Cost-effectiveness of automated external defibrillators on airlines

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
Seven strategies for the use of automated external defibrillators (AEDs) on passenger aircraft, to improve survival after cardiac arrest (CA), were examined.

Strategy A: no AED, flight attendants (FAs) trained in basic life support (BLS).
Strategy B: AED, aircraft capacity of greater than 200 passengers and all FAs trained in BLS.
Strategy C: AED, aircraft capacity of greater than 200 passengers, but not all FAs trained in BLS.
Strategy D: AED, aircraft capacity of greater than 100 passengers and all FAs trained in BLS.
Strategy E: AED, aircraft capacity of greater than 100 passengers, but not all FAs trained in BLS.
Strategy F: AED, aircraft capacity of fewer than 99 passengers and all FAs trained in BLS.
Strategy G: AED, aircraft capacity of fewer than 99 passengers, but no FA training, relies on physician-passenger to provide treatment in an emergency.

Four additional strategies, where FAs were not trained, were also considered in alternative analyses:

AED, aircraft capacity of greater than 200 passengers (strategy H);
AED, aircraft capacity of greater than 100 passengers (strategy I);
AED, aircraft capacity of fewer than 99 passengers, relies on physician-passenger to provide treatment in an emergency (strategy J); and

no AED (strategy K).

Type of intervention
Treatment (device).

Economic study type
Cost-utility analysis.

Study population
The study population was a hypothetical population of passengers on commercial aircraft.

Setting
The setting was primary care (on board an aircraft). The economic study was conducted in the USA.
Dates to which data relate
The effectiveness and resource use data were derived from studies published between 1980 and 2001. The price year was not reported.

Source of effectiveness data
The effectiveness evidence was derived from a review of completed studies.

Modelling
A decision model based on a Markov process was constructed to capture all the costs and benefits of the strategies for the 12-month period following a CA. Details of the Markov process were not provided, but the structure of the tree was presented graphically. The model ended when the whole cohort had died. After a CA, the patients were resuscitated or died immediately. Those who were successfully resuscitated were hospitalised and then could die in the hospital or were discharged alive. The latter group of patients entered into the Markov process, which modelled the possibility of death occurring on an annual basis until the death of the entire cohort.

Outcomes assessed in the review
The health outcomes assessed from the published studies were:
the number of passenger-hours per year;
the number of passenger aircraft;
the number of CAs on aircraft annually;
the number of FAs;
the number of hours of initial training in AED;
the number of hours of renewal training in AED per 2 years;
the probability of an onboard physician-passenger;
the rate of resuscitation after CA, with or without AED;
the rate of hospital discharge after CA, with or without AED;
the mortality rate in the first year after a CA and the subsequent annual mortality rate;
quality of life post-CA in three health states (unimpaired, moderately impaired and severely impaired).

Study designs and other criteria for inclusion in the review
Not stated.

Sources searched to identify primary studies
Not stated.

Criteria used to ensure the validity of primary studies
Not stated.
Methods used to judge relevance and validity, and for extracting data
Not stated.

Number of primary studies included
The effectiveness evidence was derived from approximately 17 primary studies.

Methods of combining primary studies
The primary studies were combined using narrative methods.

Investigation of differences between primary studies
Not stated.

Results of the review
The number of passenger-hours per year was 1,773 million (range: 1,600 - 2,000 million).

The number of passenger aircraft was 5,100 (range: 4,600 - 5,600).

The number of CAs on aircraft annually was 200 (range: 140 - 300).

The number of FAs was 117,500 (range: 105,000 - 130,000).

The amount of initial training in AED was 3 hours (range: 2 - 4).

The amount of renewal training in AED per 2 years was 1 hour (range: 0.5 - 1.5).

The probability of an onboard physician passenger was 0.7 (range: 0.5 - 0.85).

The rate of resuscitation after CA was 4% (range: 1 - 10) without AED and 36% (range: 21 - 51) with AED.

The rate of hospital discharge after CA was 20% (range: 13 - 27) without AED and 46% (range: 30 - 70) with AED.

The mortality rate was 17% (range: 10 - 25) in the first year after a CA. The subsequent annual mortality rate was 12% (range: 6 - 20).

Quality of life post-CA was 0.78 (range: 0.56 - 1) in an unimpaired health state, 0.07 (range: 0 - 0.38) in a moderately impaired health state, and 0 (range: 0 - 0.5) in a severely impaired health state.

Measure of benefits used in the economic analysis
The summary benefit measure used in the economic analysis was the quality-adjusted life-years (QALYs). These were derived from the decision model. Data on quality of life were obtained from a study that used the Health Utilities Index Mark-3 questionnaire, administered a mean of 9.9 (3.5) months after CA, for unimpaired survivors (see Other Publications of Related Interest). Quality of life data for the moderately and severely impaired health states came from a study of stroke survivors (see Other Publications of Related Interest). The future benefits were discounted at an annual rate of 3%.

Direct costs
A 3% annual discount rate was used because the costs were estimated for a long time. The unit costs were reported, but the quantities of resources used were not. The health services included in the economic evaluation were restricted to those for which costs were incurred by the US airline industry and the health care system. These were AED purchase and maintenance, annual AED training programme, annual additional fuel per aircraft with AED, wages for new
trainees and for renewal trainees, hospitalisation for those who survived or died, and annual medical expenses. The cost/resource boundary adopted in the study appears to have been that of the service payer. The cost of AED was derived from a survey of manufacturers, while the airline costs came from the Federal Aviation Administration and the Air Transport Association of America. Wages were estimated from the Bureau of Labor Statistics, and medical costs came from published studies. Resource use was estimated on the basis of probabilities coming from the literature. No price year was used.

Statistical analysis of costs
The costs were treated stochastically and each category of costs was assigned a probabilistic distribution. Ranges of the costs were also reported.

Indirect Costs
The indirect costs were not included in the economic evaluation.

Currency
US dollars ($).

Sensitivity analysis
To deal with uncertainty, one-way sensitivity analyses were conducted on all model inputs using the ranges observed in the literature. Two-way sensitivity analyses were then conducted on the most influential parameters. A Monte Carlo analysis using 10,000 simulations was carried out by simultaneously varying all parameters over a specified probability distribution.

Estimated benefits used in the economic analysis
The number of lives saved annually were 2 with strategy A, 7 with strategies B and C, 31 with strategies D and E, 33 with strategy F, and 15 with strategy G.

The QALYs gained per patient were 0.04 with strategy A, 0.18 with strategies B and C, 0.79 with strategies D and E, 0.84 with strategy F, and 0.38 with strategy G.

Cost results
The estimated average cost per patient was $25,100 with strategy A, $41,000 with strategy B, $30,100 with strategy C, $55,600 with strategy D, $54,700 with strategy E, $59,500 with strategy F, and $40,700 with strategy G.

Synthesis of costs and benefits
An incremental cost-effectiveness ratio was calculated to combine the costs and QALYs of the strategies under evaluation.

Strategies B, D, and G were dominated by cheaper and more effective options.

The additional cost per QALY was $35,300 with strategy G, $40,800 with strategy E, and $94,700 with strategy F.

One-way sensitivity analyses showed that the variables having the greatest impact on the study results were the resuscitation rate with AED, annual survival after CA, hospital survival rate with AED, quality of life in the unimpaired health state, and the number of CA events per year.

Two-way sensitivity analyses suggested that, for the cost per QALY to be lower than the threshold of $50,000, AED would need to resuscitate 50% of persons experiencing CA with 63% of the resuscitated patients surviving to hospital
discharge, regardless of the aircraft capacity.

Alternatively, AEDs deployed only on large aircraft (greater than 200 passengers) could resuscitate as few as 25% of the patients with an overall survival rate of only 10%, and still be cost-effective (cost per QALY below $50,000).

The Monte Carlo analysis suggested that, on large aircraft, the 95% confidence interval (CI) of the cost per QALY was $11,400 to $74,800. Only 14.9% of the simulations were above the threshold of $50,000 per QALY.

The 95% CI for the medium capacity aircraft was $23,000 to $72,100, with 22.3% of all simulations being above the threshold of $50,000 per QALY.

AED placement on all aircraft was not cost-effective, with most of the simulations (99.8%) being above the threshold of $50,000 per QALY. The alternative analysis showed that strategies H, I and K were dominated, while the cost per QALY of strategy J was $45,600.

Authors’ conclusions
The placement of automated external defibrillators (AEDs) on aircraft of large or middle capacity was likely to be cost-effective. Also, it compared favourably with the cost-effectiveness of other health care interventions and transport safety systems. The rate at which AED saved lives was the most critical parameter of the decision model.

CRD COMMENTARY - Selection of comparators
The authors selected a wide range of possible scenarios representing feasible alternative comparators for the deployment of AEDs on commercial aircraft. The basic comparator was no AED, which was appropriate because it represented the standard scenario on most US airlines. You should decide whether it represents a valid comparator in your own setting.

Validity of estimate of measure of effectiveness
The analysis of effectiveness used data derived from the literature. However, a formal review of the literature does not appear to have been undertaken and details of the primary studies were not provided. It was unclear whether the authors considered differences between the primary studies when estimating the effectiveness and the method used to combine the primary estimates was not stated. The overall internal validity of the analysis is, therefore, not easy to assess. The authors noted some problems in the reliability of data concerning the quality of life among CA survivors and the effectiveness of the AED intervention.

Validity of estimate of measure of benefit
The summary benefit measure in the economic analysis was the QALYs. This was appropriate given that QALYs capture the impact of the study intervention on the survival and quality of life of the patients' health. In addition, it permits the benefits of the present study to be compared with those of other health care interventions. The QALYs were appropriately discounted.

Validity of estimate of costs
Although the authors stated that a societal perspective was adopted, the indirect costs were not considered. Therefore, it appears more appropriate to state that the perspective of the payer was adopted. The unit costs were reported, but the price year was not. Thus, deflation exercises in other settings would be difficult. Each category of costs was attributed a probabilistic distribution, which was used in the Monte Carlo simulation to deal with uncertainty. The authors noted some limitations in their estimation of the costs, which were based on Medicare rates, thus reflecting an elderly population that may have worse outcomes and higher health costs.

Other issues
The authors made some comparisons of their findings with those from other studies. The issue of the generalisability of the study results to other settings was not explicitly addressed, but several sensitivity analyses were conducted. This enhances the external validity of the analysis. The authors stressed that their findings should be limited to commercial airlines. Some limitations of the analysis were highlighted in the study.

**Implications of the study**
The study results suggested that the programme of placing AEDs is cost-effective on large-capacity passenger aircraft and is likely to be economically feasible on medium-capacity aircraft. However, the authors note that "careful monitoring of the costs and consequences of total aircraft AED deployment is warranted to ensure efficient use of safety-related resources in the airline industry”.

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**Other publications of related interest**


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