The cost effectiveness of anesthesia workforce models: a simulation approach using decision-analysis modelling

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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 study compared five alternative anaesthesia workforce scenarios. The skill mix ranged from physician-intensive to nurse-intensive practice.

Type of intervention
Treatment.

Economic study type
The study reported a cost-effectiveness analysis from the perspective of the payer.

Study population
The study cohort comprised 24,970 patients, aged over 12 years of age, who received anaesthesia between February 1997 and April 1999 at a teaching hospital (Strong Memorial Hospital, University of Rochester School of Medicine and Dentistry). The patients were initially divided into high-, intermediate- and low-risk categories, then further subdivided in accordance with their insurance coverage. The patient inclusion and exclusion criteria were unclear.

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

Dates to which data relate
The study used data from trials published between 1980 and 1992. The cost data and demographics were obtained from patients receiving anaesthesia between February 1997 and April 1999. The cost year was 1998.

Source of effectiveness data
The effectiveness data were obtained from a review and synthesis of previous studies. Due to the absence of outcome studies comparing mortality as a function of anaesthesia provider, the author also developed a set of baseline assumptions from the available literature.

Modelling
Decision-analysis modelling was used to compare the incremental cost-effectiveness of alternative delivery systems for anaesthesia. The analysis included a decision tree model and a Markov sub-tree.

Outcomes assessed in the review
The outcomes assessed in the review were the primary and secondary operative and post-operative mortality rates. Adjustments were made for the skill mix of the staffing scenario and the risk-category of the patients.
Study designs and other criteria for inclusion in the review
The data were obtained from the “Confidential Inquiry into Perioperative Death”, a retrospective review, a prospective study, a published survey, and a cohort study conducted in Strong Memorial Hospital. No specific inclusion and exclusion criteria were used to select the studies. There were no randomised controlled trials evaluating the outcome as a function of provider mix.

Sources searched to identify primary studies
The author did not report the sources searched, or the search strategy used to identify the studies for the data synthesis.

Criteria used to ensure the validity of primary studies
The author did not report the criteria used to ensure the validity of the studies included in the review.

Methods used to judge relevance and validity, and for extracting data
The author did not report the methods used to judge the relevance or validity of the data, or to extract the data.

Number of primary studies included
Six published studies and one cohort study were included in the review.

Methods of combining primary studies
The author did not describe the method used to combine the data from the primary studies.

Investigation of differences between primary studies
The author did not report whether there were any differences in the estimates of probability of events between the studies.

Results of the review
The estimates for the model were as follows.

The primary mortality rate was 1 in 185,000 (range: 2 in 100,000 - 1 in 1,000,000).

The skill mix adjustment factors for primary mortality rate were: 1 for physicians working alone, 5 (range: 2.5 - 10) for CRNAs working alone, 1 for an ACT with a physician to CRNA ratio of 1:2, 1 for an ACT with a ratio of 1:4, and 2.5 (range: 1.25 - 5) for an ACT with a ratio of 1:8.

The risk category adjustment factors for primary mortality rate were 10 for high-risk patients, 1 for intermediate-risk patients, and 0.1 for low-risk patients.

The secondary mortality rate was 7.4 in 10,000 (range: 1 in 10,000 - 50 in 10,000).

The skill mix adjustment factors for secondary mortality rate were: 1 for physicians working alone, 5 (range: 2.5 - 10) for CRNAs working alone, 1 for an ACT with a physician to CRNA ratio of 1:2, 1 for an ACT with a ratio of 1:4, and 2.5 (range: 1.25 - 5) for an ACT with a ratio of 1:8.

The risk category adjustment factors for secondary mortality rate were 10 for high-risk patients, 1 for intermediate-risk patients, and 0.1 for low-risk patients.
Methods used to derive estimates of effectiveness
In the absence of outcome studies comparing mortality as a function of anaesthesia provider, the author developed a number of baseline assumptions using the limited outcome data from the available literature.

Estimates of effectiveness and key assumptions
The following baseline assumptions were included in the model.

1. Patients treated by CRNAs working alone would have twice the mortality of those treated by a non board-certified anaesthesiologist. All anaesthesiologists in the model were board-certified.

2. Patients treated by CRNAs working alone would have a mortality rate 5 times that of patients treated by a solo anaesthesiologist, or by ACTs with physician to CRNA ratios of 1:2 or 1:4.

3. Patients treated by ACTs with a physician to CRNA ratio of 1:8 would have a mortality 2.5 times that of patients treated by solo anaesthesiologists, because of the nominal nature of physician supervision.

4. Patients treated by ACTs with a physician to CRNA ratio of 1:2 or 1:4 would have outcomes equivalent to patients treated by physicians working alone. This was based on the premise that the advantage of physician-only anaesthesia was offset by the presence of "two sets of eyes" in an ACT.

Measure of benefits used in the economic analysis
The measure of benefit used in the analysis was the number of years-of-life saved (YLS).

Direct costs
The direct costs of the labour required for anaesthesia provision were the only costs included in the model. The direct costs were reported as a function of the number of anaesthesia units, the type of insurance coverage, the dollar charge per unit, and the provider mix. The anaesthesia cost was calculated and subsequently adjusted for the skill mix. The costs per anaesthesia unit were assumed to be $34 (range: 17 - 68) for Blue Cross/Blue Shield, $17 (range: 8.5 - 34) for Medicare, $5 (range: 2.5 - 10) for Medicaid, and $34 (range: 17 - 68) for "other". The cost adjustment factors were 1 for physicians working alone, 0.65 for CRNAs working alone, 1 for an ACT with a physician to CRNA ratio of 1:2, 0.75 for an ACT with a ratio of 1:4, and 0.625 for an ACT with a ratio of 1:8. The future YLS were discounted at a rate of 5% per annum (range: 2.5 - 10).

Statistical analysis of costs
No statistical analysis of costs was reported.

Indirect Costs
The indirect costs were not included in the model.

Currency
US dollars ($). No currency conversions were reported.

Sensitivity analysis
A one-way sensitivity analysis was used to explore the effects of varying the baseline assumptions used in the model. The following parameters were analysed: outcome adjustment factor, primary mortality rate, secondary mortality rate, the proportion of high-risk patients, the proportion of Medicare patients, the dollar cost per unit, and the discount rate. The analysis was applied to all three ACTs and the physician-intensive models.
Estimated benefits used in the economic analysis
The baseline values of effectiveness, in terms of mortality rate, were estimated for each skill mix. These were:

- 19.0 in 10,000 for the nurse-intensive model,
- 8.10 in 10,000 for the third-team model,
- 7.39 in 10,000 for the second-team model,
- 7.39 in 10,000 for the first-team model, and
- 7.39 in 10,000 for the physician-intensive model.

Cost results
The cost of each intervention was not reported.

Synthesis of costs and benefits
The incremental cost-effectiveness of the third-team model versus the nurse-intensive model was $4,900 per YLS. The incremental cost-effectiveness of the second-team versus the third-team model was $31,000 per YLS. The second-team model dominated both the first-team and physician-intensive models because all three yielded equivalent outcomes, but the second-team was the least expensive.

Authors' conclusions
There were three main conclusions.

1. A physician-intensive model, in which intermediate- and low-risk patients are anaesthetised by the anaesthesiologists working alone, may not be cost-effective.

2. An anaesthesia care team (ACT) approach with a physician to certified registered nurse anaesthetist (CRNA) ratio of 1:2 appeared to be cost-effective for intermediate-risk patients, when compared with staffing models in which the CRNAs worked independently.

3. Medical supervision of CRNAs caring for low-risk patients was also cost-effective when the CRNA to physician ratio was 8:1.

The findings of the study favoured a staffing model that combined both physician and ACT approaches.

CRD COMMENTARY - Selection of comparators
The study compared five possible staffing and skill mix scenarios for the provision of anaesthesia. The author reported that there was debate and uncertainty on the most appropriate method to be used. You should decide if any or all of these comparators represent current practise in your own setting.

Validity of estimate of measure of effectiveness
The author stated that a review of the literature had been undertaken, but it was unclear if the review was conducted in a systematic way to identify relevant research and minimise bias. In addition, no details were provided of the methods used to judge the relevance and validity of the studies, and to extract the data. It was reported, however, that the literature review provided limited outcome data and that there was an absence of outcome studies comparing mortality as a function of anaesthesia provider. The author, therefore, opted to develop a set of baseline assumptions that were justified by the relevant medical literature. The estimates were investigated using sensitivity analyses with appropriate ranges.
Validity of estimate of measure of benefit
The author used the number of life-years gained as the measure of benefit. This was an appropriate measure of the mortality consequences of anaesthesia, although it did not capture the morbidity consequences of short- or long-term disability or other morbidity, which may result from alternative providers of anaesthesia.

Validity of estimate of costs
The author stated that it was assumed that drug and material costs would be independent of the provider mix, and therefore, only labour costs were included in the model. As a result, the cost-effectiveness of the staffing scenarios may have been underestimated. In addition, the staffing scenarios themselves may affected other resources used, such as the length of operating or recovery room time, or additional therapy for adverse events resulting from anaesthesia. This may have also resulted in an underestimation of the costs for some or all of the strategies, and thus affected the conclusions of the analysis. The authors did not report sufficient data to assess the implications of this. You should decide if the omission of these costs is likely to have an impact in your own setting. The costs and quantities were reported separately.

The resource use quantities were taken from a cohort study of approximately 25,000 participant, performed in a teaching hospital. The unit costs were also taken from this study and were categorised according to insurance coverage.

Other issues
The authors did not compare their findings with those from other studies, as there were no relevant studies available. The issue of generalisability to other settings was not addressed explicitly. However, it was suggested that the cost-effectiveness analysis provides an ideal framework for the discussion of the relative merits of alternative staffing scenarios in anaesthesia.

The study considered a range of anaesthesia providers across three risk categories of patients, and this was reflected in the author's conclusions.

The author reported a number of limitations to the study. The most significant of these was the absence of reliable data on anaesthesia outcomes, as a function of skill mix, for the decision analysis. Another limitation was the problem of defining under what set of conditions anaesthesia “contributes” to mortality. Finally, the model limited the outcomes to life or death, rather than assessing the significant morbidity resulting from anaesthesia. The study reported that an ACT approach with a physician to CRNA ratio of 1:2 was the preferred staffing scenario for intermediate-risk patients. Although medical direction of CRNAs caring for low-risk patients was cost-effective, the small improvement in outcome associated with increasing the physician to CRNA ratio from 1:8 to 1:4 may not be justified by the additional cost.

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