is being studied, it is important to control for potential confounding factors to accurately assess the link. If hospitals with high-intensity medical staffing had low nurse staffing levels and the analysis did not account for medical staffing factors, the relationship between nurse staffing and mortality could be inaccurately portrayed in the opposite direction. Furthermore, the influence of contributions from other staff members must not be overlooked. Collaboration across several disciplines in the treatment of very ill patients in intensive care units is standard in today's practice. Shortages of nurses may have been offset by increased ICU staffing from other healthcare professions including respiratory therapists and allied healthcare professionals. The extent of contribution or distribution of work among different disciplines is expected to differ depending on the unit. Quantifying the employment of experts other than nurses may be challenging, leading to a lack of measurement and control. The study that found a statistically
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significant independent correlation focused on mortality in relation to staffing levels beyond only nursing staff (Tarnow-Mordi 2000).

Another significant variable that needs to be accounted for is the patient's risk of mortality. Administrative databases did not provide very accurate measures for assessing the severity of patient problems. Hospitals with higher nurse-to-patient ratios may be where the most critically ill patients with a high risk of mortality are cared for. Without adequately accounting for patient risk, high-staffing ICUs may suggest increased mortality rates, even if the reality is the contrary. Only three out of the nine studies analyzed utilized risk-adjusted mortality calculated via a systematic scoring system. Other variables were obtained from administrative or project databases and then modified for use in multiple regression analysis. Even minor inaccuracies in measuring confounding variables can skew the connection in either direction, making risk adjustment using the crude measure of patient mortality risk a significant issue.

Moreover, since hospital mortality was the primary endpoint in all ICU studies analyzed, the medical care patients got outside the ICU could be an additional factor influencing the results. Some recognized that 30-day mortality is a common measure for hospital mortality, but in-hospital mortality was chosen due to its direct connection to the nursing care given during patients' hospitalization. The studies did not properly differentiate or consider the treatments/services that patients received both within and outside critical care facilities. Excluding ICU death as a patient outcome in ICU studies seems reasonable, as the decisions to discharge patients from the ICU significantly impact the result. If pre-ICU or post-ICU treatments/care varied between units and were linked to nurse staffing levels in a consistent manner across study sites, not considering these factors could have influenced the relationship.

Although we focused on nursing skill-mix difficulties in critical care settings, it is assumed that all nurses can offer quality care equally. The study analyzed the effect of RN : LPN ratio and LPN : patient ratio on patient mortality since the authors believed these characteristics could be important for their study population. The study showed a correlation between LPN staffing levels and hospital mortality that was separate from the influence of RN staffing levels. The strength of the connection decreased after accounting for other factors. The ratio of Registered Nurses to Licensed Practical Nurses was not statistically significant in any of the models presented by Person et al. in 2004. The nursing workforce consists of nurses with varying lengths of clinical experience. Diverse levels of experience are taken into account while
creating staff schedules. Thus, the lack of a statistically significant effect of nurse staffing levels on mortality may be due to the use of basic indicators for nurse staffing.

Historically, evaluation of results in critical care has mostly centered on mortality. Benefits of using mortality data include the availability of the date and its objective definition not influenced by societal factors. Underreporting or inaccurate reporting issues are improbable. Although other potential outcomes such as 'failure to rescue' and adverse events are believed to be more responsive to nurse staffing levels in specific patient groups (Unruh 2003), our analysis indicates that mortality may not be sufficiently responsive to reflect the influence of nurse staffing levels. It is crucial to establish patient outcome measures with strong definitions and practical data gathering methods in different facilities. Moreover, in addition to mortality and adverse events, it is important to investigate outcomes that demonstrate the beneficial effects of intensive nursing care in critical care settings (Brooks et al., 1995; Hayes et al., 2000; Black et al., 2001).

The little research on the relationship between nurse staffing and mortality may be due to methodological difficulties and insufficient resources allocated to such research in healthcare systems. Adequately organized research are urgently needed to address the quality of patient treatment from the perspective of nursing and other health care specialties' staffing. Randomized controlled trials and prospective multi-center cohort studies would be optimal if accurate and dependable measures of nurse staffing and related factors were defined, and if data were consistently gathered from all locations included. Meanwhile, well-executed single-center studies continue to be valuable. Our review only included one single-center trial. If these studies were carried out at several locations with diverse unit configurations in various countries, the collected evidence could be compelling. Accurate workload metrics including the quantity of nurse staffing, demand for nursing care, and nursing expertise will be crucial for next research. New measurements have been noted in recent investigations by Adomat & Hewison (2004), Junger et al. (2004), and Iapichino et al. (2005). More studies on the impact of nurse staffing levels are likely to be conducted in the future.

CONCLUSION
The evaluation highlighted methodological difficulties in the studies included, including issues with measuring nurse staffing levels, unaccounted for or inaccurately measured confounding factors, and probable insensitivity of the chosen outcome measure (mortality). Without
addressing these challenges and executing research with adequate scientific rigor, an impartial assessment of the impact of nurse staffing on patient outcomes remains elusive. Due to a worsening nursing shortage, many facilities may encounter reduced staffing levels in terms of coverage, licensure levels, and experience compared to previous standards. Staff and supervisors must engage in advance planning and meticulous outcome monitoring to guarantee patient safety. Healthcare managers and executives should compare staffing levels and nursing-sensitive outcomes, analyze recruitment and retention challenges, and create strategies to address the expected shortages in nursing personnel in the future.
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