Cost effectiveness of telemedicine for the delivery of outpatient pulmonary care to a rural population
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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 a telemedicine service for the provision of outpatient pulmonary care to a rural population. Patients at the remote site, together with a trained nurse, underwent a telemedicine consultation with the physician at the hub site, who conducted a partial physical exam via live teleconference with an electronic stethoscope. Under this scenario, only patients who required a special diagnostic test or procedure, and those for whom telemedicine was not successful, were requested to travel to the hub site.

Type of intervention
Diagnosis.

Economic study type
Cost-effectiveness analysis.

Study population
The study population comprised patients requiring pulmonary specialist care.

Setting
The setting was specialist care (VAMC). The economic study was carried out in the USA.

Dates to which data relate
The effectiveness evidence, as well as some resource use and cost data, was gathered in 2000. The price year was 2000.

Source of effectiveness data
The effectiveness evidence was derived from a single study and some opinions.

Link between effectiveness and cost data
The costing was partially carried out on the same sample of patients as that used in the effectiveness study.

Study sample
Power calculations to determine the sample size were not reported. A sample of 65 patients (corresponding to 99 visits) who required pulmonary specialist consultation was identified from January to December 2000. The patients’ characteristics were not reported. It would appear that no patient was excluded from the initial study sample or refused to participate.
Study design
This was a prospective case series and a single group of patients (those using the telemedicine service) was considered. The patients were not followed after the teleconsultation took place. A single centre (the remote site) was used to identify the patients included in the study. The centre formed part of the VAMC’s telepulmonary programme.

Analysis of effectiveness
It appears that all the patients included in the initial study sample have been considered in the analysis of effectiveness. The main outcome assessed was the number of patients who successfully received pulmonary outpatient consultation with the telemedicine service (named health care access). A successful telemedicine consultation was defined as one after which the patients did not have to make any additional in-person visits to the hub site.

Effectiveness results
All of the patients who were offered the option of the telemedicine service accepted it. Only 5 patients travelled to Milwaukee because they required further diagnostic tests or procedures. They would have needed to travel even if they had received the initial visit under the routine care strategy. Therefore, the effectiveness of the telemedicine service, defined as health care access, was 95%.

Clinical conclusions
The effectiveness analysis showed that all patients considered in the study chose the telemedicine service. Only 5% of the patients had to use the standard approach. This piece of information was entered into the decision model.

Modelling
A computerised decision tree model was used to assess the costs and benefits of the three alternative options for pulmonary specialist care. The time horizon of the study was unclear (1 or 5 years). Details of the model were not provided.

Methods used to derive estimates of effectiveness
The authors made some assumptions that were used in the decision model.

Estimates of effectiveness and key assumptions
The authors assumed that the success rate for routine and on-site care was 100%. They also assumed that there was no difference between the medical benefits provided by the three alternative strategies.

Measure of benefits used in the economic analysis
The summary benefit measure used in the economic analysis was the number of successful patient visits under each of the three options, multiplied by the utility of the visit. The opinions of a group of 10 physicians who regularly provided services to patients from the Iron Mountain VAMC were sought. The physicians were contacted and asked to assign a utility value to five scenarios on a scale of 0 (worst) to 100 (best). The utility was defined as the preference for each type of visit. The five scenarios were a best scenario, a worst scenario and three intermediate scenarios.

In the best scenario, the patient received an in-person consultation at the remote site and did not need to travel (scenario 1). In the worst scenario, no access to the service was available (scenario 2). In one intermediate scenario, the patient received the telemedicine service and did not travel to the hub site, but the teleconsultation was considered less desirable than a face-to-face evaluation (scenario 3). In another intermediate scenario, the patient received outpatient consultation at the hub site (scenario 4). In the remaining intermediate scenario, the patient received the telemedicine consultation, which was considered as unsuccessful, and a further visit to the hub site was required (scenario 5).

On the basis of the averaged experts’ opinion, it was estimated that the utility values were 1 for scenario 1, 0 for
scenario 2, 0.9 for scenario 3, 0.8 for scenario 4 and 0.5 for scenario 5. An annual discount rate of 3% was applied although the time horizon of the study was unclear.

**Direct costs**
A 3% discount rate was applied to those costs incurred in the future, although it was unclear whether discounting was relevant. It was stated that the duration of the project was 5 years but it was not stated whether this was the time horizon of the study. The unit costs and the quantities of resources used were reported for most of the cost items. The health services included in the economic evaluation were telemedicine (hardware, software and ancillary equipment), overhead services to the VAMC system (for both remote and hub sites), travel by bus and car, services of lodging a patient at the hub site, and personnel. The costs of one-time capital investment were amortised using an annual rate of 3%, and a 20% scrap value was assigned to all equipment. The costs of medications, laboratory tests and radiology were not included in the analysis and were assumed to be constant across the three options. The cost/resource boundary of society was adopted.

The resource use data estimated on the basis of assumptions as well as data derived from the sample of patients included in the effectiveness study. The costs were estimated mostly from the VAMC cost distribution report. Salary data were derived from the average salary and benefit rates for the Milwaukee VAMC. Personnel costs were pro-rated based on the percentage of full-time professional effort devoted to the programme. All the capital costs were pro-rated according to the actual use of equipment and facilities across the multiple clinical users that shared these resources (10.4%). All the costs were inflated to 2000 values using the medical care component of the consumer price index.

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

**Indirect Costs**
The indirect costs, namely productivity losses, were included in the analysis since a societal perspective was adopted. A discount rate of 3% was applied, and, as in the analysis of the direct costs, all the costs were presented in 2000 values. The number of lost days was estimated on the basis of the authors' opinions. The authors calculated the full-time wage after adjusting for gender, age and the productivity loss for a person who was not working (cost of leisure time lost). The costs were estimated using data from the US Bureau of Labor Statistics. To be conservative, it was assumed that 100% of the patients in the study were unemployed.

**Currency**
US dollars ($).

**Sensitivity analysis**
One-way sensitivity analyses were carried out to handle uncertainty in the key variables used in the decision model. The ranges of values used in the analysis were derived from actual values or authors' assumptions. The threshold values at which the ranking of the alternative strategies changed were also reported.

**Estimated benefits used in the economic analysis**
The effectiveness of the interventions was 57.2 for telemedicine, 52 for routine care and 65 for on-site care.

**Cost results**
The annual pro-rated cost was $17,886 with telemedicine, $30,418 with routine care and $75,820 with on-site care. It should be noted that two different figures were reported for the costs of the telemedicine service, $18,705 (Table 2) and $17,886 (Table 3). However, the latter figure ($17,886) seems to have been the one used in the cost-effectiveness ratio reported in Table 2.
Synthesis of costs and benefits
Average and incremental cost-effectiveness ratios were calculated to combine the costs and benefits of the alternative strategies under evaluation.

The average cost-effectiveness ratio was $313 with telemedicine, $585 with routine care and $1,166 with on-site care. It should be noted that a different figure for the cost-effectiveness ratio of telemedicine ($335 rather than $313) was reported in the abstract.

The incremental analysis showed that routine care was dominated, while the incremental cost per successfully treated patient with on-site care relative to telemedicine was $7,427.

The sensitivity analysis showed that the most influential factors were the number of patient visits, pro-rated percentage, the effectiveness of telemedicine, the utility of telemedicine, the cost of telemedicine equipment and the indirect costs. However, telemedicine remained the most cost-effective strategy under a wide range of plausible scenarios.

In the secondary analyses, from which all direct and indirect patient costs were excluded, the average cost-effectiveness ratios were $76 with routine care, $216 with telemedicine and $1,102 with on-site care.

Authors' conclusions
The telemedicine service for pulmonary outpatient visit was cost-effective in comparison with routine care or on-site care. This conclusion was sensitive to some factors, such as the need for services at the remote site, the sharing of telemedicine equipment, the effectiveness of the teleconsultation, and the indirect cost-savings. In particular, the inclusion of indirect costs represented a critical issue because, when the third-party payer perspective was adopted, the most cost-effective strategy was routine care.

CRD COMMENTARY - Selection of comparators
The authors provided an explicit justification for their choice of the comparators. The on-site strategy, although not available, was considered as an alternative option for comparative purposes. You should decide whether telemedicine, on-site care and routine care represent valid strategies for the management of patients requiring a pulmonary specialist visit in your own setting.

Validity of estimate of measure of effectiveness
The analysis of effectiveness was based both on a sample of patients, who were assessed during a one-year period, and on assumptions. The source of the data was not reliable since the study was not comparative. The issue of uncertainty was addressed in the sensitivity analysis.

Validity of estimate of measure of benefit
The choice of the summary benefit measure was likely to have been appropriate for detecting the impact of the interventions on the patients' preferences for the service. However, the true effect of each strategy on patient health was not estimated, as the authors assumed that there was no difference between the study interventions in terms of medical benefits. The benefit measure was also specific to the interventions considered in the study and does not appear to have been comparable with the benefits of other health care interventions. It was also noted that the use of a more complete measure (e.g. quality-adjusted life-years) would have been more appropriate, but was not possible due to the lack of data on survival and quality of life. The authors acknowledged that the opinions of a group of experts may be different from the patients' utility values. The opinions of each expert were averaged, but a process similar to a Delphi panel was not applied. The authors acknowledged the uncertainty around those estimates derived from opinions and carried out extensive sensitivity analyses.

Validity of estimate of costs
The authors carried out the economic evaluation from a societal perspective and all the relevant categories of costs were included in the study. Some categories of costs were not included as they were likely to be similar in the three groups. The resource use quantities and the unit costs were reported separately for most of the cost items and the price year was provided. This will facilitate the replication of the study in other settings. The source of the cost data was reported for most items. The resource use data were mainly derived from authors' assumptions. Conservative estimates for the indirect costs were made. The costs were treated deterministically, but sensitivity analyses were conducted to account for variability in the cost estimates.

**Other issues**
The authors compared their findings with those from other studies that showed similar results favouring the telemedicine service. In terms of the generalisability of the study results to other settings, the authors acknowledged that the VA population was unique and the results could not be generalisable to other patient populations. The authors discussed some limitations of their study. In addition, it was stated that extensive sensitivity analyses were performed to address the issue of uncertainty in the data, which represented the main limitation to the validity of the analysis.

**Implications of the study**
The authors suggested that future studies should be carried out to better assess all the costs and benefits associated with the benefits of telemedicine services.

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