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# Nurse Staffing and Healthcare Outcomes

## A Systematic Review of the International Research Evidence

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The relationship between quality of care and the cost of the nursing workforce is of concern to policymakers. This study assesses the evidence for a relationship between the nursing workforce and patient outcomes in the acute sector through a systematic review of international research produced since 1990 involving acute hospitals and adjusting for case mix. Twenty-two large studies of variable quality were included. They strongly suggest that higher nurse staffing and richer skill mix (especially of registered nurses) are associated with improved patient outcomes, although the effect size cannot be estimated reliably. The association appears to show diminishing marginal returns. **Key words:** *failure to rescue, mortality, outcomes, quality nursing care, research methods, skill mix, staffing, systematic review, workforce*

## BACKGROUND

Healthcare systems are struggling to control costs and improve the quality and safety of care. Given that a high proportion of healthcare expenditure is on staffing, particularly nursing, there is considerable interest in seeing how this resource contributes to patient outcomes. In some parts of the world, greater investment in qualified nurses is part of a strategy to improve quality of care, whereas in other areas policymakers are seeking to substitute qualified nursing workforce numbers with less expensive assistive staff. There is considerable research capable of informing this debate but it is often selectively quoted to support arguments. In this article, we report on a systematic review of the international research on the relationship between the nursing workforce (level and skill mix) and patient outcomes (including mortality, failure-to-rescue, and complications) in the acute sector and consider its relevance for policy.

## METHODS

We carried out a systematic review of the literature[1] and a policy analysis and conducted interviews with key researchers in the field in both the United States and the United Kingdom.

### Search strategy

The aim was to retrieve research on nurse staffing and healthcare outcomes published since 1990. We searched a combination of electronic databases, Internet, and organizational Web sites, and contacted researchers

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and other experts. The following electronic databases were searched in March 2004 from 1990: Medline, Cinahl, EMBASE, PsycINFO, HMIC (including DH Data, King's Fund, and HELMIS), SIGLE, Cochrane Library, British Nursing Index, and NLM Gateway Web of Knowledge. Relevant "grey" literature was identified (ie, produced by government, academics, or business in print and electronic formats, but not controlled by commercial publishers) by searching organizational Web sites such as the American Nurses Association, Agency for Healthcare Research and Quality, Australian Resource Centre for Healthcare Innovations, Audit Commission, UK Department of Health, International Association of Health Policy, Royal College of Nursing and World Health Organization.

Multiple terms are used internationally to describe qualified nurses and nursing support staff, so synonyms were retrieved by identifying key authors, selecting their articles using agreed criteria, and acquiring them to check their search terms and strategies. Search terms were adjusted to take into account those listed in the thesaurus of the databases searched. MeSH terms were used where possible.

### Inclusion and exclusion criteria

We included empirical research, published since 1990 in any language, on the relationship between nurse staffing and one or more of the following patient outcomes: mortality rate, complication rate (pneumonia, urinary tract infections, nosocomial infections, wound infections), failure-to-rescue, incidence of adverse events (falls, medication errors), length of stay, or patient satisfaction. Observational studies were included if they had adjusted for case mix and hospital characteristics. Purely qualitative studies were excluded, as were those undertaken in a single ward or unit.

### Study quality and assessment

For each relevant study, data were extracted systematically using a predesigned table to describe the type and feature of the workforce, the setting, the outcome(s), the methods used, the results found, the quality of the studies, and the limitations. One reviewer abstracted each study and a sample was checked.

### Analysis

Studies report different outcomes and use different measures of staffing and ways of summarizing the association between staffing and outcome. Because of the heterogeneity, we were not able to conduct a formal meta-analysis of the results.[1] Instead, we carried out a more qualitative synthesis to explore patterns in the data and possible explanations for inconsistencies such as study design, analysis, context, and setting.[2] To aid analysis and comparison, we attempted to impose a common measure of staffing level/skill mix. Some studies use *hours per patient day* (HPPD) as a staffing measure[3,4]—the average total number of patients in hospital divided by the total number of nursing hours of staff on duty. Where this includes only productive hours, it may be termed worked hours per patient day (WHPPD). We converted the results of studies that did not use HPPD to a common currency of *converted hours per patient day* (CHPPD) where possible.

Another commonly used measure is the *Nurse-to-patient ratio*—the number of patients for whom one nurse has direct responsibility at any one time. This ratio may relate to RNs alone or to RNs and LPN/LVNs, together known as "licensed nurses." Figures seldom include unlicensed assistive personnel. To convert a *nurse-to-patient ratio* to *hours per patient day*, the number of patients assigned to an RN is converted to a 24-hour day, so a 1:4 ratio becomes $24/4 = 6$ CHPPD. *Full-time equivalents*, the number of full-time employees, may or may not include staff on maternity/sick leave and may include clinical nurse specialists and managers without direct responsibility for patient care. One FTE is approximately equal to 2080 hours paid or 1920 worked after allowing for 4 weeks' annual leave. We have used the lower figure for

US studies, so the conversion is as follows: CHPPD = (FTEs × 1920)/(patient census × 365).

## RESULTS

A total of 8644 nonduplicate references were downloaded. The title and abstracts were then scanned for relevance and identified for retrieval using preagreed criteria. Four hundred twenty-two references were selected, retrieved, and recorded. After the application of the inclusion and exclusion criteria, 61 studies were identified, 38 of which dealt with acute general hospitals. Of these, 22 studies were multisite and attempted to adjust for case mix.[4–25]

Their results are summarized in Table 1 as 20 sets of studies because 4 articles are re/subanalyses of 2 studies.[10,11,24,25] Table 2 shows the mean and range of staffing levels in those large studies that have used measurements that can be expressed as CHPPD (column 5) although these should be treated with caution. Column 6 records the main associations between RN staffing and patient outcomes.

### Longitudinal studies

Mark et al[5] analyzed data submitted by 422 hospitals (in 11 US states) to the Healthcare Cost and Utilization Project National Inpatient Sample. In-hospital mortality, decubitus ulcers, pneumonia, and urinary tract infections were examined against staffing data submitted to the American Hospitals Association (AHA) database. Hospital characteristics were adjusted for technology, market data, and calendar year. Patient risk adjustment was carried out by means of Medstat's Disease Staging methodology and complications-of-care software. The longitudinal design took account of unknown variables by comparing hospitals with their own performance in previous years and allowing for "feedback effects" (such as high mortality in 1 year leading to increased staffing in the next). The authors found that an increase in RN staffing levels was associated with reduced rates of pneumonia, urinary tract infections decubitus ulcers, and mortality. Interestingly, the size of the effect decreased the greater the base level of staffing (Table 2).

In the only other risk-adjusted longitudinal study, Unruh explored the effect of RN and LPN staffing in 211 Pennsylvania hospitals from 1991 to 1997 to determine whether there was a correlation with complication rates.[6] During the 7 years, Mediqual-based patient acuity-adjusted nurse staffing levels fell, with a mean 3.3 licensed nurses per 1000 adjusted patient days (CHPPD = 6.9). Hospitals with higher RN and LPN (licensed nurse) staffing had lower incidences of atelectasis, decubitus ulcers, falls, and urinary tract infections.

### Cross-sectional studies

Some of the most influential work in the field has been carried out in the University of Pennsylvania. The 1988 study of Aiken et al reported a lower 30-day case mix adjusted mortality rates in 39 Magnet hospitals than in a matched sample of 195 non-Magnet hospitals.[7] The RN staffing was 1.6 per patient (CHPPD = 8.4) in Magnet hospitals as opposed to 1.2 for controls (CHPPD = 6.3) although the authors attributed this to differences in organizational culture.

Silber et al,[8] using data from 73,737 patients in 147 hospitals in 1991 and 1992, found that after adjusting for case mix and other factors, higher ratios of nurses per bed were associated with both lower mortality and lower failure-to-rescue (mortality amongst patients who developed complications). In a later study, using a data set consisting of all Medicare patients having general or orthopedic surgery between 1991 and 1994, they again found that hospitals with higher RN/bed ratios were consistently associated with reduced death and failure-to-rescue rates.[9]

Aiken et al[10] analyzed 30-day mortality and failure-to-rescue (defined here as 30-day mortality among rates patients with complications

**Table 1.** Summary of findings relating nurse staffing to mortality, failure to rescue, and common complications*

| Author(s) | Mortality | Failure to rescue | Urinary infection | Pneumonia | Wound infection | Decubitus ulcers | Medication errors | Falls | Complaints/ satisfaction |
|---|---|---|---|---|---|---|---|---|---|
| Aiken et al[7] | RNH | X | X | X | X | X | X | X | X |
| Aiken et al[10,11] | RNH; Degree% | RNH; Degree% | X | X | X | X | X | X | X |
| Blegen and Vaughan[18] | X | X | X | X | X | X | RN% | RN% | X |
| Bond[24,25] | RNH | X | X | X | X | X | RNH (-ve) | X | X |
| Cho[20] | X | X | NS | RNH; RN% | NS | TNH | X | NS | X |
| Jarman[15] | NS | X | X | X | X | X | X | X | X |
| Kovner and Gergen[16] | X | X | RNH | RNH | X | X | X | X | X |
| Kovner et al[17] | X | X | NS | RNH | X | X | X | X | X |
| Lichtig et al[19] | X | X | RN% | RNH | RN% | RN% | X | X | X |
| Manheim et al[23] | RNH | X | X | X | X | X | X | X | X |
| Mark et al[5] | RNH | X | RNH | RNH | X | RNH | X | X | X |
| McGillis et al[4] | X | X | NS | X | LN% | X | LN% | NS | X |
| Needleman[14] | NS | RN%;RNH | RN%;RNH | RN%;RNH | X | X | X | X | X |
| (Medical) | NS | RNH;LNH | RN%;LNH | RN%;LNH | X | X | X | X | X |
| (Surgical) | | | | | | | | | |
| Person[13] | RNH | X | X | X | X | X | X | X | X |
| Silber et al[8] | RNH | RNH | X | X | X | X | X | X | X |
| Silber et al[9] | RNH | RNH | X | X | X | X | X | X | X |
| Sovie and Jawad[22] | X | X | TNH | X | X | NS | X | RNH | RNH |
| Tourangeau[12] | RN% | X | X | X | X | X | X | X | X |
| Unruh[6] | X | X | LNH | NS | X | LNH | X | LNH | X |
| Whitman[21] | X | X | X | X | X | NS | TNH | LNH | X |

*RN% indicates proportion of RNs to total nursing staff; LN%, proportion of RNs + LPNs to all nursing staff; RNH, total RN hours or TEs per patient or per bed; LNH, total hours for RNs + LPNs (licensed nursing staff); TNH, total hours or FTEs from all nursing staff; Degree%, % of nurses with bachelor's degree; and NS, no statistically significant association.

**Table 2.** Nursing hours from reports yielding comparable data

| Author(s) | Reported staffing unit | Mean | Reported range | Mean† (range) CHPPD | Relationship of staffing to patient outcome |
|---|---|---|---|---|---|
| Aiken et al[7] | RNs per adjusted daily census | 1.6 (Magnet)<br>1.2 (controls) | NA | 8.4 (Magnet)<br>6.3 (controls) | Better mortality in Magnet hospitals. |
| Aiken et al[10,11] | RN: patient ratio,<br>Proportion of nurses with a bachelor's degree | | 1:4–1:8<br>0%–77% | (3–6) | Mortality increases by 7% for every patient added to caseload.<br>A 10% increase in the % of nurses with a bachelor's degree was associated with a 5% decrease in the likelihood of patients dying within 30 days of admission. |
| Blegen and Vaughan[18] | All hours per patient day and RN proportion | 8.6‡ | 5.7–18 | 8.3 | Improvements in rates of medication errors, patient falls, and cardiopulmonary arrests as RN hours increased.<br>Rate of medication errors decreased as RN proportion varied from 50% to 85% but beyond this figure the effect disappeared. |
| Cho[20] | RN HPPD | 6.3 | 4–8 | 6.3 | 8.9% decrease in pneumonia with 1 RN hour per patient day.<br>10% increase in RN proportion associated with a 9.5% decrease in pneumonia. |
| Kovner et al[17] | RN/adjusted patient day | 6.6§ | 4.7–8.1 | 6.2 | Rate of pneumonia dropped as RN hours and RN proportion increased. Increase of 1 RN HPPD resulted in an 8.9% decrease in pneumonia; 10% increase in RN proportion associated with a 9.5% decrease in pneumonia. |
| Mark et al[5] | RN FTE/100 patient days | 3.3 | 2.7–4.0 | 6.4<br>(5.1–8.9) | Staffing increase in poorest-staffed 25% of hospitals showed greatest improvement in patient outcomes. Increasing staffing in the best 25% of hospitals (mean 8.9 CHPPD) showed little change, and even some deterioration |
| Needleman et al[14] | RN HPPD | 7.8‖ | NA | 7.2 | Higher proportion of care provided by registered nurses and/or more RN HPPD correlated with a reduction in urinary tract infections, pneumonia, length of stay, upper gastrointestinal bleeding, shock, and failure-to-rescue, but not in mortality. |
| Person[13] | RNs per ADC | NA | 2.1–1.4 | (7.4–11.2) | Mortality for patients treated in high RN environments lower than that for patients treated in low RN environments |
| Silber et al[9] | RN/bed | NA | 0.7 – 1.7 | 6.3 (3.7–8.9) | Reduced failure-to-rescue rates at higher staffing levels |
| Unruh[6] | LN/1000 adjusted patient days | 3.3 | 3.1–3.6 | 6.9 | 10% increase in LNs would lead to an estimated 1.5% decrease in atelectasis, 2% reduction in pressure ulcers, 3% reduction in falls, and 1% reduction in urinary tract infections. |

*RN indicates registered nurse; LN, licensed nurse; CHHPD, converted hours per patient day, using 1920 hours per FTE and are approximations for purposes of comparison only; ADC, adjusted days of care; and NA, information not available.
†Figures relate to the staffing unit described in column 2.
‡HPPD calculated on 2000 hours per FTE.
‖HPPD calculated on 2080 hours per FTE.
§HPPD calculated on 2040 hours per FTE.

plus deaths without a recorded complication) in 232,342 patients who had undergone common general, orthopedic, and vascular surgical procedures in 168 acute hospitals. Nurse staffing data and nursing outcomes were derived from a survey of 50% of RNs registered and working in Pennsylvania in 1999. They reported a significant inverse relationship between nurse staffing and both mortality and failure-to-rescue, after controlling thoroughly for hospital and patient characteristics. However, because of the way the staffing data were collected, the nursing staff ratios derived at a hospital level may not apply to the units from which the patient data were collected. The methodology has since been repeated in England, Scotland, Canada, and Germany, and results are expected imminently.

Aiken et al later reanalyzed these data and also found that after adjusting for patient characteristics, hospital structural characteristics, and the staffing levels, the odds of mortality and failure-to-rescue after surgery were reduced in settings with a higher proportion of nurses educated to at least a baccalaureate degree (odds ratio = 0.95; 95% confidence interval [CI], 0.91–0.99).[11] As before, we do not know the educational level of the actual nurses who cared for the patients in the study.

Tourangeau et al investigated the effects of nursing-related variables on risk-adjusted 30-day mortality rates for hospitalized patients with a diagnosis of acute myocardial infarction, stroke, pneumonia, or septicaemia, using data from nearly 4000 nurses and 46,941 patients discharged from 75 hospitals in Ontario.[12] After adjusting for case mix and patient care need, they found that a richer skill mix of RNs was associated with lower 30-day mortality whereas the total amount of nurse staffing was not. Overall, a 10% increase in the proportion of RNs across all hospital types was associated with a 0.5% point reduction in mortality.

The study of 200,000 acute myocardial infarction patients in over 4000 US hospitals[13] used a sophisticated series of statistical models on the Cooperative Cardiovascular Project data set (collected from patient charts by trained reviewers) for case mix and hospital characteristics adjustment. They found that mortality for patients treated in high RN (low LPN) environments was lower than that for patients treated in low RN (high LPN) environments. However, as with the Pennsylvania studies, the staffing data related to the whole hospital, rather than the unit in which the patients were nursed.

Needleman et al used administrative data for 799 hospitals in 11 US states (representing 26% of all US hospitals) to examine the relationship between the amount of care provided by nurses at the hospital and various nurse-sensitive patient outcomes.[14] Among medical patients, a higher proportion of care provided by registered nurses and/or more RN hours per day correlated with a reduction in urinary tract infections, pneumonia, length of stay, upper gastrointestinal bleeding, shock, and failure-to-rescue (using a restricted set of complications). Among surgical patients, a higher proportion of RN hours and higher numbers of licensed nurse (RN + LPN) hours was strongly associated with a lower failure-to-rescue rate and more weakly, but still significantly, with lower rates of pneumonia and urinary tract infections. They found no association with mortality.

Canadian Nursing Staff Mix Outcomes study of McGillis et al examined the association between RNs, registered practical nurses (RPNs), and unlicensed staff and a range of patient outcomes in 19 Canadian teaching hospitals.[3,4] The study used hierarchical modeling and both staffing and patient outcomes data were collected at ward or unit level. They found that the lower the proportion of RN and RPNs on the unit and the less experienced the nurses, the higher the number of medication errors and wound infections. They also found a positive association between the proportion of regulated staff (RNs and RPNs) on the unit and patient activities of daily living and social functioning, which disappeared at 6-week follow-up.

Jarman analyzed the records of 8 million patients discharged from English public

hospitals during 1991–1995.[15] Inpatient mortality was inversely related to the number of hospital doctors per hospital bed, the ratio of doctors to population, and a high percentage of lower grade nursing assistants. This study, although similar in design to those described above from North America, suffers from the lack of good case mix data held routinely by the UK National Health Service.

Kovner and Gergen examined the relationship between nurse staffing levels and a range of postsurgical adverse events sensitive to nursing care in 506 US hospitals in 1993.[16] Using Medicare risk-adjustment and controlling for hospital characteristics, they reported a negative correlation between RN FTEs per adjusted inpatient day and urinary tract infection, pneumonia, thrombosis, and pulmonary compromise. However, when they repeated the analysis, using data in 530–570 hospitals for 1990 to 1996, they found a statistically significant association only for pneumonia.[17] The study was unusual in also examining doctor hours, uncovering a positive association between resident/intern HPPD and all adverse events except urinary tract infections.

Blegen and Vaughan studied 39 medical, surgical units and intensive care units in 11 hospitals, all of which routinely submitted adverse event data to the Institute for Quality Healthcare.[18] Using case-mix–adjusted data from 1993 to 1995, they found a significant inverse relationship between the proportion of RNs and medication administration errors and patient falls. As the RN proportion varied from 50% to 85%, the rate of medication errors decreased but above this, the effect disappeared.

Lichtig et al and Knauf et al reported the results of the American Nursing Association's[19,26] study in 3 US states, examining the outcomes related to all nursing staff per patient day, which ranged from 6.95 HPPD in New York in 1992 to 10.18 HPPD in California in 1994, with RN percentages ranging from 56.7 to 77.3, respectively. They found that, for California and New York, pressure ulcers, pneumonia, urinary tract infection, and postoperative infections were inversely significantly related to RN skill-mix and, to a lesser extent, higher nursing hours per acuity-adjusted patient day. The authors reported that the Massachusetts data were significantly poorer and no significant relationship emerged.[26] Cho et al in their study of 124,204 patients in 232 Californian hospitals also found that as RN hours and RN proportion increased, the rate of pneumonia dropped, but not pressure ulcers, UTIs, or wound infections.[20]

Whitman et al examined staffing and outcomes in 1999 in 95 patient care units across 10 hospitals in the Eastern United States.[21] Data for central line infection rates came from monthly surveillance and pressure ulcer data from a monthly systemwide, prevalence study conducted on all units. Medication errors and falls data were retrieved from hospital risk management reports. No statistical relationship was found between staffing, pressure ulcer rates, and rates of central line infection. In cardiac intermediate care units, higher hours worked per patient day was associated with fewer falls. Medication error rates were higher in CCU and noncardiac intermediate units when staffing levels were lower. The mean for hours worked per patient day (including the unit secretary and manager) in this study was said to be low (4 WHPPD for medical and surgical; 8.4–8.9 for intermediate care).

Sovie and Jawad[22] investigated both the impact of restructuring on the organization and delivery of patient care and that of nursing structure and processes on the incidence of falls, nosocomial infections, pressure ulcers, and urinary tract infections. Examining data from 29 university hospitals more than 2 years, they found that that increased RN hours worked per patient per day was associated with lower fall rates although these were "minimal" when the levels reached 6 RN HPPD. Higher patient satisfaction levels were seen when RN hours worked per patient day increased from 4–4.5 to the 5–6 hour range. Lower urinary tract infection rates were also associated with an overall rise in nurse staffing numbers.

Manheim et al, using Health Care Financing Administration (HCFA) data from 1987 in 3796 hospitals, found that as the percentage of board-certified doctors and the percentage or number of RNs per adjusted admission increased, so the mortality rates decreased.[23] Bond et al studied full-time staffing ratios per occupied bed, using HCFA and AHA data from 1992 in 3762 US hospitals, and found a negative correlation between the mortality rate and the number of RNs and a positive relationship with LPNs per occupied bed.[24] Using the same data in a subset of 1116 hospitals, Bond et al also explored medication errors from the national clinical pharmacy services database survey.[25] They found that as the number of RNs and the ratio of RNs to LPN/LVNs increased so did the number of medication errors although these calculations did not allow for the number of drugs administered.[25]

## DISCUSSION

This systematic review of research on the relationship between nursing staffing and patient outcomes in general acute settings identified 61 studies, 38 of which dealt with acute general hospitals and were published since 1990. Many of these studies were of poor quality, using data from only 1 unit or hospital or failing to control for case mix variations. The 22 studies discussed in this article were the most robust but are still of variable methodological quality using a range of designs and settings and measuring a variety of different staffing inputs and patient outcomes. Here we discuss the pattern of results and how these might be affected by study design and quality.

Ideally, one would look for rigorous randomized trials or quasi-experimental methods accompanied by rich qualitative organizational research to evaluate whether and how changes in the level of the nurse staffing influences patient outcomes. We did not find any such research. The majority of the research is cross-sectional, relying on the analysis of data from groups of hospitals or large public administrative data sets to identify correlations between one measure (eg, nurse staffing) and a second measure (eg, mortality). Although these studies are likely to be generalizable because of the size and representative nature of the patient data analyzed, they had weaknesses.

### Accuracy and completeness of staffing data

Many studies obtained staffing data from the AHA, which do not distinguish between RNs involved in direct care and those employed by the hospital in indirect or management roles. The distribution of RN roles in hospitals with similar AHA-recorded RN staffing levels may be different with some providing more direct patient care. Moreover, the AHA staffing data reflect paid hours and so overestimate productive hours. Finally, in many of the studies, the data on staffing is taken from the hospital as a whole[12,13] rather than accurately reflecting the staffing on the units/wards from which patient data were collected.[4] This may result in (probably random) error in the measurement of nurse staffing and a reduction in the estimated effect.

### Adjustment for confounding

Most of the large cross-sectional studies adjust for case mix by using data derived from administrative systems such as Mediqual or Medstat's disease staging. This is better than the rather poorer data Jarman acquired from the English NHS,[15] but not as good as those obtainable from clinical databases such as that collected as part of the Cooperative Cardiovascular Project.[13] The importance of adjustment is illustrated by results presented in the study of Aiken et al in surgical patients.[10] The unadjusted odds ratio of dying of a unit increase in the number of patients cared for per nurse was 1.14; after adjusting for patient case mix, it was 1.09 and fell further after adjustment for hospital characteristics to 1.07 (95% CI: 1.03–1.12). Not only does this show how confounding can result in an overestimation of the effect of staffing but also shows that the effect size is sufficiently small as to be due to

residual confounding. However, studies with better case mix adjustment such as Person[13] and Tourangeau[12] also showed significant associations between nurse staffing level and mortality. Therefore, it is unlikely that the reported associations are entirely due to confounding.

Studies also varied in their adjustment for hospital characteristics (eg, rural/urban, ownership, mergers, and capacity utilization, technology, teaching status, patient volume). Only McGillis[4] used a multilevel modelling approach for analyzing such hierarchical data. One major weakness in most of the studies is the omission of data about doctors. It is possible, for example, that hospitals with higher levels of nursing staff also have more and better qualified doctors. In the United Kingdom, for example, Jarman found that doctors were the most important professional group associated with reductions in mortality. Although most North American studies took hospital teaching status into account, only a few looked at doctors specifically and they found that the number of residents/interns,[16] the level of training of doctors,[10,11] and number[6] or percentage of board-certified subspecialists[23] contributed to explaining variations in patient outcomes. However, they all found that the effect of nurse staffing was over and above any association with medical staffing. Thus, although the estimates of the effect size of nurse input may be wrong, the effect itself is unlikely to be due to this omission.

In the absence of experimental research, which would be less susceptible to confounding than observational studies, the most robust design is longitudinal. If the effect of nurse staffing is real, patient outcomes should change in relation to variations in nurse staffing over time. Because hospitals can act as their own controls over time in longitudinal studies, attribution of causality is also easier. We identified 2 longitudinal studies both of which found that increases in RN input over time was correlated with reductions in the inpatient mortality rate[5] and patient complications (UTIs, pressure ulcers, and falls).[6]

Despite the variability in the quality of the studies, there is a consistent pattern of results. Nine large acute studies found a significant inverse relationship between RN staffing levels and mortality rates (Table 1).[5,7-10,12,13,23,24] Four studies also found negative associations between nurse staffing and failure to rescue (variably defined).[8,9,10,14] Only Jarman[15] in the United Kingdom failed to find a significant correlation between nursing numbers and any measure of mortality (including failure to rescue), although he did establish a positive relationship between low-grade nurses and mortality.

The pattern of association between the nursing workforce and complications is slightly less consistent. Seven of 8 studies showed a positive association between RN or LN hours or RN proportion and pneumonia.[5,14,16,17,19,20,22] Two thirds of all the studies that examined the following outcomes also found a link between nurse staffing and urinary tract infections,[5,6,14,16,19,22] decubitus ulcers,[5,6,19,20] falls,[6,18,21,22] and wound infections.[4,19] It is possible that this reflects the poorer reporting of patient complications other than death and pneumonia. There does not appear to be anything distinctive about the studies that did not find a relationship with these complications and they all found associations with at least some outcomes.

The possibility of publication bias has to be considered, especially with regard to the smaller studies, where there may be a tendency to publish selectively those studies that found a significant positive association. However, the estimates of association do not vary by study size and so this is unlikely to be important.[1]

## Skill mix

It appears from many of the studies that the relationship between nurse staffing and patient outcomes is associated more with RN staffing levels and the proportion of RNs in the total staff mix. In acute settings, total staffing and LPN staffing tend not to demonstrate a link with improved outcomes.

Needleman et al[14] found that high numbers of licensed practical/vocational nurses (LPN/LVNs) in the United States correlated with higher levels of complications. Unruh pointed out that this may be due to the tendency to use LPNs to replace RNs and so their numbers tend to be higher where RNs are lower.[6] In Canada, McGillis found that a mixture of RNs and aides gave better outcomes than when second-level practical nurses were included in the staffing mix.[4] This was also found in a UK prospective study using direct observation of nursing activity which found that the quality of nursing care improved as the ratio of qualified and further trained staff to patients increased and with increasing grade mix.[27]

## Causal mechanisms

The results of our review are consistent with, but extend, the findings of previous reviews.[28-31] There is a tendency amongst some authors to interpret the relationship as causal. Although this is more convincing in the longitudinal studies, other factors may be operating in cross-sectional studies such as nurses being attracted to hospitals with better outcomes or nurses favoring jobs in "better" areas. However, the weight of evidence from different studies by time and place and method is strongly suggestive.

Fundamental nursing care is often referred to as "basic" for much of what nurses do appears deceptively simple. However, it is during these "basic" tasks that a complex interaction occurs—nurses assess patients' physical and psychological status and patients talk to, and receive information from, nurses. This can be important in detecting early signs of clinical deterioration[32] or complications.[33] If the nursing resource is stretched because of contextual factors (geographical disposition, decreased skill mix, increased patient dependency, and unit activity) then the ability to provide proactive care, cope with the unpredictable, and maintain flexibility can be adversely affected.[34] Where RN ratios are lower, much of the frontline care may be given by less qualified and less empowered staff. In addition, noting deterioration does not of itself improve outcomes and, having decided that an intervention is needed, a nurse may need to persuade medical staff to attend the patient. This requires nurses to be able to present the case logically and confidently; prompt attendance by medical staff is more likely if the doctor called has respect for the nurse.

This may also explain why the English study[15] (and others that did not meet our entry criteria) found less evidence for an association between nurse staffing and mortality than those in North America. In the United States, there is more emphasis on formal assessment of the patient's condition by nurses. Nurses are often expected to undertake a full physical assessment of the patients for whom they are responsible at the commencement of each shift, including where appropriate, auscultation of the chest, not routinely practiced in the United Kingdom. The US hospitals also do not generally have the 24-hour cover by onsite doctors, as is the case in most acute facilities in the United Kingdom, a luxury that may diminish with the introduction of the European Working Time Directive and the consequent reduction in hours worked by junior medical staff.

Interestingly, 2 studies reported that the relationship between increasing nursing levels and improved outcomes tailed off at higher RN levels[5] or percentage[18] (see Table 2). Such a curvilinear relationship indicating diminishing marginal returns to increased RN levels and skill mix has more face validity than the linear relationship assumed in most studies and is of considerable policy importance. At higher RN levels, these staff probably increasingly carry out the work that could be equally well done by less qualified staff.

In the United States, the Californian Department of Health Services has set absolute minimum ratios for licensed nurses (RNs and licensed vocational nurses) at 1:6 (4 CHPPD), day and night for medical and surgical areas, although the introduction of the 1:5 (4.8 CHPPD) ratio has recently been postponed to

2008.[35] In Australia, the state of Victoria has recommended that RN ratios should be 1:4/5 (4.8–6 CHPPD) for day shifts in general medical and surgery, depending on the type of hospital. However, the research evidence presented here does not support a precise recommendation on staffing levels, and the evidence of diminishing returns implies that the cost-effectiveness of using nurse staffing as a quality improvement lever must fall as levels increase. More research is needed to investigate the resource implications alongside the impact on patient outcomes.

The findings of this review are particularly relevant to countries such as England that have low levels of RN staffing relative to the ratios reported here (around 1:10; 2.4 CHPPD in 1999). Proposals to dilute the skill mix by the introduction of assistive personnel[36] may be a false economy as the savings of reducing the RN staffing mix may be more than offset by the costs associated with complications and adverse events. McCue et al, analyzing longitudinal data from 1990 to 1995, concluded that although hospitals experienced increased operating costs when they raised RN staffing levels, there was no significant impact on profit margins.[37] Sovie and Jawad found that when the percentages of RNs rose from 40–50 to 60–70, costs per discharge fell by 3%.[22]

Future research to estimate these relationships needs now to move up a level and ideally should be large, longitudinal, and, where possible, experimental. Both staffing data and patient outcomes should be gathered at ward or departmental level. Because these data are structured in a hierarchical way, multilevel modeling techniques should be used.

Associated qualitative organizational research is important to try and improve our understanding of the causal mechanisms and elucidate what it is about the nursing work processes that affect patient outcomes, and how this varies by skill mix and experience. We must now move beyond the correlational studies in which the attribution of causality is difficult and which treat the nursing process as a "black box." Future research needs to elucidate the mechanisms through which nursing care affects outcomes, be more theoretically based,[38] and also consider the resource implications.

## CONCLUSIONS

Overall, there is accumulating evidence of a relationship between nurse staffing, especially higher skill mix, and patient outcomes. However, the estimates of the nurse staffing effects are likely to be unreliable. There is emerging evidence of a curvilinear relationship that suggests that the cost-effectiveness of using RN levels as a quality improvement tool will gradually become less cost-effective.

## REFERENCES


1. Centre for Reviews and Dissemination. *Undertaking Systematic Reviews of Research on Effectiveness.* York, Pa: University of York; 2001. CRD Report No. 4.
2. Mays N, Roberts E, Poppay J. Synthesising research evidence. In: Fulop N, Allen P, Clarke A, Black N, eds. *Studying Organization and Delivery of Health Services: Research Methods.* London: Routledge; 2000:188–220.
3. McGillis HL, Doran D, Baker GR, et al. *The Impact of Nursing Staff Mix Models and Organisational Change Strategies on Patient, System, and Nurse Outcomes.* Toronto, Ontario, Canada: University of Toronto; 2001.
4. McGillis H, Doran D, Pink G. Nurse staffing models, nursing hours, and patient safety outcomes. *J Nurs Admin.* 2004;34:41–45.
5. Mark BA, Harless DW, McCue M, Xu Y. A longitudinal examination of hospital registered nurse staffing and quality of care. *HSR.* 2004;39:279–301.
6. Unruh L. Licensed nurse staffing and adverse events in hospitals. *Med Care.* 2003;41:142–152.
7. Aiken LH, Smith HL, Lake ET. Lower medicare mortality among a set of hospitals known for good nursing care. *Med Care.* 1994;32:771–787.
8. Silber JH, Rosenbaum P, Ross R. Comparing the contributions of groups of predictors: which outcomes

vary with hospital rather than patient characteristics. *JASA.* 1995;90:7–18.

9. Silber JH, Kennedy SK, Even-Shoshan O, et al. Anesthesiologist direction and patient outcomes. *Anesthesiology*. 2000;93:152–163.
10. Aiken LH, Clarke SP, Sloane DM, Sochalski J, Silber JH. Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. *JAMA.* 2002;288:1987–1993.
11. Aiken LH, Clarke SP, Cheung RB, Sloane DM, Silber JH. Educational levels of hospital nurses and surgical patient mortality. *JAMA.* 2003;290:1617–1623.
12. Tourangeau AE, Giovannetti P, Tu JV, Wood M. Nursing-related determinants of 30-day mortality for hospitalized patients. *Can J Nurs Res.* 2002;33:71–88.
13. Person SD, Allison JJ, Kiefe CI, et al. Nurse staffing and mortality for medicare patients with acute myocardial infarction. *Med Care.* 2004;42:4–12.
14. Needleman J, Buerhaus P, Mattke S, Stewart M, Zelevinsky K. Nurse-staffing levels and the quality of care in hospitals. *NEJM.* 2002;346:1715–1722.
15. Jarman B, Gault S, Alves B, et al. Explaining differences in English hospital death rates using routinely collected data. *BMJ.* 1999;318:1515–1520.
16. Kovner C, Gergen PJ. Nurse staffing levels and adverse events following surgery in U.S. hospitals. *Image J Nurs Sch.* 1998;30:315–321.
17. Kovner C, Jones C, Zhan C, Gergen P, Basu J. Nurse staffing and post surgical adverse events: an analysis of administrative data from a sample of U.S. hospitals: 1990–1996. *HSR.* 2002;37:611–629.
18. Blegen MA, Vaughn T. A multisite study of nurse staffing and patient occurrences. *Nurs Econ.* 1998;16:196–203.
19. Lichtig LK, Knauf RA, Milholland DK. Some impacts of nursing on acute care outcomes. *JONA.* 1999;29:25–33.
20. Cho SH, Ketefian S, Barkauskas VH, Smith DG. The effects of nurse staffing on adverse events, morbidity, mortality, and medical costs. *Nurs Res.* 2003;52:71–79.
21. Whitman GR. The impact of staffing on patient outcomes across specialty units. *J Nurs Admin.* 2002;32:633–639.
22. Sovie MD, Jawad AF. Hospital restructuring and its impact on outcomes: nursing staff regulations are premature. *J Nurs Adm.* 2001;31:588–600.
23. Manheim LM, Feinglass J, Shortell SM, Hughes EF. Regional variation in medicare hospital mortality. *Inquiry.* 1992;29:55–66.
24. Bond CA, Raehl CL, Pitterle ME, Franke T. Healthcare professional staffing, hospital characteristics, and hospital mortality rates. *Pharmacotherapy.* 1999;19:130–138.
25. Bond CA, Raehl CL, Franke T. Medication errors in United States hospitals. *Pharmacotherapy.* 2001;21:1023–1036.
26. Knauf RA, Lichtig LK, Rison-McCoy R, Singer AD, Wozniak LM. *Implementing Nursing's Report Card: A Study of RN Staffing, Length of Stay and Patient Outcomes*. Washington, DC: American Nurses Publishing; 1997.
27. Carr-Hill R. The impact of nursing grade on the quality and outcome of nursing care. *Health Econ.* 1995;4:57–72.
28. Hickam DH, Severance S, Feldstein A, et al. *The Effect of Health Care Working Conditions on Patient Safety*. Rockville, Md: Agency for Healthcare Research and Quality; 2003.
29. Schultz MA, van Servellen G. A critical review of research on hospital mortality among medical-surgical and acute myocardial infarction patients. *Nurs Health Sci.* 2000;2:103–112.
30. Carr-Hill R, Currie L, Dixon P. *Skillmix in Secondary Care: SDO Scoping Exercise*. York, Pa: University of York, Centre for Health Economics; 2003.
31. Buchan J, Dal Poz M. Skill mix in the health care workforce: reviewing the evidence. *Bull World Health Organ*. 2002;80:575–580.
32. Franklin C, Mathew J. Developing strategies to prevent inhospital cardiac arrest: analyzing responses of physicians and nurses in the hours before the event. *Crit Care Med.* 1994;22:244–247.
33. Naughton C, Prowroznyk A, Feneck R. Reasons for prolonged hospital stays following heart surgery. *Br J Nurs.* 1999;8:1085–1087.
34. Ball C, McElligot M. Realising the potential of critical care nurses. *Intensive Crit Care Nurs.* 2003;19:226–238.
35. Rapaport L. State eases nurse staffing law until 2008 [Sacramento Bee online]. Available at: http://www.sacbee.com/content/news/medical/story/11326042p-12240753c.html. Accessed March 1, 2005.
36. Workforce Development Confederations' standing conference. *A Proposal to Develop a National Framework for Assistant Practitioners and Advanced Practitioners.* Greater Manchester, England: Workforce Development Confederation; 2003.
37. McCue M, Mark BA, Harless DW. Nurse staffing, quality, and financial performance. *J Health Care Finance.* 2003;29:54–76.
38. Sidani S, Doran DM, Mitchell PH. A theory-driven approach to evaluating quality of nursing care. *J Nurs Scholarsh*. 2004;36:60–65.