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Radiology services for remote communities: cost minimisation study of telemedicine

Peder Andreas Halvorsen, Ivar Sønbo Kristiansen

Abstract

Objectives—To determine the social costs of providing a rural population with radiology services under three different systems: the existing system (a small x ray unit at the remote site and all other examinations at the nearest radiology department (the host site)); a teleradiology system (most examinations at the remote site and more advanced examinations at the host site); and all examinations at the host site.

Design—Cost minimisation study.

Setting—Primary health care in a remote community in Norway.

Subjects—A randomly selected sample (n=597) of all patients (n=1793) having radiological examinations in 1993.

Main outcome measures—Annual direct medical costs, direct non-medical (travel) costs, and indirect costs (lost production) of the three options.

Results—After exclusion of costs common to the three systems the direct medical, direct non-medical, and indirect costs of the three options were, respectively, £9000, £51 000, and £31 500 (total £91 500) for the existing system; £108 000, £2000, and £13 500 (total £123 500) for the teleradiology option; and £0, £75 000, and £42 000 (£117 000 in total) for the "all at host" option. Sensitivity analyses indicated that the existing system is the least costly option except when lost leisure is valued as highly as lost production.

Conclusion—The teleradiology option did not seem to be cost saving in the study community. Such systems, however, may be justified on the grounds of equity of access and quality of care.

Introduction

Increasingly, health care systems are under pressure to reduce costs and at the same time to improve the quality of

their services.^{1,2} Teleradiology is a technology which, it is claimed, meets both these ends simultaneously.^{3,4} It entails the transmission of diagnostic images between two locations⁵ within or between institutions. The latter ("interfacility") technology entails transmission from remote sites to radiology centres ("host sites") where the images are interpreted by radiologists.

We examined the possible introduction of an inter-facility teleradiology system⁶ in the municipality of Alta in north Norway. Most (14 000) of the population live in the town itself, the rest (4000) in the surrounding rural area. Like the United Kingdom, Norway has a public (and mainly free) health care system in which general practitioners and hospitals are the core. Currently, most examinations requested by general practitioners in Alta are performed at Hammerfest (general) Hospital, located about 140 km away. Additionally, the Alta Medical Centre (a small rural hospital) carries out some examinations, mainly of the peripheral skeleton, with a small x ray unit. Taken by nurses, the radiographs are interpreted by the general practitioners as there are no radiologists at Alta.

Teleradiology represents an alternative option. With this technology, only a minority of the patients referred by general practitioners would be transferred to Hammerfest. A third option is to perform all radiological examinations at Hammerfest (the "all at host" option).

We determined the costs to society of these three options. Radiology examinations associated with inpatient and outpatient hospital services were disregarded as their costs are equal under the three options. We assumed that the three options have the same health consequences (see discussion below). A so called cost minimisation study was then appropriate.⁷

Methods

Through the computerised patient record system at Alta all referrals (n=1793) to Hammerfest for radiologi-

Institute of Community Medicine, University of Tromsø, N-9037 Tromsø, Norway
Peder Andreas Halvorsen, research fellow
Ivar Sønbo Kristiansen, associate professor

Correspondence to:
Dr I S Kristiansen, National Institute of Public Health, Section for Health Services Research, PO Box 4404 Torshov, N-0403 Oslo, Norway.

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Table 1—Annual costs (£000s) of three different programmes providing radiological examinations for the population of Alta, Norway

Costs	Existing system*	Teleradiology†	All at host‡
Direct medical costs:			
Running costs of x ray unit§	6.0	35.5	0.0
Running costs of electronic equipment§	0.0	24.0	0.0
Hiring telephone lines	0.0	1.5	0.0
Salary	0.0	40.0	0.0
Office accommodation	3.0	7.0	0.0
Direct non-medical costs:			
Patient travel	51.0	2.0	75.0
Indirect costs:			
Production losses	31.5	13.5	42.0
Total	91.5	123.5	117.0

*Minor examinations performed at remote site, rest performed at host site.

†Most examinations performed at remote site, major examinations at host site.

‡All examinations performed at host site.

§Includes interest, depreciation, and maintenance costs.

cal examination during 1993 were identified. One third of these (n=597) were randomly selected for further study. We consulted general practitioners' records, hospital discharge notes, reports from x ray examinations, and the records of the Alta and Hammerfest branches of the National Health Insurance (which refunds travel costs) to obtain information on patients' age, sex, occupation, employer, place of residence, the types of examination, absence from work, travel costs, and costs of accommodation at Hammerfest and of an accompanying person when necessary. We excluded 25 referrals because the patient did not show up for the examination and 19 referrals for other reasons (missing information, etc). The mean (range; SD) age of the patients for the remaining 553 referrals was 45 years (0-90; 18), and 315 were female. Two hundred and seventy one were currently working. On average, 1.65 examinations were performed per referral.

Of these 553 referrals, 164 would not result in avoided travel costs: 49 were concurrently referred to other hospital services, 146 had examinations not provided by the teleradiology unit (for example, computed tomography or ultrasonography), while six patients were living closer to the host site than to the remote site. Thus, teleradiology would be an option for 389 referrals or 1167 for the whole year.

It was not possible to identify the patients currently examined at the remote site. Based on the use of x ray films the annual number was estimated at 900. If we assume 1.65 examinations per referral, these would represent 545 avoided transfers to the host site. Consequently, 73% of the referrals (1167 plus 545) were candidates for teleradiology. These referrals represented about 2800 examinations (84% skeleton, 15% chest, 1% other).

TRAVEL COSTS

Patients' travel costs under the current system were calculated on the basis of detailed information about the 389 referrals to the host site. When the National Health Insurance had no claims data, we assumed that the patient had used a private car. For those examined at the remote site, we included no travel costs related to radiology as these patients had to see their general practitioner anyway.

Under the teleradiology alternative, travel costs to Alta medical centre were estimated on the basis of detailed knowledge of patients' home addresses, local geography, and communication systems. Under the all at host option those currently examined at the remote site (n=545) would have to be transferred and thus add to the travel costs of the current system. On the basis of discussions with the general practitioners the average cost per visit of the study sample (n=389) was used when we calculated these extra costs.

HEALTH CARE COSTS

Assuming the same number of examinations under all three options, we estimated only those costs that were different across the options, thus excluding the costs, for example, of x ray film and interpretation of the images. The current system incurs the costs of running the small x ray unit (£15 000) and a film processor (£10 000) at Alta medical centre. Because of the relatively low number of x ray pictures, no additional staffing costs were included.

The teleradiology option incurs capital equipment costs (a medium sized x ray unit (£140 000), a film processor (£10 000), a 2048*2048*12 laser scanner (£19 200), a 77 GB exabyte robot for picture archiving (£7200), a workstation including two monitors with 1280*1024*8 bits resolution (£12 000), and necessary software (£40 000)); the salaries of two radiology technologists (£34 000 a year); and the cost of storage tapes (£100 a year) and of hiring telephone lines (£1500 a year). It is more time consuming to interpret teleradiology images on a multiscreen monitor than analogue images on a traditional light box.^{2 8-11} As a result we added £6000 in extra radiologist fees. The cost of office accommodation was based on market prices (£80 per m² per year, representing £3000 annually under the current system and £7000 under a teleradiology system).

When calculating the cost of capital equipment we applied a standard annuitisation formula with a 6% interest rate.⁷ The assumed working life of x ray units and film processors was 10 years,¹² whereas six years was assumed for other types of capital equipment. In line with previous reports,^{13 14} the annual maintenance cost for all types of capital equipment was set at 10% of the purchase price. We assumed that implementation of the teleradiology or the all at host option would not result in a change in staffing or the need for x ray equipment at the host site.

COST OF TIME

Having a radiological examination represents a loss of leisure or of production for those employed. The production loss was assumed to be equivalent to the number of hours absent from work (as observed from the claims data) multiplied by the national average hourly wage rate (£10).¹⁵ The cost of lost leisure was assumed to be zero, but alternative assumptions were explored through sensitivity analyses. All costs were measured in Norwegian kroner and converted to British pounds (£1 = Kr10). The study was approved by the Directorate of Health, the National Health Insurance, and the Norwegian Data Inspectorate.

Results

The existing system—The estimated annual cost of running the small radiology unit at the remote site was £9000. On average the patients travelled about 280 km at a cost of 15.7 pence/km (28% public transport, 69% private car, and 3% taxi). Annual costs were £51 000 (table 1) and the estimated production losses £31 500, in total £91 500.

Teleradiology—The annual cost of running a teleradiology unit would be £108 000. Travel costs were estimated at £2000 (table 1), production losses at £13 500. The total cost would be £123 500.

All at host—There were no direct medical costs in addition to those incurred in all three options. The estimated annual travel costs and production losses were £75 000 and £42 000, respectively. This option amounted to £117 000 annually.

Sensitivity analyses—To explore the extent to which these results were sensitive to changes in the assumptions on which they were built we changed one variable at a time upwards and downwards within reasonable limits to estimate the effects on total costs. Teleradiology seemed to be slightly more costly than the

Table 2—Sensitivity analysis: total annual costs (£000s) of providing radiological services under changing assumptions

Variable	Assumption	Total costs (£000s)		
		Existing system	Teleradiology	All at host
Cost of leisure (per hour in £):				
Basic	0	91.5	123.5	117.0
Low	3.33	112.0	132.0	144.0
High	10	153.0	149.5	198.0
Cost of x ray unit (£000s):				
Basic	150	91.5	123.5	117.0
Low	100	91.5	111.5	117.0
High	200	91.5	135.0	117.0
Salary of radiology technologist (£000s):				
Basic	34	91.5	123.5	117.0
Low	25.5	91.5	115.0	117.0
High	42.5	91.5	132.0	117.0
Cost of maintaining x ray unit (% capital cost):				
Basic	10	91.5	123.5	117.0
Low	5	90.5	115.5	117.0
High	15	93.0	130.5	117.0
Cost of electronic equipment (£000s):				
Basic	78.4	91.5	123.5	117.0
Low	51.5	91.5	115.0	117.0
High	104.5	91.5	131.0	117.0

existing system under most assumptions. The ranking of the teleradiology and all at host options was sensitive to small changes in several of the assumptions (table 2). A threshold analysis showed that if lost leisure was valued at £9 an hour teleradiology and the existing system would be equally costly. This would also be the case if the number of referrals was 1755 (instead of 1167) or if the average travel costs were 25.4 pence/km (and not 15.7). If leisure was valued at £1.10 an hour the teleradiology and the all at host options were equally costly.

Discussion

METHODOLOGICAL ISSUES

Even though this study is based to a large extent on empirical data the findings should be interpreted cautiously. Because we concluded, contrary to a previous Norwegian report,⁴ that teleradiology will not be cost saving we intentionally favoured the teleradiology option. Optimal utilisation was assumed, and depreciation and maintenance costs were chosen from the lower end of the scale. Exclusion of the 25 referrals who failed to show up had a similar effect. The total cost of teleradiology might therefore be underestimated.

Both teleradiology and the all at host option would result in small changes (less than 10%) in the current production volumes at the host site. This is why, in accordance with the views of the chief radiologist at Hammerfest Hospital, we believe that these options will not change the need for x ray equipment or staffing here.

The inclusion of production losses in economic evaluation is controversial as it will tend to favour health care programmes directed towards the (potentially) productive.¹⁷ As there were no such ethical concerns in this study we included production gains.

In line with common practice the cost of leisure was set to zero.⁷ "Leisure" here includes non-market work such as childcare and household tasks. Valuing leisure above £9 would change the conclusion in favour of teleradiology. In a previous study, however, a much more modest value was reported,¹⁸ and we doubt that the patients really would be willing to pay as much as £9 an hour to avoid a trip to Hammerfest. Valuation of leisure is a controversial issue, but a further discussion is beyond the scope of this paper.

HEALTH OUTCOME OF THE OPTIONS

Possible variation in the quality of the imaging is a central issue. Though some studies indicate that the

diagnostic performance of digitised images and teleradiology systems is just as good as that of analogue images,^{10 19-24} others conclude that it results in an inferior performance.^{9 25-29} Such conflicting results seem to depend on the type of investigation, the spatial resolution of the systems,³⁰⁻³⁵ and various other factors.³⁶⁻⁴¹

Radiographs taken by nurses and read by general practitioners (current system) might yield inferior diagnostic performance compared with the all at host option. Limited resolution of the workstation monitors (teleradiology) might have a similar effect. A possible reduction in diagnostic performance, however, will not necessarily have clinical consequences.¹⁹ Unfortunately, imaging technologies are infrequently tested with respect to health outcomes.^{1 42} Lacking any hard evidence here,⁴³ we assumed equal health outcomes between the options, even if in practice the quality of imaging might differ.

UTILISATION

An increase in the annual number of referrals by about 590 would make teleradiology a cost saving procedure. Recently, it was claimed that the number of examinations performed is too high in Norway.^{44 45} As Alta already has a utilisation about the national average we doubt that any further increase through teleradiology is desirable.

EQUITY ISSUES

The concept of equal access to quality care for equal need is central to most health care systems. Clearly, teleradiology systems can be seen as an integral part of efforts to meet such equity objectives. Firstly, teleradiology will increase access to care. Secondly, it might improve the quality of imaging in remote areas. Thirdly, it may help the recruiting and retaining of physicians in rural areas.⁴⁶ Offering general practitioners the opportunity to be involved with high tech medicine such as teleradiology is likely to increase job satisfaction.

CONCLUSION

Whether interfacility teleradiology systems are cost saving will depend on the size of the populations served, the utilisation rates, the travel distances, and the relative magnitude of the cost components. In our study, the total costs of the different options were not very different, but teleradiology systems may be justified on equity and quality grounds even if they are not cost saving.

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Key messages

- Teleradiology entails transmission of diagnostic images through electronic networks
- Few, if any, studies of the cost effectiveness of this technology have been published
- This study indicates that in remote primary health care, teleradiology is not less costly than conventional technologies
- Teleradiology may be justified as a means to increase equity in access to high quality health care in remote communities
- The subject calls for further studies in other countries

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Prospective study of hepatitis B vaccination in patients with chronic hepatitis C

Voishim Wong, Tim G Wreghitt, Graeme J M Alexander

Department of Medicine,
University of Cambridge
School of Clinical
Medicine, Addenbrooke's
NHS Trust, Cambridge
CB2 2QQ
Voishim Wong, research fellow
Graeme J M Alexander,
lecturer

Department of Virology,
Addenbrooke's NHS Trust
Tim G Wreghitt, honorary
consultant virologist

Correspondence to:
Dr Alexander.

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Chronic hepatitis C results in liver disease, cirrhosis, and hepatocellular carcinoma. Its prevalence is estimated to be 70-92% among intravenous drug misusers,¹ who are also at risk of parenterally or sexually transmitted hepatitis B. Coinfection with hepatitis B virus may accelerate underlying liver damage due to hepatitis C.²

Effective vaccines against hepatitis B have been available for a decade.³ Universal vaccination is being adopted in countries where hepatitis B is common. When vaccination has been targeted at promiscuous people and intravenous drug misusers uptake has been suboptimal and the incidence of hepatitis B has increased.⁴⁻⁵ We therefore investigated whether carriers of hepatitis C were being vaccinated against hepatitis B.

Patients, methods, and results

We prospectively studied 126 consecutive patients attending our hepatology clinic who had positive results for antibodies to hepatitis C virus in two second generation enzyme linked immunoassays (ELISAs; Murex Diagnostics, Dartford, and Sanofi Diagnostic Pasteur,

Guildford). Their median age was 38 years, and 86 were men. We documented demographic details including risk factors. Each patient was asked about the number of health service workers with whom they had had contact since they knew that they were positive for antibody to hepatitis C virus and whether they had been advised to be vaccinated against hepatitis B. Hepatitis B surface antigen, hepatitis B surface antibody, and hepatitis B core antibody were measured in Amerlite assays (Johnson and Johnson Diagnostics, Amersham).

Eighty eight patients were intravenous drug misusers, 22 had been exposed to blood or blood products, and 16 had no identifiable risk factor. Table 1 shows the results of serological tests for hepatitis B. Seventy five patients were negative for all serum markers of hepatitis B and were therefore still at risk; 52 of them had a history of drug misuse. None of the 75 patients had been offered vaccination, though they had seen an average of two doctors (range 1-4) and other healthcare professionals between being diagnosed as having hepatitis C and attending this clinic. Only nine of the 126 patients said that they had been advised to be vaccinated because of the risk of hepatitis B, and seven had followed this advice. Three further patients had been vaccinated because of travel or occupational risk.

Comment

In this series 41% of patients had been infected with hepatitis B (51/126), confirming the risk in carriers of hepatitis C. Only 7% (9/126) had been offered vaccination, although hepatitis B could have been prevented by