Improving nurse-to-patient staffing ratios as a cost-effective safety intervention

Rothberg M B, Abraham I, Lindenauer P K, Rose D N

Record Status
This is a critical abstract of an economic evaluation that meets the criteria for inclusion on NHS EED. Each abstract contains a brief summary of the methods, the results and conclusions followed by a detailed critical assessment on the reliability of the study and the conclusions drawn.

Health technology
The health technology studied was patient-to-nurse staffing ratios ranging from 8:1 to 4:1.

Type of intervention
Secondary prevention.

Economic study type
Cost-effectiveness analysis.

Study population
The hypothetical target population was implicitly hospitalised patients of unspecified condition.

Setting
The setting was secondary care. The economic study was carried out in the USA.

Dates to which data relate
The effectiveness and resource use data were derived from studies published in 2002. The price year was 2003.

Source of effectiveness data
The effectiveness data on the nurse staffing levels in reducing mortality were derived from a single study (Aiken et al. 2002, see 'Other Publications of Related Interest' below for bibliographic details). The impact on length of stay of additional nurse hours was derived from a large multi-state study (Needleman et al. 2002, see 'Other Publications of Related Interest' below for bibliographic details).

Effectiveness results
A staffing ratio of 5.3 patients per nurse was associated with a mean 30-day mortality rate of 2.0%. For each additional patient cared for by a nurse, the adjusted mortality rates increased by 7% over the range from 4 patients per nurse to 8 patients per nurse.

Clinical conclusions
Mortality rates decline with increased nurse staffing.

Modelling
The data, which were obtained from various sources, were combined in a model to produce a cost-effectiveness estimate. Sensitivity to its determining parameters was examined using Monte-Carlo simulations in which parameter
values were drawn from probability distribution functions that were assumed to be normally distributed. Further details about the model were not reported.

**Outcomes assessed in the review**
The model parameters obtained from the review were the mortality increase per 1 patient increase in patient-to-nurse ratio and the change in length of stay per additional registered nurse hour.

**Study designs and other criteria for inclusion in the review**
No details were reported.

**Sources searched to identify primary studies**
No details were reported.

**Criteria used to ensure the validity of primary studies**
No details were reported.

**Methods used to judge relevance and validity, and for extracting data**
No details were reported.

**Number of primary studies included**
It would appear that two studies have been used to derive the main model parameters.

**Methods of combining primary studies**
The mortality parameter was obtained from a single study. The change in length of stay per additional registered nurse hour, which has been interpreted as a proxy for effectiveness, was also derived from a single study. The parameter was then used to obtain length of stay for each of the patient-to-nurse ratios, although it was unclear how this was done.

**Investigation of differences between primary studies**
Not reported.

**Results of the review**
The mortality increase per 1 patient increase in the patient-to-nurse ratio was 1.07 (range: 1.02 - 1.12).

The change in length of stay per additional registered nurse hour was -0.09 (range: -0.05 - 0.13).

**Measure of benefits used in the economic analysis**
The health benefits were measured in lives saved.

**Direct costs**
The costs comprised a cost per hospital day (derived from other studies), with nursing reported separately using an hourly wage rate from the Bureau of Labour Statistics. The nursing costs were modelled as an inverse function of nursing intensity, with more nurses per patient resulting in fewer complications, shorter hospital stays, and reduced staff turnover costs. Marginal costs were incorporated in the modelling of savings as the reduced length of stay resulting from reductions in complication rates. The health care costs associated with morbidity and mortality were excluded. A
further analysis examined the impact of changes in the demand for nurses on wage rates. The costs were reported in 2003 US dollars. Given the short time horizon used in the study, discounting was not necessary. The quantities and the costs were entered into the model separately.

**Statistical analysis of costs**
See under the 'Sensitivity Analysis' section.

**Indirect Costs**
In line with the perspective adopted, the indirect costs were not included in the model.

**Currency**
US dollars ($).

**Sensitivity analysis**
One-way sensitivity analyses were performed. The parameters investigated were hourly nurse compensation, cost per hospital day, supply elasticity, relative risk of mortality, relative risk of nurse dissatisfaction, and the decrease in length of stay per nurse hour. In addition, a probabilistic sensitivity analysis was conducted in which all estimates were varied simultaneously.

**Estimated benefits used in the economic analysis**
The estimated benefits used in the economic analysis were reported only in incremental values. The incremental lives saved per 1,000 admissions from changing from 8 to 7 patients per nurse was 1.5, from 7 to 6 patients per nurse it was 1.4, from 6 to 5 patients per nurse it was 1.3, and from 5 to 4 patients per nurse it was 1.3.

In addition, the authors presented the percentage mortality rate and length of stay for each of the patient-to-nurse ratios.

**Cost results**
The costing results were reported for three viewpoints. One viewpoint was nursing costs only. A second was nursing costs plus savings from a reduction in the number of adverse events and consequent decreased length of stay. The third was the total costs, incorporating increased wages resulting from changes in the demand for nursing services.

Under the baseline case (8 patients per nurse), the nursing cost per patient was $525 per patient. With reductions in the number of patients per nurse (shown in parenthesis), the nursing costs per patient were $595 (7), $687 (6), $811 (5) and $990 (4). The incremental savings per patient as a result of savings from reduced length of stay were also presented.

The incorporation of additional demand pressures into nursing staff costs resulted in a nursing cost per patient of $1,073 at a patient-to-nurse ratio of 4 patients per nurse.

**Synthesis of costs and benefits**
The costs and benefits were synthesised as incremental cost-effectiveness ratios. The incremental cost per life saved increased from $45,900 for a reduction from 8 to 7 patients per nurse, to $207,700 for a reduction from 5 to 4 patients per nurse. After adjusting for reductions in complications and hence length of stay, the incremental costs per patient fell to $24,900 for a reduction from 8 to 7 patients per nurse and to $136,300 for a reduction from 5 to 4 patients per nurse. When the effect of increased demand was incorporated into the analysis, the incremental nursing cost per patient was $207,700 when reducing the number of patients per nurse from 5 to 4.

The cost-effectiveness estimates were most sensitive to the estimated effect of staffing on mortality, particularly at high staffing levels. As the estimated effect of staffing on mortality moved between extremes (from a relative risk of 1.02
per unit reduction in patients per nurse to a relative risk of 1.12), the cost per life saved fell from $449,000 to $84,000 when considering a change from 5 to 4 patients per nurse. The cost-effectiveness of low patient-to-nurse ratios was reported to improve with:

- reductions in nurse wages;
- increases in the cost of additional days spent in hospital;
- greater reductions in length of stay resulting from increased nurse staffing; and as wage elasticity increased.

None of these variables had as much impact as the effect of staffing on mortality. The impact that high patient-to-staff ratios had on turnover, and hence recruitment costs, was relatively small because the absolute effect of high turnover rates was small when staff levels were low.

The probabilistic sensitivity analysis revealed that the incremental cost per life-year saved when reducing the number of patients per nurse from 5 to 4 resulted in a cost per life-year saved of less than $316,000 in 95% of the replications. The 25th, 50th and 75th percentiles were at incremental costs per life-year saved of $101,000, $133,000 and $179,000, respectively.

Authors’ conclusions
As a patient safety intervention, patient-to-nurse ratios of 4:1 are reasonably cost-effective and in the range of other commonly accepted interventions.

CRD COMMENTARY - Selection of comparators
The various staffing levels used within the model were discussed in the light of current practice and recent recommendations. You should decide if the levels assessed represent valid comparators in your own setting.

Validity of estimate of measure of effectiveness
The paper contained insufficient information to enable a proper assessment of the validity of the measure of effectiveness. The only evidence provided appears to have been derived mainly from a single study (Aiken et al. 2002). Further, the impact of nurse time on length of stay seems to have been used as a proxy effectiveness measure, although this was not explicitly reported. This made it difficult to determine whether more than one study has been used for effectiveness. For this reason, this abstract has been written on the assumption that the change in length of stay was a proxy for the effectiveness of the changes in the patient-to-nurse ratio. Further details on how the studies were selected for inclusion would have enhanced the overall quality of the results obtained. As it is, it was difficult to ascertain if the best available evidence had been used in this study.

Validity of estimate of measure of benefit
No summary measure of benefit was derived. The reader is referred to the comments in the ‘Validity of estimate of measure of effectiveness’ field (above).

Validity of estimate of costs
Nursing staff remuneration was reported and modelled separately from the quantity of nursing staff. The hourly nursing pay rate was derived from a government source and was subjected to an appropriate sensitivity analysis. It was likely to be a valid representation of the costs. Other determinants of cost were not so secure (as the authors themselves acknowledged). The relationship between reduced length of stay and the number of nursing hours per patient was derived from a single study, although this is likely to reflect effectiveness as well as impact on resource costs. The saving in non-nursing hospital costs associated with reductions in length of stay was acknowledged to be difficult to assess, with inconsistencies in the literature. The authors adopted the position that reductions in length of stay resulted because higher nursing levels prevented expensive complications. Hence, the savings were not typical of marginal
reductions in length of stay over all patients, that is, reductions in length of stay do not save low cost marginal days but save high cost complications. This position is tenable, but calls for further research. The use of Monte-Carlo simulations to provide a probabilistic sensitivity analysis for the cost-effectiveness results was appropriate. The currency and price year were also appropriately reported.

Other issues
The authors reported that no other studies had addressed this important question. The question of whether their findings, based as they were on mortality following surgery, were applicable to other settings was reported as a possible weakness. The authors’ conclusion that “improved” nurse staffing levels are cost-effective should, perhaps, be restricted to surgery until more evidence on other settings is available.

Implications of the study
The authors called for further research in the form of a large randomised trial with an accompanying economic analysis.

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None stated.

Bibliographic details

PubMedID
16034292

Other publications of related interest

Indexing Status
Subject indexing assigned by NLM

MeSH
Cost-Benefit Analysis; Hospital Mortality; Humans; Length of Stay /economics; Nursing Staff, Hospital /economics /legislation & jurisprudence /statistics & numerical data; Quality of Health Care /economics; Safety

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