Cost-effectiveness of ward based non-invasive ventilation for acute exacerbations of chronic obstructive pulmonary disease: economic analysis of randomised controlled trial

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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 standard medical treatment with the addition of noninvasive ventilation was studied in patients with an acute exacerbation of chronic obstructive pulmonary disease (COPD) and mild to moderate respiratory acidosis.

The standard medical treatment consisted of controlled oxygen to maintain oxygen saturation (SpO2) at 85 to 90%, nebulised salbutamol (5 mg, 4 - 6 hourly), nebulised ipratropium bromide (500 microg, 6 hourly), prednisolone (30 mg once daily for a minimum of 5 days) and an antibiotic agent.

Noninvasive ventilation consisted of bilevel positive pressure ventilation through a face or nasal mask, inspiratory pressure at initially 10 cm water (H2O) increased to 20 cm H2O, expiratory pressure 5 cm H2O, target duration (first day 24 hours, second day 16 hours, third day 8 hours, fourth day discontinued), and oxygen in the circuit to maintain SpO2 at 85 to 90%.

Type of intervention
Treatment.

Economic study type
Cost-effectiveness analysis.

Study population
The study population comprised patients admitted to hospital with an acute exacerbation of COPD and mild to moderate acidosis (pH 7.25 - 7.35) secondary to respiratory failure. No specific inclusion and exclusion criteria were reported.

Setting
The setting was secondary care (hospitals). The economic study was carried out in the UK.

Dates to which data relate
The dates to which the effectiveness and cost data related were not reported in the paper. However, we have been advised by the authors that the study was undertaken between 1996 and 1998. In addition, 1997-98 prices were used.

Source of effectiveness data
The effectiveness data were derived from a single prospective study. The effectiveness analysis was published elsewhere (Plant et al., see 'Other Publications of Related Interest' below for bibliographic details). This paper briefly reported the outcome results and the cost analysis.
Link between effectiveness and cost data
It appears that the costing has been carried out retrospectively on the same sample of patients as that used in the effectiveness study.

Study sample
Power calculations were not reported in this paper, however, correspondence with the authors has indicated that power calculations were conducted and have been reported in Plant et al Lancet 2000, (see 'Other Publications of Related Interest' below for bibliographic details). A total of 236 patients were included in the study. These were randomised to receive either the standard medical treatment alone (n=118) or the standard treatment plus noninvasive ventilation (n=118).

Study design
The study was based on a randomised controlled trial (RCT) that was conducted in 14 hospitals in the UK. The nurses administered noninvasive ventilation according to a predefined protocol until the morning of a patient's fourth day. Once a patient met the criterion "need for intubations", the attending doctor was free to offer ventilatory support (invasive or noninvasive) at his or her discretion. The duration of follow-up was not reported. Further details on the study design can be found in Plant et al 2000 (Thorax) (see 'Other Publications of Related Interest' below for bibliographic details). This paper was also included data on 1 year survival and was used in modelling the need for ventilatory support in a typical UK hospital.

Analysis of effectiveness
The analysis was based on all the patients who entered the study. The primary health outcomes were:

- the need for intubations, using predefined criteria (pH <7.20; pH 7.20 - 7.25 on two occasions 1 hour apart; hypercapnic coma; PaO2 <6 kPa despite maximum tolerated Fio2; cardiorespiratory arrest),
- in-hospital mortality, and
- hospital stay.

The two groups had similar characteristics on admission.

Effectiveness results
Twenty-seven per cent of the standard group (32 of 118 patients) had a need for intubation compared with 15% (18 of 118) of the noninvasive ventilation group, (p<0.02).

Twenty per cent of the standard group (24 of 118 patients) died compared with 10% (12 of 118) of the noninvasive ventilation group, (p=0.046).

No statistical difference in need for intubation or mortality between the centres was found.

The median length of stay in hospital was similar between the two groups, at 10 days (standard group: 2 - 119 days; noninvasive ventilation group: 4 - 137 days; p=0.27).

Clinical conclusions
Noninvasive ventilation was more effective than standard medical treatment alone in decreasing the mortality rate in hospital.

Modelling
The authors modelled the costs and effects of providing and not providing noninvasive ventilation in a typical hospital.
in the UK treating, per year, 56 patients with respiratory acidosis who had a pH between 7.25 and 7.35 (population 250,000, standardised death rate for COPD 100).

**Measure of benefits used in the economic analysis**
The health benefit measure used was the in-hospital mortality (the number of deaths with each strategy). This was derived from the effectiveness study.

**Direct costs**
The perspective of the NHS was adopted. The cost categories considered in the economic evaluation were ward costs, the cost of noninvasive ventilation and the cost of intensive care units.

The ward costs covered nursing staff, pharmacy and overheads such as heating, lighting and buildings. The cost of nursing was calculated using the cost of a bed day on each ward, multiplied by the length of stay, and by adding the extra cost of nursing identified from the log (kept at the end of the bed for the first 5 days of the admission). The pharmacy costs were derived from the standard treatment protocol valued from the British National Formulary (March 1997). The authors assumed that the costs for investigations and wards were equal in the two groups.

The cost of noninvasive ventilation covered the initial purchase of consumables and the selection of masks, replacement of consumables, annual servicing and staff training. The authors assumed that training was given by both (50% each) a specialist registrar in the middle of the incremental pay scale and by an F-grade nurse specialist. The costs of annual servicing were derived from one centre, while the costs of bed day in intensive care were derived from each hospital and apportioned.

The quantities and the unit costs were reported separately. The authors estimated valuations used for the financial year 1997-98 and derived them from the units participating in the study, using a bottom-up approach. The costs were discounted at an annual rate of 5%.

**Statistical analysis of costs**
Statistical analyses of the costs were carried out. The significance of negative cost-effectiveness ratios was assessed using cost-effectiveness acceptability curves.

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

**Currency**
UK pounds sterling ( ).

**Sensitivity analysis**
A sensitivity analysis on each parameter was not carried out. However, non-parametric bootstrap techniques were applied to cost data for deaths avoided. The mean costs for 1,000 bootstrap replications were reported. In addition, the effectiveness and cost data in a typical hospital in the UK was modelled.

**Estimated benefits used in the economic analysis**
Noninvasive ventilation was associated with a 50% reduction in mortality (12 deaths were avoided).

**Cost results**
Noninvasive ventilation was associated with an increase in nursing workload of 26 minutes in the first 8 hours of
admission, \( p<0.05 \). Consequently, the costs were increased on the respiratory wards in the noninvasive ventilation group \( \$139,243 \) compared with the standard group \( \$127,355 \).

The median length of stay in intensive care was similar between the standard group (5 days, range: 1 - 53) and the noninvasive ventilation group (6 days, range: 2 - 15), \( p=0.38 \). The standard group had 116 bed days in intensive care, whereas the noninvasive ventilation group had 43 bed days.

The total costs were \$337,435 in the standard group and \$288,073 in the noninvasive group. Noninvasive ventilation was associated with a \$49,362 reduction in the costs.

The main area of cost-saving was in the use of the intensive care unit \( \$142,576 \) in the standard group versus \$52,981 in the noninvasive ventilation group.

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The mean costs, performing 1,000 bootstrap replications, were \$2,800 (95% confidence interval, CI: \$1,896 - \$4,388) for the standard group and \$2,255 (95% CI: \$1,742 - \$2,966) for the noninvasive ventilation group. The saving was \$645 per patient receiving noninvasive ventilation (95% CI: \$2,310 - \$386).

**Synthesis of costs and benefits**

Noninvasive ventilation was a dominant strategy (more effective and less costly).

The acceptability curve showed an 80% probability that noninvasive ventilation had a negative cost-effectiveness ratio, meaning that it was cheaper and more effective.

At a ceiling cost of \$5,000 per death prevented, the probability that noninvasive ventilation was more cost-effective than standard treatment was 95%.

The modelled data indicated that a typical UK hospital providing a noninvasive ventilation service would avoid 6 deaths and 3 to 9 admissions to intensive care units per year, with an associated cost reduction of \$12,351 to \$53,078 per year.

>From the hospital's perspective, the provision of noninvasive ventilation would incur costs only if the use of intensive care units fell by 55%.

**Authors' conclusions**

Noninvasive ventilation is a highly cost-effective treatment for patients with chronic obstructive pulmonary disease (COPD) who have mild to moderate acidosis. The procedure both reduced the total costs and improved mortality in hospital.

**CRD COMMENTARY - Selection of comparators**

The comparator represented current practice in the study setting, standard treatment without noninvasive ventilation. You should decide whether this is standard practice for acute exacerbations of COPD in your own setting.

**Validity of estimate of measure of effectiveness**

The effectiveness data were taken from an RCT, which was an appropriate study design. The authors did not comment on the appropriateness of the study sample. Power calculations were not carried out. Consequently, the sample size was likely to have been too small to reveal statistical differences. The study groups were comparable at baseline and, therefore, confounding factors should be low. Full details of the study were published elsewhere (Plant et al., see 'Other Publications of Related Interest' below for bibliographic details).

**Validity of estimate of measure of benefit**

The measure of health benefit was derived from the effectiveness study.
Validity of estimate of costs
The authors specified the economic perspective adopted (i.e. the NHS). As such, all the categories of costs relevant to this perspective appear to have been included in the analysis. The cost analysis was handled credibly. The sources, quantities and year to which the prices referred were reported. The costs were reported separately from the quantities, which should aid the generalisability of the study. A statistical analysis and sensitivity analysis were performed on the costs. Hence, the robustness of the results was examined. Discounting was appropriately undertaken since the costs appear to have been estimated for over 2 years. However, the duration of follow-up was not reported.

Other issues
The authors did not present their results selectively and their conclusions reflected the scope of the analysis. They made appropriate comparisons of their results with the findings from one published cost-effectiveness analysis that showed similar conclusions. The authors acknowledged that the features of the UK setting may reduce the generalisability of both the mortality data and the cost-effectiveness analysis to countries with better provision of intensive care units. The authors did not report any limitations of their study.

Implications of the study
The authors did not provide any recommendations for practice or suggest any further research.

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Other publications of related interest


Indexing Status
Subject indexing assigned by NLM

MeSH
Acute Disease; Cost-Benefit Analysis; Critical Care /economics; Great Britain; Hospital Costs; Hospital Mortality; Hospitalization /economics; Humans; Pulmonary Disease, Chronic Obstructive /economics /therapy; Respiration, Artificial /economics; Treatment Outcome