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TELEMAM: A cluster randomised trial to assess the use of telemedicine in multi-disciplinary breast cancer decision making

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ABSTRACT

Aim: The TELEMAM trial aimed to assess the clinical effectiveness and costs of telemedicine in conducting breast cancer multi-disciplinary meetings (MDTs).

Methods: Over 12 months 473 MDT patient discussions in two district general hospitals (DGHs) were cluster randomised (2:1) to the intervention of telemedicine linkage to breast specialists in a cancer centre or to the control group of 'in-person' meetings. Primary endpoints were clinical effectiveness and costs. Economic analysis was based on a cost-minimisation approach.

Results: Levels of agreement of MDT members on a scale from 1 to 5 were high and similar in both the telemedicine and standard meetings for decision sharing (4.04 versus 4.17), consensus (4.06 versus 4.20) and confidence in the decision (4.16 versus 4.07). The threshold at which the telemedicine meetings became cheaper than standard MDTs was approximately 40 meetings per year.

Conclusion: Telemedicine delivered breast cancer multi-disciplinary meetings have similar clinical effectiveness to standard 'in-person' meetings.

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1. Introduction

Multi-disciplinary management has been identified as a key factor in improving breast cancer outcomes[1] and is an important element of UK cancer policy[2–5]. A multi-disciplinary meeting has been defined by the UK Department of Health as 'a group of people of different health care disciplines, which meets together at a given time (whether physically in one place, or by video or teleconferencing) to discuss a given patient and who are each able to contribute independently to the diagnostic treatment decisions about the patient'[6]. Despite the widespread use of MDTs throughout the UK the evidence of their clinical effectiveness is sparse and a recent review concluded that most studies on MDTs were observational and retrospective[7]. Telemedicine provides a flexible means to link health care professionals between geographically remote locations (Fig. 1) and to reduce staff travelling time. The application of telemedicine within the NHS has been a priority of the Scottish Executive[8] and its importance to the future delivery of health services in Scotland, building and strengthening collegial networks between health care professionals, is emphasised in the Kerr Report [9]. The feasibility of linking multi-disciplinary teams (MDTs) of cancer professionals at cancer centres and remote cancer units via telemedicine has been demonstrated for breast cancer[10]. However, experience of telemedicine in this setting has been mixed[10,11]. In addition, the literature on the economic evaluation of telemedicine in general is limited. There are few randomised trials in telemedicine[12,13] and no level I evidence on clinical effectiveness and costs of telemedicine delivered MDTs for breast cancer.

We carried out a multi-centre cluster randomised controlled trial to demonstrate equivalence in clinical effectiveness between telemedicine delivered multi-disciplinary breast cancer meetings between two district general hospitals (DGHs) and a university cancer centre compared to standard DGH based 'in-person' meetings. On the assumption that the primary outcome was equivalent in both arms of the trial, we conducted a cost-minimisation analysis.

2. Patients and methods

2.1. *Setting and participants*

The TELEMAM trial took place in two NHS rural district general hospitals (DGHs) and a university cancer centre in Edinburgh (UCC) in southern Scotland. These three units form part of a regional managed clinical network, the administrative framework for breast cancer and other malignancies in Scotland. The breast cancer service at Dumfries & Galloway Royal Infirmary (DGRI) serves a predominantly rural population of approximately 150,000 in SW Scotland, 80 miles from the UCC (4 h round trip by car). Standard 'in-person' meetings of the multi-disciplinary team (MDTs) were held weekly in DGRI, with an oncologist travelling from the UCC. The breast cancer service at Queen Margaret Hospital, Dunfermline (QMH) serves a population of approximately 350,000 and is 15 miles north of the UCC (1 h round trip by car). The 'in-person' MDTs in QMH were also held weekly, with breast surgeon(s), clinical and medical oncologist travelling from the UCC to attend the MDT.

Discussions of all patients with histologically proven newly diagnosed or recurrent breast cancer whose management would normally be discussed at the multi-disciplinary meetings in the two DGHs were included in the trial from March 2004 to April 2005. The trial participants were members of the breast cancer multi-disciplinary teams in these three institutions. Our analysis was confined to core members: consultant breast surgeons, medical and clinical oncologists, radiologists, pathologists and breast care nurses. Patients do not attend the multi-disciplinary meetings and were not directly involved in the trial.

Fig. 1 – A telemedicine linked multi-disciplinary breast cancer meeting between a regional cancer centre (foreground) and a rural district general hospital (right panel) with display of mammograms (left panel).

2.2. Interventions

The weekly breast cancer multi-disciplinary team meetings at each DGH were delivered using telemedicine to link members of the breast cancer team at the DGH to staff at the university cancer centre (Figs. 2 and 3). Staff who usually travelled from the UCC for the 'in-person' meetings were able to remain at the UCC. For the DGRI meetings there were also some additional members of the breast team at the UCC involved in the telemedicine meetings, who did not travel to DGRI for 'in-person' meetings. Telemedicine included viewing of mammograms, CT scans and pathology as well as videoconferencing.

2.3. Telemedicine network infrastructure

Each participating site was equipped with a fully integrated videoconferencing suite for multi-disciplinary team meetings comprising a Tandberg 2500 videoconferencing codec, twin digital projectors, networked PC, microscope and X-ray viewing system for mammograms, CT/MRI scans and plain radiographs. The systems were connected through a mixture of NHS Internet Protocol (IP) networks and Integrated Services Digital Network (ISDN). The core of the network was a Tandberg Multi-point Control Unit (MCU) bridge, gatekeeper and gateway at the headquarters of Lothian Health in Edinburgh.

2.4. Primary outcomes

The primary outcome measures were (a) clinical effectiveness measured by (i) satisfaction of multi-disciplinary team members with the quality of decisions on breast cancer management, (ii) compliance with best practice guidelines for breast cancer (Scottish Intercollegiate Guidelines Network, 1998 [SIGN]) and (b) infrastructure costs of service delivery as modified by cost avoidance due to teleconnectivity. The satisfaction of each member of staff with the decision making process involved measuring their level of agreement for each patient discussion with three statements concerning (a) appropriate sharing of the decision on management, (b) consensus on next steps in management and (c) confidence in the decision made.[14] Responses were recorded by participants on a standardised template using a five point Lickert-type scale from 'Strongly disagree' (1) to 'Strongly agree' (5). We report on the primary outcome measures only.

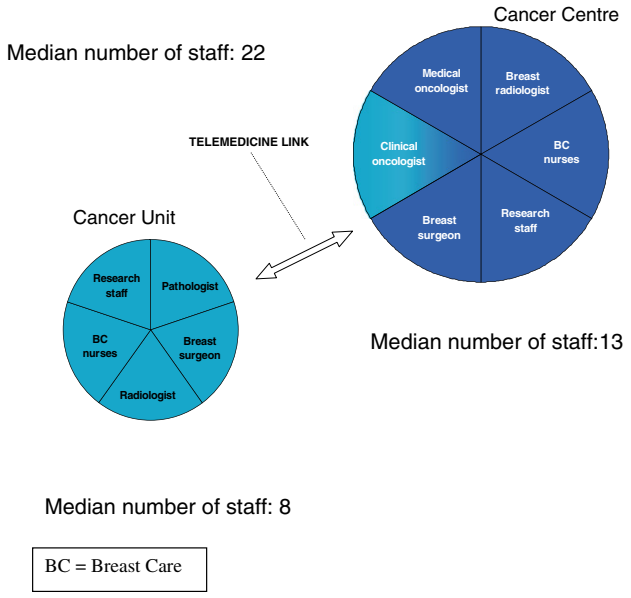


Fig. 2 – Telemedicine linked multi-disciplinary breast meeting between Dumfries and Edinburgh.

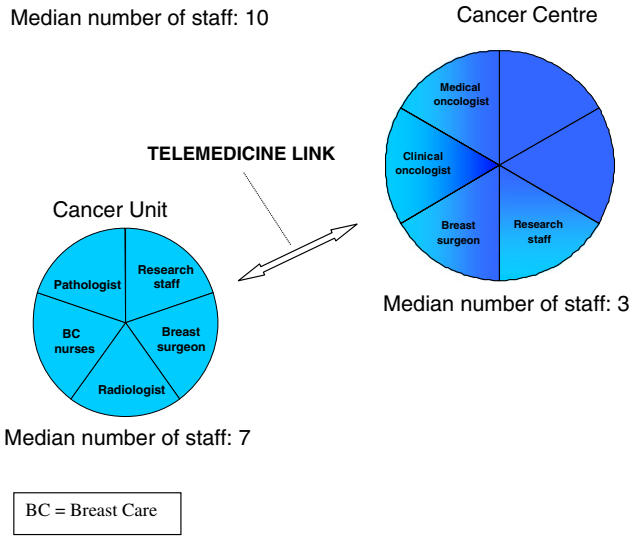


Fig. 3 – Telemedicine linked multi-disciplinary breast meeting between Dumfermline and Edinburgh.

2.5. Secondary outcomes

The secondary outcome measures not reported here were (i) pre- and post-trial attitudes to 'in-person' and telemedicine delivered multi-disciplinary clinics (Personal Report of Communication Apprehension), (ii) measures of objective patterns of interaction, (iii) subjective measures of interaction (Group Behaviour Questionnaire, Group Behaviour Inventory, Group Dimensions Description Questionnaire), (iv) communication content (Interaction Process Analysis), and (v) general dimensions of output (satisfaction with communication, group atmosphere, involvement, trust and agreement).

2.6. Sample size

Based on annual numbers of referrals it was predicted that 230 newly diagnosed patients (150 from Fife, 80 from Dumfries) would be discussed at multi-disciplinary breast cancer meetings in one year. In the absence of previous data for our primary outcome variables it was calculated that a population difference of between 0.38 SD and 0.60 SD would be detected with 80% power at the 5% level of significance, depending on the magnitude of the cluster effect. In practice, discussions of all breast cancer patients were included extending the sample size to 473 discussions.

2.7. Randomisation

Twelve 4 week periods of time (clusters) were randomised, in two permuted blocks of six, to either telemedicine or 'in-

person' meetings in a ratio of 2:1. Thus, within the first 6 months of the trial, four of the 6 months were randomised to telemedicine meetings and two to 'in-person'. Within the second 6 months another similar but independently conducted randomisation was performed.

2.8. Statistical methods

The levels of agreement of the core staff with each statement for discussions at the 'in-person' and telemedicine meetings were compared using a mixed model with mode of delivery and DGH as fixed effects, and 4 week block (cluster), meeting, patient discussion, and core staff member as random effects. This method allows for the potential for correlations between responses within each cluster, within each meeting, within each patient discussion, and from each staff member. The duration of patient discussions in the 'in-person' and telemedicine meetings was compared using a mixed model with mode of delivery and DGH as fixed effects, and 4 week block (cluster) and meeting as random effects. There was almost total compliance with best practice guidelines for the discussions where this was recorded; therefore only descriptive statistics have been presented for this outcome. All analyses were carried out using SAS (version 9.1).

2.9. Economic methodology

Multi-disciplinary care necessitates a commitment to make available the skilled personnel necessary to discuss the management of each patient. 'In-person' MDTs require some NHS staff to travel from the cancer centre to the DGH to attend meetings; telemedicine demands the installation and maintenance of equipment for this purpose. We used a within-trial, cost-minimisation methodology to quantify from a societal perspective the point at which the total cost of the telemedicine meetings would be the same as that of 'in-person' meetings. The economic assessment we undertook was from the perspective of the health service provider. Specifically, we compared the cost of weekly 'in-person' MDTs with the annual number of meetings at which the additional cost of videoconferencing was just balanced by the value of the time saved from the use of videoconferencing. We analysed the clinical effectiveness of telemedicine led and 'in-person' meetings and found them to be equivalent. This led on to a cost-minimisation form of analysis.

The cost-minimisation analysis assumed comparable effectiveness of 'in-person' and telemedicine based MDT interaction, and analysed the point at which the investment in the new technology would be cost neutral to the health service. Accordingly, the investment included technology acquisition, operation, maintenance and management, while the offset was a reduction in MDT personnel travel time and costs. Other modelling assumptions followed accepted practices for a cost-minimisation analysis. The inputs to the cost-minimisation analysis are shown in Table 1. The parameters and assumptions of the economic model are shown in Table 2.

Given the different economic inputs for each MDT site, the point of cost neutrality varies slightly. In this paper, for ease of interpretation, we report on the analysis for breast cancer MDTs conducted between Dumfries and the UCC.

Table 1 – Inputs to cost-minimisation analysis

Parameter	Comment
Costs	
Capital cost	Costs for infrastructure at each hospital
Project management	Operating costs for multi-specialty TM system management, e.g. meeting scheduling, divided by number of sites
IT/AV support	Cost of technical service support, including service contract
Videoconferencing line charges	Cost of on-line MDT meetings, allocated according to technology in place and usage (includes ISDN costs at some sites)
Savings	
Travel cost savings	# Miles multiplied by NHS reimbursement rate (40 p per mile)
Consultant time saving	# hours multiplied by personnel total costs (£50 per hour)
System use	
Share of activity	Breast cancer MDT as a proportion of all system usage, by site

3. Results

Data were collected from 28 'in-person' meetings and 48 telemedicine delivered meetings held between March 2004 and April 2005. There were on average slightly less patients discussed but more core staff at telemedicine meetings than the 'in-person' meetings. Similar percentages of the possible assessments by core staff of the patient discussions were completed in the two arms of the study (Fig. 4). There was a lower median number of patients discussed per telemedicine led MDT (5 versus 7) by a larger median core number of cancer professionals (9 versus 6) than the in-person meetings. The lower total number of patients in the telemedicine led arm was due to a number of factors. There were technical difficulties with the network supporting the telemedicine equipment which led to a failure to complete the planned teleconference on five occasions. The frequency of problems related to the network improved in the second 6 months of the trial. Five meetings were cancelled because of annual leave of a surgeon or clinical oncologist. Three meetings were cancelled because of lack of access to the telemedicine facility because of a prior booking. On two occasions a power cut precluded the teleconference taking place. One meeting was cancelled on one occasion when the telemedicine facility had not been booked in the DGH. In the control 'in-person arm, four meetings were cancelled because of annual leave of medical staff.

There were similar proportions of newly diagnosed cancer, for post-operative assessment, and with recurrent cancer dis-

Table 2 – Parameters and assumptions of the economic model

Parameter	Value	Assumption
Capital cost		
K_1 Teaching Hospital	43,408	
K_2 Hub-and-Spoke Model DGH	37,928	
K_3 Satellite model DGH	37,191	
Share of activity		
α_1	0.60	Breast TM as a proportion of all usage
α_2	0.25	
α_3	0.40	
Project management		
p_1	5000	Divided Teaching Hospital total by 4
p_2	5000	
p_3	10,000	
IT/AV support		
a_1	387	Includes cost of service contract (£387 per room per year)
a_2	2887	
a_3	5387	
Videoconferencing		
v_1	2622	Divided Teaching Hospital total by 4
v_2	2294	
v_3	4343	
ISDN		
s_1	0	
s_2	1116 + 5.3	30 min duration @£10.60 per hour
s_3	n_2	
Travel cost saving	0	
t_2	32	80 miles @ 40 p/mile
t_3	8	20 miles @ 40 p/mile
Consultant time saving		
c_2	225	4.5 h @ £50 per hour
c_3	75	1.5 h @ £50 per hour

cussed during intervention and control group meetings (Table 3).

3.1. *Agreement of cancer professionals with statements about the multi-disciplinary decision making process*

3.1.1. *Sharing of discussion*

The core staff 'Agreed' or 'Strongly agreed' that discussion of a patient was appropriately shared by participants for a very high percentage of their assessments of discussions in both 'in-person' and telemedicine meetings, at 96% and 91%, respectively (Table 4). The mean level of agreement that discussion of a patient was appropriately shared, after allowing for correlation of responses within a 4 week block (cluster), within a meeting, within a discussion, and from the same member of staff, was slightly lower for telemedicine meetings than 'in-person' meetings but this difference was not statistically significant (Table 5).

A total of 16 participants had previously had a little or a great deal of work related videoconferencing experience and 6 had an equivalent amount of videoconferencing experience at home. A training session to show how the teleconferencing equipment worked was made available to MDT participants and attended by a limited number of members. No specific training was provided in how to communicate using videoconferencing within an MDT setting.

3.1.2. *Reaching consensus*

The percentage of assessments of discussions in which the core staff 'Agreed' or 'Strongly agreed' consensus as to next steps in caring for patient was reached by all parties involved was also very high for both 'in-person' and telemedicine meetings, at 96% and 92%, respectively (Table 4). The mean level of agreement that consensus was reached, after allowing for correlation of responses within a 4 week block (cluster), within a meeting, within a discussion and from the same member of staff, was slightly lower for telemedicine meetings than 'in-person' meetings although this difference was just significant at the 5% level (Table 5).

3.1.3. *Confidence in treatment decision*

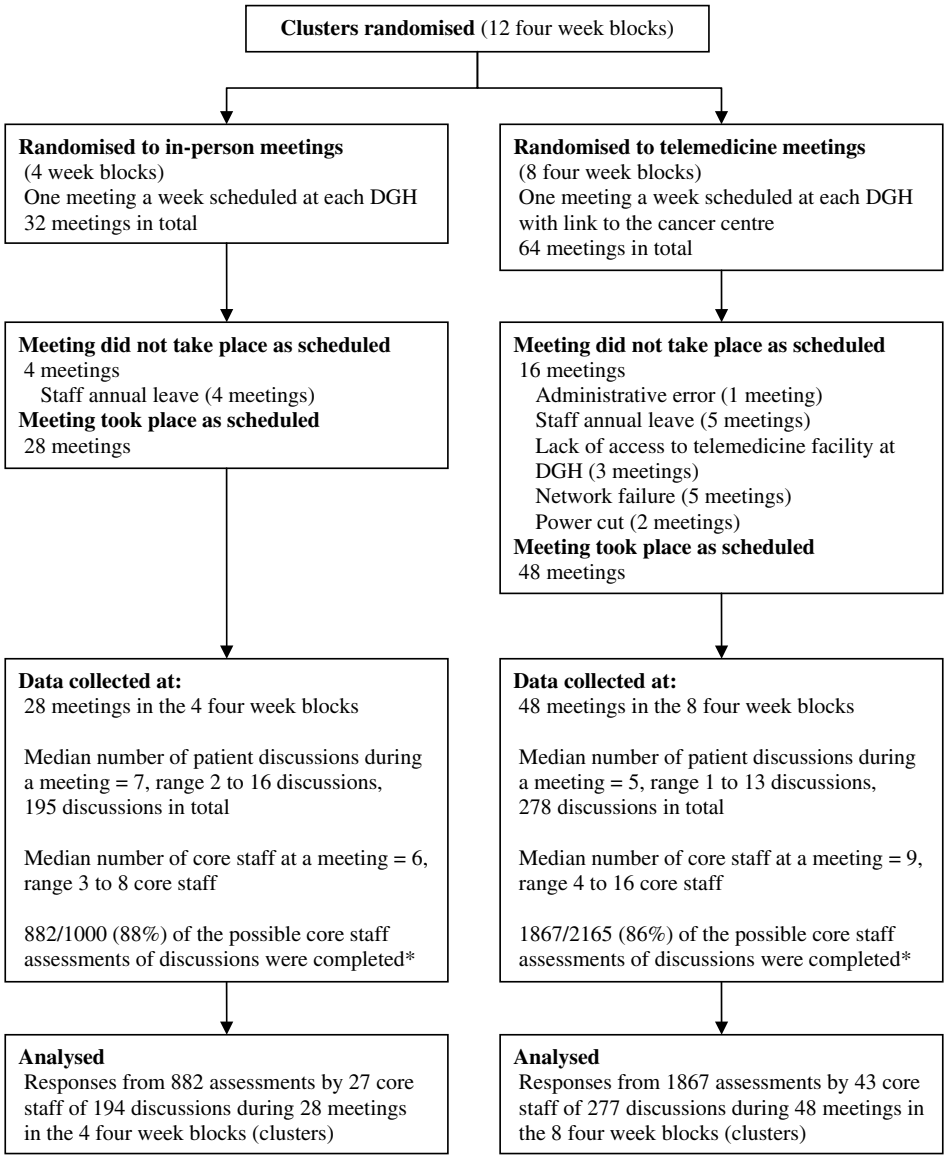
The core staff 'Agreed' or 'Strongly agreed' that they were confident the decision reached was in the best interests of the patient for a very high proportion of their assessments of discussions in both 'in-person' and telemedicine meetings, at 96% and 93%, respectively (Table 4). The mean level of agreement that they were confident in the treatment decision, after allowing for correlation of responses within a 4 week block (cluster), within a meeting, within a discussion and from the same member of staff, was only slightly lower for telemedicine meetings than 'in-person' meetings and this difference was not statistically significant (Table 5).

The estimates of the variance components for the three statements varied as follows: 4 week block (0.003–0.008), meeting (0.028–0.036), discussion (0.000 throughout), staff member (0.086–0.104), and residual (0.175– 0.212). The intracluster correlation coefficient was only 0.036 or less but because of the small number of 4 week blocks (clusters) and the average number of discussions in the clusters the SEs of the treatment differences were increased up to threefold by the clustering. The meeting to meeting SDs were less than 0.2 and the between staff member SDs were around 0.3.

There was no evidence that the effect of mode of delivery on levels of agreement with the three statements about the multi-disciplinary decision making process differed between the two DGHs (hospital by treatment interactions: all $p > 0.26$). There was also no evidence of any difference between the first and second 6 months of the trial in the effect of telemedicine on the levels of agreement (time by treatment interactions: all $p > 0.27$) nor was there any evidence that the category of patient discussed modified the effect of the intervention on the levels of agreement with the three statements (category by treatment interactions: all $p > 0.10$).

3.2. *Compliance with best practice guidelines*

Data were not collected on all discussions since in the early part of the trial capturing the surgeons' provisional



*excludes three core staff who chose not to participate in the assessment of patient discussions

Fig. 4 – Clusters, multi-disciplinary team meetings and patient discussions in the trial.

Table 3 – Category of breast cancer patient discussed at MDT meetings

Category	'In-person' meetings	Telemedicine meetings
Newly diagnosed patients	87 (45)	118 (42)
Patients who had undergone surgery	75 (38)	116 (42)
Patients with a recurrence of breast cancer	33 (17)	44 (16)

Values are number (%) of patient discussions.

preferred surgical management on a standardised template in the notes proved difficult. Subsequently compliance of the decisions with SIGN guidelines on best practice was recorded by the consultants who chaired the multi-disciplinary meetings for 253 (53%) of the 473 patient discussions. At the 'in-person' meetings there was adherence to the guidelines for 100% of discussions (116 out of 116 with compliance recorded). There was adherence in 99% of the discussions at telemedicine meetings (136 out of 137 with compliance recorded).

3.3. *Duration of discussions*

Discussions on individual patients during the telemedicine meetings were on average non-significantly longer ($p = 0.14$) than those in the 'in-person' meetings, mean (SD) of 5.6 (3.7) min compared to 5.0 (2.7) min, respectively, with estimated difference of only 41 s (95% CI: −13 to 96).

Table 4 – Responses by core staff at MDT meetings to three statements about each patient discussion

Statement	Response	'In-person' meetings	Telemedicine meetings
I feel that the discussion of this patient for decision making was appropriately shared by participants	Strongly agree	211 (24)	276 (15)
	Agree	621 (71)	1411 (76)
	Neutral/undecided	33 (4)	106 (6)
	Disagree	6 (1)	42 (2)
	Strongly disagree	0 (0)	14 (1)
Consensus as to the next steps in caring for the patient was reached by all parties involved	Strongly agree	218 (25)	287 (15)
	Agree	632 (72)	1421 (77)
	Neutral/undecided	29 (3)	110 (6)
	Disagree	2 (<1)	31 (2)
	Strongly disagree	0 (0)	8 (<1)
I am confident that the decision reached was in the best interests of the patient	Strongly agree	208 (24)	291 (16)
	Agree	628 (72)	1428 (77)
	Neutral/undecided	34 (4)	115 (6)
	Disagree	2 (<1)	11 (1)
	Strongly disagree	0 (0)	8 (<1)

Values are number (%) of responses.

Table 5 – Responses by core staff at MDT meetings to three statements about each patient discussion scored from 1 for strongly disagree to 5 for strongly agree

Statement	'In-person' meetings	Telemedicine meetings		
	Adjusted mean (SE)	Adjusted mean (SE)	Difference in adjusted means (95% CI)	*p*-Value
I feel that the discussion of this patient for decision making was appropriately shared by participants	4.17 (0.079)	4.04 (0.066)	−0.13 (−0.30 to 0.04)	0.12
Consensus as to the next steps in caring for the patient was reached by all parties involved	4.20 (0.067)	4.06 (0.058)	−0.14 (−0.27 to −0.00)	0.048
I am confident that the decision reached was in the best interests of the patient	4.16 (0.064)	4.07 (0.056)	−0.10 (−0.22 to 0.03)	0.12

3.4. *Economic analysis*

A cost-minimisation analysis balanced the costs and cost savings associated with the use of videoconferencing for MDT meetings. The point of intersection between average cost saving (per MDT) and the average cost (per MDT) indicates the annual number of meetings at which the additional cost of videoconferencing is just balanced by the value of the time savings resulting from its, use ie, the value of physician time that is not spent travelling to an 'in-person' MDT. Using the within-trial data (Table 1), health service investment favoured telemedicine MDT meetings (versus 'in-person' meetings) at a frequency of ~40 meetings/year.

Sensitivity analyses were conducted for three potential future scenarios: S1 – technology costs could halve, S2 – utilisation of the telemedicine system could double and S3 – both the aforementioned scenarios could occur. Given the decrease in the cost of computing and telecommunications technologies, and the current increasing dependence on high technology these scenarios are feasible within an NHS setting. The sensitivity analysis reduces the number of MDT meetings required for telemedicine to be cost neutral to between 20 and 30 meetings per year.

It should be noted that the economic analyses do not take into account personnel preferences for work patterns, the benefits of enhanced inter-disciplinary communication and education, seasonal challenges such as weather influencing travel plans, or the need to continue some in-person MDTs (or DGH clinic visits) to care for specific patients during the study period.

4. Discussion

The TELEMAM trial is, to our knowledge, the first randomised trial providing level I evidence on the clinical effectiveness and costs of telemedicine delivered breast cancer multi-

disciplinary meetings. We found similar and high quality decision making (i.e. appropriate sharing, consensus on management and confidence in the decision) and adherence to clinical guidelines (SIGN) in telemedicine-led compared to standard 'in-person' MDTs. We acknowledge that clinical effectiveness can also be measured longer term in terms of disease free and overall survival. However these endpoints were not realistic within the time horizon of a 1 year trial. Given the high degree of compliance with clinical guidelines in both arms of the trial we think that the differences would be small.

While our study primary endpoints are 'softer' endpoints (versus the 'classical' cancer trial endpoints of morbidity and mortality) they are the standards that would have to be met for telemedicine led joint MDTs between cancer centres and district general hospitals to be incorporated into routine service.

It is recognised as other authors have affirmed that 'in-person' meetings are the gold standard.[11] Telemedicine therefore as a channel of communication has to show equivalence in clinical efficacy.

In our trial levels of satisfaction of MDT members for all three measures of the quality of the decision making (sharing, consensus and confidence) were slightly lower in the telemedicine delivered arm compared to control arm but the differences were small and not statistically significant. There is a learning curve for the use of new technologies and we think it likely that these differences will decline with increased familiarity with the equipment.

The reduced need for cancer professionals to travel to DGHs to participate in MDTs may have a beneficial impact on productivity, e.g. by releasing valuable time for other NHS related clinical or administrative activity.

In addition telemedicine facilities allow greater flexibility in the timing of MDT meetings for busy cancer professionals. Also, when adverse weather conditions preclude travel there is the possibility of maintaining the service by conducting telemedicine MDTs between cancer centre and rural district general hospital thus supporting the equitable access policy promoted by the Kerr report [9].

While proportionately fewer numbers of patients than predicted by the randomisation were discussed in the telemedicine led arm of the trial, we believe this would be significantly increased by more consistent performance of the teleconferencing network. A greater degree of reliability of the network and efficiency of the use of the telemedicine resource should be achievable by higher standards of quality of service guaranteed by providers of telecommunications in the NHS. The larger number of core staff in the telemedicine arm reflects the incorporation of a pool of expertise from the cancer centre. While we did not formally assess the 'added value' to patient care of this link, there were several occasions on which suggestions for different surgical diagnostic procedures and advice on breast reconstruction were made from the cancer centre.

The evaluation of telemedicine services poses methodological challenges, most commonly that the new service, invariably established as part of an independently funded research project, incurs significant initial capital investment and near-term operating costs driven by technology acquisition and maintenance[15,16]. Any delays in service implementation or uptake by users further challenge the chance of demonstrating a positive return on investment irrespective of any offset from greater efficiencies in staff, patient or caregiver resource use, e.g. reduced travel or health benefits. Encouragingly, economic sensitivity analyses of established telemedicine-based services affirm that greater system use and lower technology costs lower the threshold of cost-neutrality to payers[17,18].

The economic modelling was based around different scenarios of projected future cost. It is likely that the costs of a TM service will fall if the hours of usage increase with the extension of the MDT facility to other cancer sites. If this is the case, the point of cost neutrality will be at fewer meetings per year. However, we acknowledge the recognised challenges of cost-minimisation analyses and the limitations of generalising from an economic analysis that use locally derived cost data. We have used a very simple model: (a) the number of MDTs per annum is assumed not to change as a result of introducing tele-meetings, (b) the staff time per 'in-person' and per tele-meeting is assumed the same except for travel time (c) savings in travel time are utilised for work-related rather than leisure purposes, (d) the cancellation of a meeting is assumed to have no cost consequences. If any of these assumptions are markedly at odds with practice our conclusion regarding the number of meetings above which TM is the cost-minimising option should be treated with greater caution. If the introduction of TM leads to more meetings overall or if meetings take longer (more staff time) or if cancelling a meeting is costly (and there are more cancellations with TM) or if travel time savings are used for non-work-related purposes the number of tele -meetings per year required for cost neutrality will rise.

5. Conclusion

We found that in terms of the quality of decision making and compliance with guidelines of best practice, the intra-regional telemedicine delivered multi-disciplinary breast cancer meetings were clinically effective. The point at which the total cost of telemedicine meetings became cheaper than standard 'in-person' meetings was at about 40 MDT meetings per year. Our findings should encourage the service development of telemedicine supported regional multidisciplinary meetings for breast cancer.

Contributors

I.H.K. was the principal investigator, initiated the proposal and was involved in the study design.

I.H.K., R.J.P., R.J.L., J.R.M. and J.C, wrote the manuscript. R.J.P. did the sample size calculation. R.J.L., R.J.P., J.R.M. and J.C. undertook the analysis. R.G.F., J.A.B., J.R.M., J.C., R.J.P., A.D.F.W., J.M.D. and G.N, were involved in the design of the study. A.D.F.W. coordinated the study in Dumfries, A.B. and G.N. in Dunfermline and U.C. and J.M.D. in Edinburgh. I.H.K., J.A.B., R.G.F., J.R.M., R.J.P., J.C., A.B., M.M. and S.S. were involved in the development and evaluation of the study instruments. M.M. and S.S. were involved in the data collection and preparation of the manuscript. T.W.G. was responsible for the de-

sign and running of the Telemedicine network. M.E.S. was responsible for the design of the radiological aspects of the study. All authors approved the final draft of the manuscript. J. MacCoubrey contributed to the initial coordination of the study. G. Stewart assisted with data collection. A.J. Lee established the database and undertook some of the analysis. D. Thom entered the data on satisfaction of the participants into the database.

Independence: All researchers were independent from the funders.

Conflict of interest statement

All authors have nothing to declare.

Ross MacLean is an employee and stockholder of Bristol-Myers Squibb Company.

Ethical approval: Ethical approval for the trial was obtained from the local ethics committees in Dumfries, Fife and Lothian.

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