Effect of nurse-to-patient ratio in the intensive care unit on pulmonary complications and resource use after hepatectomy

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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 use of different nurse-to-patient ratios at night, in the intensive care unit (ICU), for the postoperative management of patients undergoing hepatic surgery. The ratios considered were:

- a 1:1 or 1:2 nurse-to-patient ratio ("more ICU nurses") versus
- a 1:3 or lower nurse-to-patient ratio ("fewer ICU nurses").

Type of intervention
Treatment.

Economic study type
Cost-effectiveness analysis.

Study population
The study population comprised all adult patients (age 18 years or over) who underwent hepatic resection as the primary procedure.

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

Dates to which data relate
The effectiveness and resource use data were collected retrospectively for the period 1994 to 1998. The price year was 1998.

Source of effectiveness data
The effectiveness evidence was derived from a single study.

Link between effectiveness and cost data
The costing was undertaken retrospectively on the same patient sample as that used for the effectiveness study.

Study sample
No sample size calculation was reported to have been performed in the planning phase of the study, in order to assure a certain power. A total of 569 consecutive patients who underwent hepatic resection as the primary procedure in 33 Maryland acute hospitals between 1994 and 1998 were identified from the non-confidential hospital discharge data.
available from the Maryland Health Service Costs Review Commission. In addition, an ICU survey, based on a validated questionnaire, was performed to identify the nurse-to-patient ratios in each centre. In total, 2% of patients from 2 centres appear to have been excluded from the effectiveness analysis as their hospitals did not respond to the ICU survey. The final study sample comprised 556 patients. Of these, 240 patients at 25 hospitals had fewer ICU nurses at night, while 316 patients in 8 hospitals had more ICU nurses at night. The study sample appears to have been representative of the Maryland study population since it considered all patients discharged from Maryland hospitals during the study period.

**Study design**
This was a multi-centred, retrospective cohort study that was based on 33 Maryland acute hospitals. The follow-up period appears to have been until discharge. As the authors reported, investigators blinded to the hospital's name, ICU characteristics and patients' outcomes performed the data extraction.

**Analysis of effectiveness**
The primary outcomes were:

- in-hospital mortality,
- pulmonary postoperative complications (i.e. aspiration, pulmonary insufficiency, pneumonia, and reintubation),
- non-pulmonary postoperative complications (i.e. septicaemia, postoperative infection, cardiac arrest, myocardial infarction, and acute renal failure), and
- the length of hospital stay.

Compared with patients in the "more ICU nurses” group, patients in the “fewer ICU nurses” group had a higher percentage of urgent surgery, were more often non white and more often had a hepatic lobectomy. They also had fewer myocardial infarctions as co-morbid history. Univariate and multivariate analyses were performed to adjust the primary outcomes for confounding factors associated with patient and hospital characteristics (age, gender, race, nature of admission, type of operation, co-morbid conditions, and hospital and surgeon volumes). The Romano-Charlson Comorbidity Index was used to adjust for co-morbid conditions.

**Effectiveness results**
The results of the univariate analysis showed mortality rates of 2.5% for patients with more ICU nurses and 7.1% for patients with fewer ICU nurses. However, the multivariate analysis found no statistically significant differences in mortality between the two groups.

The median length of stay was 8 days (interquartile range, IQR: 6 - 12) for patients with fewer ICU nurses and 7 days (IQR: 6 - 10) for patients with more ICU nurses. The authors reported that this difference was not significant.

According to the univariate analysis, patients with fewer nurses at night had an increased risk of reintubation (odds ratio 5.7, 95% confidence interval, CI: 2.4, 13.7; p<0.001) and pulmonary failure (odds ratio 3.6, 95% CI: 1.30, 10.1; p=0.006).

The authors reported that when the multivariate analysis was performed, only the higher risk of reintubation remained significantly associated with fewer nurses at night.

Differences for septicaemia, postoperative infection, cardiac arrest, myocardial infarction and acute renal failure were not significant between the two groups.

**Clinical conclusions**
The study showed a significant increase in postoperative pulmonary complications for patients receiving postoperative...
care in ICUs in which one nurse provided care for 3 or more ICU patients at night.

**Measure of benefits used in the economic analysis**
The authors did not develop a summary measure of benefit for use in the economic analysis. In effect, a cost-consequences analysis was carried out.

**Direct costs**
The direct costs included in the study appear to have been those of the hospital, although the authors did not specifically identify the different categories of costs actually included. The same database used in the effectiveness analysis was used to identify some of the resources used, and a published study also appears to have been consulted. However, no further cost sources were identified. The costs were adjusted for inflation using the Consumer Price Index for health care, and hospital-specific cost-to-charge ratios (averaged for the study period) were applied. The authors limited their report on the costs to the total extra cost of patients with fewer nurses above those with more nurses. The price year was identified. Discounting was not performed, although this was appropriate given the short time horizon considered for the cost estimation.

**Statistical analysis of costs**
The costs were treated stochastically. Univariate and multivariate analyses were also performed, to account for some of the confounding factors that could affect the cost analysis.

**Indirect Costs**
No indirect costs were included in the study.

**Currency**
US dollars ($).

**Sensitivity analysis**
No areas of uncertainty were identified or investigated.

**Estimated benefits used in the economic analysis**
See the 'Effectiveness Results' section.

**Cost results**
Patients with fewer ICU nurses had total costs that were 14% above the median cost (95% CI: 3, 23; p=0.007) in comparison with patients with more ICU nurses, or incurred an additional $1,248 (95% CI: 384 - 2,112; p=0.005).

**Synthesis of costs and benefits**
The costs and benefits were not combined because of the cost-consequences approach adopted.

**Authors’ conclusions**
Patients undergoing hepatic surgery, who received postoperative care in intensive care units (ICUs) where one nurse provided care for 3 or more patients at night, presented a significant increase in postoperative pulmonary complications and use of resources and, therefore, incurred higher direct hospital costs. This supported the hypothesis that ICU nurse-to-patient ratios can contribute directly to the patients’ outcomes.
CRD COMMENTARY - Selection of comparators
The rationale for the choice of the comparator was clear. It represents standard practice in the ICUs in Maryland hospitals, and reflects general practice in the USA. You should decide which of the nurse-to-patient ratios is most widely used in your own setting.

Validity of estimate of measure of effectiveness
This was a retrospective cohort study. It may have been appropriate, given the type of data collected for the effectiveness analysis, although it is likely to be subject to bias. The authors acknowledged several limitations of the study. First, the potential for bias in the accuracy of coding in administrative databases. Second, the fact that data on severity of illness were not prospectively collected or adjusted. Third, the fact that the validity of the ICU survey instrument might be a limitation in itself. Finally, an evaluation of nurse-to-patient ratios is a relatively simple measure of nurse staffing and hospitals could have changed their nurse-to-patient ratios either before or after the survey, thus introducing bias. Univariate and multivariate analyses were performed to account for confounding factors, which might have reduced the potential for selection bias. However, as the authors reported, some relevant confounding factors might not have been identified by the database. Although appropriate statistical analyses appear to have been undertaken on the effectiveness data, it is unclear whether the analysis was handled credibly, particularly as no power calculations were reported.

Validity of estimate of measure of benefit
Not applicable as a cost-consequences approach was adopted. Therefore, the reader is referred to the comments in the 'Validity of estimate of measure of effectiveness' field (above). The lack of a general summary measure of benefit means that it would be difficult to make comparisons with other studies and technologies, which would be necessary to help decision-makers in the allocation of resources.

Validity of estimate of costs
The perspective was unclear and, although it appears to have been that of the hospital, the fact that the cost categories considered for the cost estimation were not described makes it difficult to establish whether all the relevant hospital costs were included. The reporting of the cost estimation was rather limited. Statistical analyses were performed, and they appear to have been appropriate. In addition, adjustments were made so as to account for some relevant confounding factors. The authors limited their report on the costs to the total extra costs of the "fewer nurses" group over the "more nurses" group, but they did not report all the resource quantities separately from the costs. They also did not report the total costs associated with each of the ICU nursing alternatives. These facts introduced uncertainty into the reliability of the cost results and would hinder reflation exercises in other settings.

Other issues
The authors made extensive and detailed comparisons of their findings with those of prior research and stated that this study showed a similar trend. However, the issue of the generalisability of the study results was not addressed because of the limited reporting of the costs. The generalisability of the results has been reduced.

Implications of the study
The authors highlighted that efforts of hospital policy makers to reduce the costs by using such low nurse-to-patient ratios (e.g. 1:3 or 1:4) may be counterproductive, resulting in increased morbidity among patients and increased health care costs, as shown by the results of this study. According to the authors, these results supported a relatively straightforward change in health policy (i.e. instituting a nurse-to-patient ratio of 1:1 or 1:2 at night), which is practically achievable and would most likely improve both clinical and economic outcomes for postoperative patients. They stated that further research is needed to evaluate how specific characteristics and processes of nursing care further affect clinical and economic outcomes for high-risk surgical patients.

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Other publications of related interest


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