Impact of a program of intensive surveillance and interventions targeting ventilated patients in the reduction of ventilator-associated pneumonia and its cost-effectiveness

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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 a new programme consisting of intensive surveillance and preventive and intervention strategies to the old management strategy of ventilated patients in intensive care units (ICUs). Interventions implemented comprised: elevation of the head of the bed, use of sterile water, replacement of stopcocks with enteral valves for nasogastric feeding tubes and prolongation of the changing of in-line suction catheters from 24 hours to an as-needed basis.

Type of intervention
Primary prevention.

Economic study type
Cost-effectiveness analysis.

Study population
The study population comprised adult patients who were ventilated for more than 48 hours in medical and surgical ICUs. No further inclusion or exclusion criteria were reported.

Setting
The setting was a tertiary-care teaching hospital (University of Massachusetts Medical Center). The economic study was carried out in the USA.

Dates to which data relate
The effectiveness data were collected between January 1997 and December 1998. Cost data were reported for the years 1997 and 1998.

Source of effectiveness data
Effectiveness data were derived from a single study.

Link between effectiveness and cost data
Costing was carried out prospectively on the same patient sample as that used in the effectiveness analysis.

Study sample
Power calculations, using the PC-SIZE Consultant power analysis program, showed that the number of patients who received ventilation in the surgical and medical ICUs in the authors' setting per year (around 300 and 600 respectively) was adequate for detecting a 10% or more change in the number of ventilated patients and a 5% or more change in device utilisation with more than 90% power. All adult patients admitted to the 16-bed medical and 7-bed surgical ICUs
from January 1997 through December 1998, who were ventilated for more than 48 hours, were included in the study. Ultimately, a total of 153 ventilated patients in the surgical ICU (74 in 1997 and 79 in 1998) and a total of 409 ventilated patients in the medical ICU (212 in 997 and 197 in 1998) were included in the study.

**Study design**
The analysis was based on a prospective observational study in which the interventions were introduced at different stages over a period of 2 years. The house staff and the ICU attending physicians were not aware of the implementation of the programme. Hence, the diagnosis of pneumonia is not likely to have been influenced by knowledge of the interventions. Data were collected for two years and each patient was followed-up during ventilation and for 48 hours after extubation.

**Analysis of effectiveness**
The primary outcomes used in the analysis were the VAP rate (calculated as the number of cases per 1,000 ventilator-days) and the device utilisation ratio (number of days devices were used to patient-days). The two outcomes were compared with the pooled mean data of the National Nosocomial Infections Surveillance System (old management strategy). The population was different at each stage of the study, which may explain why population characteristics were not compared in the paper.

**Effectiveness results**
In the surgical ICU the overall VAP rate was 45.1 per 1,000 ventilator-days in 1997 and 27.9 per 1,000 ventilator-days in 1998, resulting in a reduction of 17.2 per 1,000 ventilator days (incidence rate difference, 17.2; 95% confidence interval (CI): 2.85 - 31.56).

In the medical ICU the overall VAP rate was 22.4 per 1,000 ventilator-days in 1997 and 11.6 per 1,000 ventilator-days in 1998, resulting in a reduction of 10.8 per 1,000 ventilator-days (incidence rate difference, 10.8; 95% CI: 4.65 -16.91).

A reduction in the VAP rate was observed when the heads of the beds were elevated (when not contraindicated), when sterile water for enteral feeding and one-way enteral valves were introduced, and when new beds that elevated more easily were purchased.

There was a further reduction in the VAP rate when the changing of the in-line suction catheters was prolonged from 24 to 72 hours.

The authors did not provide any justification for not recording the VAP rates when the in-line suction catheters were changed as needed.

**Clinical conclusions**
The authors concluded that the rates of ventilator-associated pneumonia decreased after the implementation of the programme (intensive surveillance and interventions) and there was a progressive reduction as each intervention was introduced.

**Measure of benefits used in the economic analysis**
No summary measure of health benefit was used in the economic analysis and therefore the study was, in effect, a cost-consequences analysis. The authors reported net savings. The reader is referred to "Direct Costs" for further details.

**Direct costs**
Hospital costs were calculated in the study. These included the cost of VAP in medical and surgical ICU, the cost of in-line suction catheters and the cost of enteral valves. It was unclear whether overhead and capital costs were included.
Unit costs were not reported and quantities were reported only for the number of VAPs. Discounting was not necessary as the mean length of stay ranged from 8 to 9.1 days. The average cost of VAP was derived from the literature. Quantity data were derived from the effectiveness study. Costs were reported for the price years 1997 and 1998 respectively. No adjustments appear to have been made in order to have a single price year. Costs savings resulting from time saved by the respiratory therapists due to fewer in-line suction catheter changes were not included, but omission of these costs was not justified.

**Statistical analysis of costs**
Costs were treated deterministically.

**Indirect Costs**
No indirect costs were included.

**Currency**
US dollars ($).

**Sensitivity analysis**
No sensitivity analysis was performed.

**Estimated benefits used in the economic analysis**
Please refer to the effectiveness results reported earlier.

**Cost results**
The net savings were calculated to be $349,899. The total costs of each intervention were not reported.

**Synthesis of costs and benefits**
Not combined.

**Authors’ conclusions**
The authors concluded that the programme appeared to be cost-effective.

**CRD COMMENTARY - Selection of comparators**
An experts’ team in the authors setting chose the interventions implemented, but no explicit justification for the choices was provided. The comparator used appeared to represent standard practice in the authors’ setting. You should decide if this is a widely used health technology in your own setting.

**Validity of estimate of measure of effectiveness**
The analysis was based on a prospective observational study with different interventions introduced over time. This design does not help to reduce potential systematic biases between study groups that may affect the results obtained. Moreover, the study lacked a contemporaneous control group. The characteristics of the patient groups were not discussed making it impossible to comment on possible confounding factors. As the authors reported the characteristics of the study patients may have changed over time and influenced the rates of VAP, but such changes were not taken into account. The study sample seems to have been representative of the study population as it included adult patients ventilated for more than 48 hours in the ICUs.
Validity of estimate of measure of benefit
The authors did not derive a summary measure of health benefit. The study was therefore a cost-consequences analysis.

Validity of estimate of costs
The study perspective adopted was not explicitly stated by the authors, but it may have been that of a single provider. The use of summary costs makes it impossible to know whether, for example, overhead or capital costs were included. The sources of costs were only reported for the cost of VAPs. These costs were derived from the literature and were not appropriately adjusted. Resources used were derived from the effectiveness study and device utilization was appropriately evaluated using Fisher’s exact test. Costs were treated deterministically and no sensitivity analysis was conducted, which may limit the generalisability of the results. Discounting was not necessary. It was unclear whether charges were used to proxy prices. Costs were reported for years 1997 and 1998 but no adjustments were reported.

Other issues
The authors compared their results with a previously published study regarding the rates of VAP among patients with daily in-line suction catheter change and patients with no routine catheter change, but the differences reported were not discussed. Comparison with a second study demonstrated consistency with the authors’ findings. The issue of generalisability was not addressed and the lack of any sensitivity analysis may limit the generalisability of the findings to other settings. The study enrolled adult patients who were ventilated for more than 48 hours and this was reflected in the authors’ conclusions.

Further limitations of the study were reported, namely the authors’ assumption that patient characteristics did not differ from month to month during the study period, and the assumption that the infection control techniques (e.g. hand washing, barrier precautions, aseptic techniques) were applied equally by the healthcare personnel. The authors also assumed that the decreased rates of VAP were a direct result of the interventions without taking into consideration that, during some months, there were fewer critically ill patients. They also reported that, although the device utilization ratio for the surgical ICU was statistically significant, the proportions of ventilated patients for the 2-year study period for both units were not statistically significant. It is therefore possible that the decreased use of ventilators in 1998 could be attributable to the reduction of the VAP rate in the surgical unit. In addition, the elevation of the bed between 30 and 45 degrees proved to be a difficult task to implement and was therefore not applied consistently, which might explain the low decrease of VAP rates after its introduction.

Implications of the study
The authors do not make explicit recommendations for policy change or practice. No further research is explicitly identified, although the discussion highlights some areas where assumptions were made, implying the need for greater information.

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