A cost-effectiveness analysis of shipboard telemedicine
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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
Four telemedicine options to enhance medical services at sea in Navy ships. The four telemedicine strategies were as follows: telephone, including facsimile (fax) capability; e-mail and Internet connectivity, used in conjunction with a digital camera; video teleconferencing (VTC) providing real time audio and video connectivity; and teleradiology in its basic form consisting of an X-ray machine and a means of producing a digitised image of the film. The combination of various digital diagnostic instruments with the basic telemedicine options was also assessed. The add-on (peripheral) instruments were dermascope, ophthalmoscope, otoscope, stethoscope, endoscope, electrocardiograph and defibrillator, and ultrasound scanner. The assessments were performed for four distinct ship types: aircraft carriers (more than 5,000 personnel), amphibious ships (500-2,000 personnel), small ships (less than 500 personnel), and submarines (less than 200 personnel).

Type of intervention
Treatment and diagnosis.

Economic study type
Cost-effectiveness analysis.

Study population
Medical encounters in US Navy ships.

Setting
Navy medical services at sea and on shore. The economic study was carried out in the USA.

Dates to which data relate
Effectiveness and resource use data corresponded to the period between 1 September 1995 and 1 September 1996. February 1997 prices were used.

Source of effectiveness data
The evidence for final outcomes was based on expert opinion.

Modelling
A mathematical equation was used to estimate the level of benefits of telemedicine if the technology were to be adopted for the entire fleet (installing the telemedicine equipment on more than 300 ships and Fleet Marine Force units) with a lifecycle of 5 years.

Methods used to derive estimates of effectiveness
A panel of medical experts (four independent duty corpsmen (IDCs) and seven physicians) who were knowledgeable about, and had experience with, telemedicine were assembled to review the clinical data collected by a self-administered survey. The clinical data were collected by ships’ medical staff and covered information regarding medical evacuations (MEDEVACs), including diagnosis, destination, means of transportation, and potential effect of telemedicine in avoiding the MEDEVAC. The clinical data also included patient visit data provided by ships’ medical staff from a computerised data system (SAMS) used by ships to log medical encounters and covered information regarding the ICD-9 diagnostic code, symptoms and relevant medical history, and prescribed treatment, and the number of "light duty" or "no-duty" days recommended as a result of illness or injury and referral for follow-up treatment. The survey was sent to a representative sample of 120 ships that had deployed for at least 90 days during the one-year study period. The overall response rate was slightly above 50% (62 ships). The panel was asked to verify the applicability of telemedicine to the case mix reported in the medical encounter data. A two-step procedure was followed:

firstly the group of four corpsmen determined which cases needed the intervention of a physician/specialist and were therefore candidates for a telemedicine consultation;

in the second step, the possible role of telemedicine was investigated by the full panel involving estimation of the number of light-duty and no-duty days that telemedicine would have saved, determination of the type of telemedicine modalities which would have enhanced delivery of care, and identification of the type of digitised medical diagnostic instruments the onboard medical staff would need to send information to the consultant ashore.

In determining which telemedicine modality to use, panellists were asked to minimise bandwidth whenever possible. Panel members were asked to make clinical judgements and reach a consensus, basing their decisions on details in the case histories and their own experience with treating similar cases, with and without the benefit of telemedicine.

Estimates of effectiveness and key assumptions
In total, 8,000 cases of medical encounters were presented to the panel, of which 875 cases were judged to be candidates for a telemedicine consultation. The estimates of the following parameters used to compute the telemedicine benefits were derived from the clinical data: the probability that a case would need a telemedicine consult, probability that the telemedicine consult would result in a benefit, and average value of the benefit per consult. Navy ships evacuated 911 patients during the 12-month period of the study (269 from aircraft carriers, 395 from amphibious ships, 139 from small ships, and 81 from submarines). It was calculated that telemedicine would have prevented 28.3% of the MEDEVACs during the 12 month period (corresponding to 156,276 travel miles).

Measure of benefits used in the economic analysis
The benefit measures were quality-of-care enhancement, the percentage of avoidable MEDEVACs, and return to duty time. The sample estimates were projected to the medical workload of the entire fleet using a set of scale factors based on the ratio of the population to the sample size as well as to the proportion of time the ships were deployed.

Direct costs
Costs were discounted given the 5 year time frame of the cost analysis. Some quantities were reported separately from the costs and cost components were reported separately. The cost analysis covered the lifecycle costs of the telemedicine options (including off-the-shelf telemedicine equipment prices, installation, maintenance, training, and communication), and costs of MEDEVACs avoidable by TM (fuel, repairs, and maintenance savings). The perspective adopted in the cost analysis was that of the Navy. February 1997 price data were used. The cost analysis did not cover the sunk costs, i.e. costs that would exist irrespective of telemedicine.

Indirect Costs
Costs were discounted. Some quantities were reported separately from the costs. Some cost components were reported separately. The indirect cost analysis covered the costs of the foregone opportunity of resources due to the MEDEVACs and man-day savings as a result of reduced return-to-duty time. The opportunity cost of the crew involved in evacuations was measured by their compensation based on the hours of flight (as derived from the reported number of
miles flown and the typical speeds) and manning of the aircraft used. Man-day savings were transformed to dollars using the pay and benefits of a sailor in the Navy-wide average pay grade. February 1997 price data were used.

**Currency**
US dollars ($).

**Sensitivity analysis**
The cost-effectiveness analysis was based on two scenarios regarding access to bandwidth: using the ship's satellite connection (the Navy provides all the computing and memory capacity that medical departments need) or relying on a commercial satellite for all transmissions (which adds the satellite fees to the TM equipment cost).

**Estimated benefits used in the economic analysis**
If telemedicine (TM) were available to the fleet, ships' medical staffs would initiate nearly 19,000 consults (e-mail, 40%; phone, 39%; VTC, 9%; and teleradiology, 12%) in a year representing 7% of all patient visits. TM would enhance quality of care in two-thirds of these consults (of which more than 80% would not require any add-on instrument). The percentage of e-mail and Internet consultations that would result in improved quality of care for sailors ranges from 32.5% for amphibious ships to 14.3% for submarines. E-mail and the Internet would have a significantly favourable impact on quality of care on all ships. VTC would have very little impact on quality of care (under 3% on any ship). The percentage of avoidable MEDEVACs was 17% (representing 155,000 travel miles). If fully available to the fleet, TM would save 0.42 man-days per consult.

**Cost results**
A discount rate of 3.3% was applied to the costs, corresponding to the February 1997 real interest rate on notes and bonds with a 5-year maturity. The net total discounted costs per ship reflected the dollar value of man-days and MEDEVACS saved minus the cost of TM. In the scenario involving the use of the ship's satellite connection, both e-mail and Internet were cost saving for all types of ships with a range between approximately $32,650 for aircraft carriers and about $2,150 for small ships. Phone and fax were also cost saving on all ships. VTC was cost saving only on the carriers ($11,500) and amphibious ships ($3,650). Teleradiology was cost saving on aircraft carriers only ($19,550). In the case of relying on commercial satellite, e-mail and Internet would be the only modality generating enough monetary savings to offset the TM cost. In terms of the peripheral instruments, only dermascope, ophthalmoscope, and stethoscope were cost-saving for carriers. Ophthalmoscope and stethoscope were cost-saving for amphibious ships. Other instruments were not cost-saving for any other ship.

**Synthesis of costs and benefits**
Costs and benefits were not combined.

**Authors' conclusions**
E-mail with Internet connectivity and telephone with fax are cost-effective for all types of Navy ships. Video teleconferencing would be cost-effective on the larger ships (aircraft carriers and amphibious vessels). Teleradiology would be cost-effective on aircraft carriers only. A limited number of digital diagnostic instruments would be cost-effective, but only on the larger ships. If ships' medical departments need to rely on a commercial satellite, the cost of telemedicine would increase sharply.

**CRD COMMENTARY - Selection of comparators**
The strategy of not using TM was regarded as the comparator to allow the active value of TM to be evaluated.

**Validity of estimate of measure of effectiveness**
A panel of medical experts (four IDCs and seven physicians) who were knowledgeable about and had experience with telemedicine were assembled to review the clinical data collected by a self-administering survey. The study survey had only 50% response rate. The authors did not report the process by which the physicians and IDCs were selected. It was reported that time constraints made it impossible to have the cases evaluated by multiple panels to estimate inter-rater reliability. Estimates produced by the panel were not investigated by sensitivity analysis.

**Validity of estimate of measure of benefit**

Estimation of benefits was obtained directly from the effectiveness analysis by projecting the results for the entire fleet and by using a mathematical equation. The choice of the benefit measures appears to be justified.

**Validity of estimate of costs**

Some quantities were reported separately from the costs and adequate details of the methods of cost estimation were given. The price year was specified. The potential impacts of a TM approach on indirect costs (lost productivity) were investigated. Cost results may not be generalisable to other settings or countries.

**Other issues**

Given the retrospective nature of the study survey and the low response rate, the inherent limitations of estimates based on expert opinion, and the lack of sensitivity analyses, some degree of caution needs to be exercised in the interpretation of the study results. The issue of generalisability to other settings or countries was not addressed and no comparisons were made with other studies. The study sample consisted of Navy personnel and this seems to be reflected in the authors’ comments.

**Implications of the study**

Telemedicine technology would improve quality of life by improving the quality of care provided on Navy ships. It would also prevent the mission disruptions that some of the medical evacuations create.

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