A cost-effectiveness analysis of reducing ventilator-associated pneumonia at a Danish ICU with ventilator bundle
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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.

CRD summary
The objective was to assess the cost-effectiveness of implementing patient safety measures (a ventilator bundle) to reduce ventilator-associated pneumonia, in the intensive care unit. The authors concluded that the implementation of a ventilator bundle could be cost-effective in their setting. The uncertainty around the clinical inputs for the model makes the conclusions reached by the authors highly uncertain.

Type of economic evaluation
Cost-effectiveness analysis

Study objective
The objective was to assess the cost-effectiveness of implementing patient safety measures (ventilator bundle), to reduce ventilator-associated pneumonia, in the intensive care unit.

Interventions
The ventilator bundle had five elements that were not included in the standard procedures to prevent ventilator-associated pneumonia. The five elements were: elevation of the head; a sedation protocol; an extubation protocol; oral decontamination; and prevention of deep vein thrombosis. This was compared with the standard procedures, in Denmark.

Location/setting
Denmark/in-patient care.

Methods
Analytical approach:
A decision-tree model was used to assess the potential effects and costs of implementing a ventilator bundle, compared with standard procedures. The model was evaluated over the short term. The authors reported that the perspective was that of the hospital.

Effectiveness data:
The authors carried out a systematic review of the literature in PubMed and The Cochrane Library. The end date for the search was 25 May 2011, and only studies published in the previous 10 years were considered. The review’s inclusion criteria and methods were reported. All studies were reviewed by the four authors, and a panel of experts. Ten studies met the inclusion criteria. Two of these were deemed suitable for the estimation of pneumonia incidence – a prospective intervention study and a non-randomised trial, with a historical control. Mortality was from a prospective cohort study; and the length of stay was from a retrospective matched-cohort study.

Monetary benefit and utility valuations:
None.

Measure of benefit:
The summary measures of benefit were the incidence of ventilator-associated pneumonia, and deaths.

Cost data:
The direct costs were those of treatment for deep vein thrombosis and ventilator-associated pneumonia, and the elements of the ventilator bundle, including sedation administration and wake-up, extubation, elevation of head, administration of oral decontamination, prevention of deep vein thrombosis, time of physician and nurse, and education. The resource use and costs were from a costing study, in an intensive care unit, in Denmark, in which physicians and nurses recorded their time spent on each intervention. The resource use and unit costs were presented separately. The price year was 2010, and all costs were converted from Danish kroner to Euros (EUR).

**Analysis of uncertainty:**
One-way sensitivity analyses were undertaken to identify the key variables in the model. A probabilistic sensitivity analysis was performed by fitting probability distributions for each model parameter and running 1,000 Monte Carlo simulations. The results were presented in a cost-effectiveness acceptability curve. Best- and worst-case scenarios were investigated by varying all the inputs by ±25%. The results were presented as confidence intervals.

**Results**
The total costs of treating a cohort of 140 patients were EUR 1,893,789 with the ventilator bundle and EUR 1,891,979 with standard procedures.

The total cases of ventilator-associated pneumonia, in 140 patients, were three (CI four to two – worst to best case) with the ventilator bundle, and eight (CI 10 to six) with standard procedures.

The total deaths, in 140 patients, were 45 (CI 56 to 34) with the ventilator bundle, and 46 (CI 56 to 35) with standard procedures.

Compared with standard procedures, the ventilator bundle was associated with an additional cost per ventilator-associated pneumonia case prevented of EUR 4,451 (CI 910 to 11,333), or an additional cost per death prevented of EUR 31,792 (CI 9,032 to 80,949).

At a cost-effectiveness threshold of EUR 20,000 per death or ventilator-associated pneumonia case prevented, the ventilator bundle was cost-effective in over 50% of simulations per death averted, or over 80% of simulations per case prevented.

**Authors' conclusions**
The authors concluded that the implementation of a ventilator bundle could be cost-effective, in their setting.

**CRD commentary**
**Interventions:**
The additional components of the intervention were reported clearly and in detail, but the standard procedures were not outlined in the same detail.

**Effectiveness/benefits:**
The clinical and effectiveness data were identified by a review of the clinical literature. Limited details of the review were presented, but it is likely to have identified the main evidence from the past decade (which was an inclusion criterion). What was not clear is how the four studies that informed the model parameters were selected from the 10 that met the inclusion criteria. In general, the rationale or logic behind the selection was not reported and in some cases, such as mortality, the one study with a statistically significant difference was selected. This ad hoc selection of the evidence makes the model inputs highly uncertain. As highlighted by the authors, the effect measures were not derived from studies evaluating the five components, but from studies that evaluated one or two of the components. It is difficult to be sure whether this would over- or under-estimate the effects, but it is more likely to have under-estimated them.

**Costs:**
The perspective was explicitly reported to be that of the hospital, and for this perspective, all the relevant costs appear to have been included. The resource use was from a costing study, performed in a Danish hospital, using physicians and nurses who delivered the study interventions. The resource use and unit costs were presented separately, aiding transfer to other settings.
Analysis and results:
The cost and outcome information was synthesised using a decision-tree model. The details of the model structure were provided, including a diagram. The impact of uncertainty on the results was tested, using probabilistic sensitivity analysis. One limitation of the study was the narrow measure of health benefit, which restricts comparisons with other interventions for other diseases, and makes it difficult to judge whether the intervention was cost-effective. Despite the use of a systematic review, the subsequent ad hoc selection of the included studies raises concerns about the reliability of the model inputs.

Concluding remarks:
The uncertainty around the clinical inputs for the model makes the conclusions reached by the authors highly uncertain.

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