



## Multicentre randomised control trial comparing real time teledermatology with conventional outpatient dermatological care: societal cost-benefit analysis

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Further details of  
the sensitivity  
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available on the  
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### Abstract

**Objectives** Comparison of real time teledermatology with outpatient dermatology in terms of clinical outcomes, cost-benefits, and patient reattendance.

**Design** Randomised controlled trial with a minimum follow up of three months.

**Setting** Four health centres (two urban, two rural) and two regional hospitals.

**Subjects** 204 general practice patients requiring referral to dermatology services; 102 were randomised to teledermatology consultation and 102 to traditional outpatient consultation.

**Main outcome measures** Reported clinical outcome of initial consultation, primary care and outpatient reattendance data, and cost-benefit analysis of both methods of delivering care.

**Results** No major differences were found in the reported clinical outcomes of teledermatology and conventional dermatology. Of patients randomised to teledermatology, 55 (54%) were managed within primary care and 47 (46%) required at least one hospital appointment. Of patients randomised to the conventional hospital outpatient consultation, 46 (45%) required at least one further hospital appointment, 15 (15%) required general practice review, and 40 (39%) no follow up visits. Clinical records showed that 42 (41%) patients seen by teledermatology attended subsequent hospital appointments compared with 41 (40%) patients seen conventionally. The net societal cost of the initial consultation was £132.10 per patient for teledermatology and £48.73 for conventional consultation. Sensitivity analysis revealed that if each health centre had allocated one morning session a week to teledermatology and the average round trip to hospital had been 78 km instead of 26 km, the costs of the two methods of care would have been equal.

**Conclusions** Real time teledermatology was clinically feasible but not cost effective compared with conventional dermatological outpatient care. However, if the equipment were purchased at current prices and the travelling distances greater, teledermatology would be a cost effective alternative to conventional care.

### Introduction

As part of the government's commitment to modernise the NHS, telemedicine is to be implemented within the health service where there is clinical need and evidence supporting its cost effectiveness.<sup>1</sup> In the United Kingdom dermatology accounts for about 15% of consultations in general practice, with 4% of these patients referred for specialist advice.<sup>2</sup> The ratio of dermatologists to population (1:217 000) is lower than for many other medical specialties in Britain<sup>3</sup> and three times lower than in the rest of Europe.<sup>4</sup> The UK multicentre teledermatology trial is evaluating the use of real time telemedicine for delivering dermatological health care.

The diagnostic accuracy and management efficacy of videolink consultations have been shown acceptable compared with conventional hospital consultations.<sup>5-10</sup> In our multicentre trial the videolink diagnosis agreed with the face-to-face diagnosis in two thirds of cases.<sup>7</sup> There was no diagnostic agreement in 6% of cases, which is comparable with the differences in diagnosis made by two practitioners with differing levels of experience in a normal dermatology outpatient clinic. Clinical management advice given by videolink agreed with the face-to-face advice in 64% of cases. The videolink management plan was judged to be inappropriate in 9% of cases, which again may reflect the differences that exist between dermatologists in normal outpatient departments. Patient satisfaction with teledermatology consultations has also been favourable.<sup>11</sup>

Real time teledermatology is less time consuming and less expensive for patients because they are seen at the local health centre rather than at hospital. Patients required less time off work to attend the appointment, travelled shorter distances, and were seen more quickly compared with those who were seen by the dermatologist at the outpatient clinic.<sup>12</sup> To date no studies have examined the cost effectiveness of real time teledermatology from a societal or healthcare provider's perspective.

The present multicentre randomised controlled trial aimed to evaluate the health outcomes and cost-benefits of teledermatology compared with conventional outpatient dermatological care from a societal viewpoint.

## Participants and methods

### Design

We conducted a randomised controlled trial designed to measure the cost effectiveness of real time teledermatology in Northern Ireland. Two hospital dermatology departments and four health centres took part. Two of the health centres were located in rural areas and two in urban areas. Patient outcomes and cost-benefits of teledermatology consultations were compared with patient outcomes and cost-benefits of hospital outpatient dermatology consultations. Each hospital allocated a weekly session for teledermatology and a similar session for conventional outpatient appointments. Ethical approval was obtained from the appropriate committee.

Sample size calculations showed that a sample size of 200 had a power of 80% to detect a standardised difference of 0.4 at the 0.05 significance level.<sup>13</sup>

### Equipment

Standard commercial videoconferencing units (VC7000, BT) connected by basic rate ISDN lines at 128 kbit/s were installed at each of the participating sites. An additional video camera was connected to the videoconferencing unit at each health centre to enable the general practitioner to transmit close up images to the dermatologist.

### Procedure

Patients with dermatological conditions requiring a specialist referral were invited to participate in the trial by their general practitioner. Sealed envelopes containing a referral form and consent form were distributed at each health centre. The referral form contained details of the randomisation to either a teledermatology consultation or traditional hospital consultation.

Prior randomisation of the referral forms had taken place by using a table of random numbers. Each referral form had an assigned trial identification number for all subsequent patient communication between the dermatologist and general practitioner. The patient signed the consent form and was given a scheduled appointment time.

Patients randomised to a teledermatology consultation attended their own health centre and, in the company of a general practitioner, were seen by a hospital dermatologist over the videolink. Patients randomised to a hospital consultation were seen by the dermatologist in the outpatient department as normal. The dermatologist recorded a diagnosis, management plan, clinical outcome of consultation, and length of consultation time. All patients received an accelerated referral and were seen within 10 days.

Patients were asked to complete an anonymous economic questionnaire assessing the time spent and costs incurred by them immediately after their initial consultation and after the first return visit to hospital. Patient reattendance to general practice or hospital and the clinical outcome of the initial consultation were ascertained from a follow up review of patient records. A minimum period of three months elapsed before patient records were reviewed. The medical staff in the study were subsequently interviewed by an economic consultancy firm to obtain quantitative data on the costs and benefits of teledermatology.

## Results

Over 12 months, 204 patients participated in the trial; 102 were randomised to teledermatology and 102 to conventional hospital appointment. Eighty five (42%) were male and 119 (58%) female. Age ranged from 4 months to 89 years (mean (SD) 38.6 (23.8) years). In all, 125 (63%) were registered with an urban practice and 76 (37%) a rural practice.

### Clinical outcome

Table 1 shows the clinical outcome of the initial consultation. The dermatologist recommended a further hospital appointment for 47 (46%) patients seen by telemedicine and 46 (45%) patients seen conventionally. A review of patient records showed that 42 (41%) of patients seen by telemedicine and 41 (40%) patients seen conventionally actually attended a hospital follow up appointment.

Patients seen by teledermatology made fewer return visits to their general practitioner and hospital compared with patients seen conventionally. The mean number of additional visits to primary and secondary care made by the telemedicine group was 1.63 (SD 0.78, 95% confidence interval 1.43 to 1.83, range 1-4) compared with 2.12 (SD 1.93, 95% confidence interval 1.62 to 2.62, range 1-10) by the conventional group.

### Costs

Of the 204 patients in the study, 83 attended a further hospital appointment; thus the maximum possible return rate for the patient economic questionnaire was 287. A total of 169 questionnaires were returned, giving a response rate of 59%. In all, 62% (63/102) of patients randomised to teledermatology completed the questionnaire compared with 57% (9106/185) of those randomised to a conventional appointment. Table 2 shows the average patient time involved for each group.

The hourly rate of a consultant dermatologist including overhead costs was estimated to be £150.00 and the hourly rate of a general practitioner £114.00 (MedEconomics). The average cost of consultant time was £39.25 for a teledermatology consultation and £34.75 for a conventional consultation. The average cost of general practitioner time at a teledermatology consultation was £29.83.

**Table 1** Recorded and actual clinical outcome of initial consultation. Values are numbers (percentages) of patients

	Telemedicine (n=102)		Conventional (n=102)	
	Recorded	Actual	Recorded	Actual
Once only visit	22 (22)	42 (41)	40 (39)	50 (49)
General practice follow up	33 (32)	18 (18)	15 (15)	10 (10)
Hospital follow up	47 (46)	34 (33)	46 (45)	33 (32)
General practice and hospital follow up	0	8 (8)	0	8 (8)
Did not attend	0	0	1 (1)	1 (1)

**Table 2** Patient time (minutes) involved in initial dermatology appointments

Time	Telemedicine			Conventional		
	No of patients	Mean (SD) time	95% CI	No of patients	Mean (SD) time	95% CI
Travel*	55	31.2 (20.4)	25.8 to 36.6	95	48.8 (29.2)	42.9 to 54.7
Waiting	56	5.3 (7.2)	3.4 to 7.2	96	20.3 (14.1)	17.5 to 23.1
Consultation	88	15.7 (4.6)	14.7 to 16.7	52	13.9 (7.0)	12.0 to 15.8
Total		52.2 (32.2)	43.9 to 60.5		83.0 (50.3)	72.4 to 93.6

\*To and from appointment.

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**Table 3** Method of travel to dermatology appointments and distances travelled

	Telemedicine (n=58)	Conventional (n=101)
Method of travel		
Car	48 (83)	83 (82)
Public transport	2 (3)	15 (15)
Walk	8 (14)	3 (3)
Travel distance (km):		
Mean (SD)	10.3 (9.1)	26.0 (23.2)
Range	0.4 to 35.4	0.8 to 80.5
95% CI	8.0 to 12.6	21.4 to 30.6

The cost of patient time was calculated by taking the average annual income as recorded by the 130 patients who completed this section of the economic questionnaire (£12 115.38) divided by 220 working days, divided by eight working hours, divided by 60 minutes, multiplied by total patient time (table 2). Patient costs were thus £5.99 for teledermatology and £9.52 for conventional consultation.

The cost of patient travel depended on the mode of transport used and the distance travelled (table 3). We calculated the cost of car travel using the standard car mileage allowance of 25 pence a mile (15.5 p/km,

Inland Revenue). Patients attending the teledermatology consultation by car travelled a total of 570.9 km compared with 2456.6 km by those attending hospital appointments by car. Total public transport fares were £5.80 in the telemedicine group and £55.74 in the conventional group. Patients who walked had no transport costs. Thus the average travel cost incurred by patients in each group was £1.89 for teledermatology ( $(570.9 \times 0.155) + 5.80 = £94.49/50$ ) and £4.46 for conventional care ( $(2456.6 \times 0.155) + 55.74 = £437.37/98$ ).

Table 4 shows the cost of all the telemedicine equipment used in the trial (1995 prices) and the telecommunications charges relating to the trial.

## Benefits

As a result of the learning benefits and increased confidence in managing patients obtained from the joint videolink consultations, general practitioners estimated that dermatology referrals could be reduced by an average of 20% (range 10-25%) with concurrent savings of consultant time, patient time, and patient travel costs. Interview data from one of the health centres was not included in the analysis as a locum was employed to cover the teledermatology sessions and the benefits for a locum may differ from those for a practice member. The general practitioners estimated that it would require an average of 6.3 days of training (range 4.0-7.5) to gain the same experience obtained from being present at the teledermatology consultations. With the average cost of a general practitioner training course at £60.00 per day (Northern Ireland Postgraduate Council) and the cost of a general practitioner at £114.00 an hour, the cost of equivalent training would be £6123.60 per general practitioner. Table 5 shows the total calculated costs and benefits pertaining to the trial. The net cost (to society) of the initial teledermatology consultation was £132.10 (SD £24.63) a patient compared with £48.73 (£18.4) a patient for the initial conventional outpatient consultation.

**Table 4** Costs of equipment and telecommunication (to nearest £)

	Equipment			Telecommunications			
	Vide Conferencing unit	Camera	Connection	Total	Rental	Call costs	Total
Health centre 1	5 999	2 000	199	8 198	535	12	547
Health centre 2	5 999	2 000	199	8 198	535	12	547
Health centre 3	5 999	3 732	400	10 131	352	80	432
Health centre 4	5 999	3 732	400	10 131	352	112	464
Hospital 1	5 999	0	400	6 399	352	16	368
Hospital 2	5 999	0	400	6 399	352	0	352
Total	35 994	11 464	1998	49 456	2478	231	2709

**Table 5** Costs and benefits of telemedicine and conventional consultations (observed data)

	Calculation	Telemedicine (£)	Conventional (£)
<b>Variable costs</b>			
Consultant time	£150/60 min × consultation time*	39.25	34.75
General practitioner time	£114/60 min × 15.7*	29.83	
Patient travel	Average travel cost†	1.89	4.46
Patient time	Average cost of patient time‡	5.99	9.52
Total		76.96	48.73
<b>Fixed costs‡</b>			
Cost of capital	49 456 × 6% / 102	29.09	0
Depreciation	49 456 / 7 = 7065 / 102	69.27	0
Telecommunications costs	2709 / 102	26.56	0
Total		124.92	0
Total variable plus fixed costs		201.88	48.72
<b>Savings</b>			
Non-referrals due to general practitioners' learning†	20% of conventional consultant cost	6.95	0
	20% of patient travel cost	0.89	0
	20% of cost of patient time	1.90	0
Total		9.74	0
<b>Benefits</b>			
Cost of equivalent training‡	6.3 × ((114 × 8) + 60) / 102	60.04	
Total savings and benefits		69.78	0
Net societal cost	Total costs - (savings + benefits)	132.10	48.73

\*See table 2.

†See Results section.

‡See table 4. Purchase of capital equipment usually incurs a standard interest charge of 6%. The normal time for depreciating electronic equipment in the NHS is seven years (NHS Exeutive).

## Sensitivity analysis

In our trial, the break even round trip distance at which teledermatology became as cheap as conventional dermatology was 205.8 km. The main factors affecting the cost of the teledermatology consultation were additional general practitioner time, cost of purchasing equipment and depreciation, telecommunication costs, and use of equipment. The savings were reducing referrals, training benefits, reduced patient travel, and reduced patient time.

We conducted a sensitivity analysis to examine the effect of these six main factors on the comparative costs of teledermatology. If all other factors were held equal, replacing the general practitioner with a nurse practitioner made teledermatology more expensive and caused the break even round trip distance to increase to 378.9 km; using current prices for equipment caused the break even round trip distance to decrease to 131.8 km and depreciating equipment over five years instead of seven decreased the break even distance to 170.7 km; halving the telecommunications costs (both rental and call charges) caused the break even round trip distance to decrease to 177.1 km; increasing use from 0.5 patient per week to one session per week (12 patients) caused the break even

distance to decrease to 77.7 km; halving the training benefits (non-referrals reduced to 10%, three equivalent training days) caused the break even distance to increase to 304.2 km.

More efficient use of the teledermatology system almost halved the costs (that is, if each health centre had one morning telemedicine session per week). With current equipment prices and keeping all the other variables exactly the same as observed in the trial, the net cost of the teledermatology consultation falls from £132 to £98. Further details of the sensitivity analysis are available on the *BMJ's* website.

## Discussion

We found that there were no major differences in clinical outcome between teledermatology and conventional outpatient dermatology care. The dermatologist was more likely to recommend general practice follow up of patients seen by telemedicine than conventionally, which may indicate some caution. Almost half of those who were recommended to return for a general practice follow up visit failed to do so. This implies that the videolink management advice was effective and that a return visit was deemed unnecessary by the patient. The review of patient records showed that the teledermatology patients had a lower level of reattendance to both their general practitioner and the dermatology outpatient department compared with patients seen conventionally. This is consistent with results from a randomised control trial that showed that patients make fewer return visits to a general practitioner after a joint consultation with an orthopaedic specialist.<sup>14</sup> However, despite the apparent clinical effectiveness, the cost of the teledermatology consultation was considerably higher per patient compared with conventional care. We examined both the costs and benefits accrued by the health service and the patient. In some ways the trial did not reflect a real life situation as the health centres were deliberately chosen because they were near the hospital. This was done to minimise patient inconvenience and encourage participation.

The actual costs of the teledermatology consultation were calculated over one year, thus the high capital cost of the equipment and the low use (an average of 25.5 patients per health centre in one year) did not make the system economically viable in this trial.

### Factors omitted from cost-benefit analysis

Physical, social and psychological impact on the patient of the skin complaint being resolved sooner rather than later  
 Effect of long waiting lists for a specialist appointment on patient morale and ultimately patient health  
 Avoidance of paying for interim treatments while waiting for specialist appointment  
 Greater convenience to patients of being seen at their local health centre  
 Less time off work  
 Enhanced general practitioner job satisfaction  
 Equipment maintenance and repair  
 Training staff to use equipment  
 Costs of return visits

### What is already known on this topic

Telemedicine is to be implemented in the NHS where it is effective and appropriate

Real time teledermatology consultations are technically and clinically feasible

### What this study adds

Teledermatology is more expensive than conventional consultations because of the cost of equipment and general practitioner time

It becomes more cost effective when patients have to travel greater distances to hospital

Education of general practitioners in joint consultations could reduce the number of referrals

The sensitivity analyses showed that increased use of the system improved its cost effectiveness. The equipment used in the study was purchased in 1995, and these were the prices used for analysis. Current prices for similar equipment of the same standard have fallen by almost 40%, which would reduce costs. In the trial the patient was always presented to the dermatologist by a general practitioner, which increased the costs of the teledermatology consultation. One possibility for reducing costs would be to use a nurse practitioner instead of the general practitioner. Sensitivity analysis showed that if each health centre in the trial allocated one morning session a week to telemedicine and a nurse practitioner presented the patients to the specialist using equipment at current prices, the cost of the teleconsultation was £54.18 per patient compared with the conventional cost of £48.73 per patient. The cost of teleconsultation is still higher because if a nurse practitioner is used because the general practitioner could not apply knowledge gained in the teleconsultations to other patients. If the average round trip distance to hospital was increased from 27 km to 38 km, the costs of the nurse practitioner presenting the patient over the videolink would have been equal to the conventional hospital outpatient appointment.

### Factors not included in study

Some of the factors affecting the cost of teledermatology were not included in the trial design (box). For instance, long hospital waiting lists are common for non-urgent skin appointments. This implies that patients may be paying for interim treatments and losing time from work while waiting for specialist consultations. In addition, not all benefits can be measured in monetary terms—for example, greater convenience for the patient and greater job satisfaction for the general practitioner. The teleconsultations offer unique educational benefits as continuing medical education training courses do not normally use real patients. Finally, we have considered the costs of only the initial consultation; we have not taken into account the costs of the return visits or the fact that there were fewer return visits in the teledermatology group. All these factors bias the results against telemedicine.

In the context of this research trial, teledermatology was not cost effective for society in comparison with the conventional alternative. However, distances



to hospital were relatively short and use of the equipment was low; had each health centre seen 12 patients a week and the patients lived an average of 40 km from the hospital, teledermatology would have been as cheap. Other factors, such as cheaper equipment, would also improve the relative economics for telemedicine. Nevertheless it is clear that, although real time teledermatology is both clinically effective and economic in the appropriate circumstances, it is not likely to be useful in large cities, except possibly for secondary-to-tertiary consulting or for educational use. Its place in the overall management of dermatology patients from primary care, and indeed the place of pre-recorded teledermatology ("store-and-forward") remains to be established in future trials.

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## INFOPOINTS

### *Online appointment booking to rapid access chest pain clinic*

The English National Service Framework for Coronary Heart Disease recommends rapid access chest pain clinics for the prompt management of angina.<sup>1</sup> Moreover, consultations in general practitioners' surgeries should be "structured and guided by the active use of a paper or electronic practice protocol/guideline which includes the indications and arrangements for accessing ... specialist advice [and] exercise testing."

We have implemented a service that provides early, protocol driven access to exercise testing and consultation with a cardiologist. The generic methodology used could be translated without difficulty to other specialties. The service had the following design goals:

- To use web browsers via the NHSNet
- To use the hospital's web server
- To obtain a patient's history
- To use this to determine the need for referral
- To allow flexible booking of appointments with immediate confirmation
- To integrate with local hospital databases
- To allow online entering of exercise test results
- To calculate a patient's risk of coronary heart disease from the general practitioner's data and the exercise test results
- To provide a report with the patient's management plan
- To incur no additional costs for the general practitioners

Since the launch of the service at the Royal Alexandra Hospital in December 1999, 15 general practitioners have referred 100 patients. The median

time for clinic attendance has been three days (range 2-14 days), with 88% of patients seen within a week.

This service represents one of the first web based implementations of a complete protocol-driven booking, analysis, and reporting system. Comments from general practitioners have been positive and appreciative of the rapid response. They have suggested that integrating the system into their computer system would increase its usefulness. This should be achieved in the near future as part of the NHSiS—Scottish Care Information initiative.

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1 Department of Health. *National service framework for coronary heart disease*. London: DoH, 2000. ([www.doh.gov.uk/nsf/coronary.htm#chdnst](http://www.doh.gov.uk/nsf/coronary.htm#chdnst))