International Journal of Technology Assessment in Health Care, 15:1 (1999), 220–235.

TELEMEDICINE

What Happens in Remote Consultation

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Abstract

The results of a field study of three sites that used video to link primary care medical centers to hospitals are reported. The analysis was concerned with identifying the people involved, the tasks carried out in collaboration at each end of the link, and how the different communications facilities helped or hindered. The results are summarized as six task characteristics and their design implications for this model of telemedical consultation are discussed.

Keywords: Telemedicine, Computers, Communications Media, Primary Health Care

IMAGES AND TELEMEDICINE

A literal treatment of the term "telemedicine" results in a simple combination of "distance" and "medicine." One would be hard-pressed to identify a modern system of medical care that does not make extensive use of the coordination of relevant parties over distance, the telephone being an obvious case in point. However, in the modern idiom, telemedicine has come to be identified with the delivery of care via high-technology communications equipment and, in particular, the transmission of images.

Some of these telemedical services are now beginning to have a significant impact on medical practice, notably teleradiological consultation. In contrast, those services attempting to include images of the various parties in consultation, a technological attempt at "really being there," are conspicuously rare (17). Although some evidence suggests that the addition of this kind of video to an audio link might improve teleconsultation (12), at least one major investigation in the 1970s failed to demonstrate any advantage for audio-video links over audio alone (5). McLaren and Ball (9) describe the successes that have been reported as "little more than feasibility studies" and conclude that simply using the telephone or analogous audio-based technologies for telemedicine may provide as much benefit as an audio-with-video communications facility (hereafter "video link").

The authors were supported by the Economic and Social Research Council's Cognitive Engineering Programme (Grant No. L127251024): http://www.cogeng.gla.ac.uk. Thanks for help in arranging these contacts are due to the Advanced Media Unit at BT Research Laboratories, Martlesham Heath, Ipswich. We are also grateful for the time given by all our informants.

Table 1. Some Alternative Ways to Configure a Video Link[a]

Dimension	Examples of alternatives	Potential value of alternative
Viewpoint	Over-the-shoulder	Same view of work as remote partner
	Opposing	Can see remote partner's face
Scope	Whole room	Can see context/working environment and who else is present
	Upper body of remote partner	Can see gestures and what they are looking at
	Head and shoulders only	Clearest view of facial expressions
Resolution	320 × 240 pixels (common digital image resolution)	Sufficient for small scope image or where fine detail is not required
	625 × 500 pixels (equivalent to domestic TV)	Sufficient for moderate detail
	1,024 × 768 pixels (large-screen computer display)	Needed for high resolution images such as x-rays
Refresh rate (i.e., rate of image transmission)	Transmitted or "canned" still image	Powerful reminder of whom one is talking with (2)
	Slow-scan video	Sufficient to tell who is there and much of what they are doing
	Full-motion video	Needed for lip reading and interpreting rapid gesture

[a] If one provides more than one image, the number of possibilities is multiplied further.

The nuances lent to "real" face-to-face interaction by the visibility of those involved is known to be of importance (1), yet research on video communication outside of the medical arena is similarly equivocal. Benefits of using technology to provide images of people communicating with one another have proved elusive (13;22). While there may be no dramatic effects on "productivity" in the short term, the subtle effects observed may be very important to the users of this technology (10). On the other hand, experimental studies at this laboratory have shown that interpersonal awareness and synchronization of behavior is enhanced in discussion and negotiation tasks when such images are provided (21). It is also clear that the benefits of a video image of the person to whom one is talking depend on the form that the images take, as well as the tasks being performed (19).

To use a medical analogy, there is a danger of treating telemedicine as if it were a kind of drug. It may be better conceived as analogous to a new method of drug delivery. When skin patches were first considered, research was required to decide on their physical configuration, e.g., their size and the materials used. Such questions cannot be addressed without considering the drugs to be delivered by these different configurations of skin patch, and the conditions in which they might be applied. It does not make sense to attempt a clinical trial of skin patches per se; it must be a trial of skin patches constructed in a particular way and used for a particular purpose. The point is that before trying to answer questions about the efficacy of telemedicine, it is similarly important to distinguish how it is configured and what is to be delivered.

There are many ways that a video link may be configured. Table 1 lists some examples. The position of the camera and the focal length of the lens may be varied

to provide different viewpoints and scope. The way the image is processed and transmitted will usually trade off between resolution and refresh rate. Combining the alternatives in Table 1 alone results in 36 possible configurations. Furthermore, if more than one view is to be delivered, images can be combined in various ways, further enlarging the number of alternatives.

As is implied in the "potential value" column in Table 1, these alternative configurations will be more suitable for some purposes than others. In the analysis of teleconsultation below, we identify component tasks such as determining the patient's history, discussing possible treatments, viewing the patient's problem (e.g., a wound), and diagnosing from an x-ray. Only by understanding the nature of the work and the sorts of material required to support it can predictions be made about optimal configurations for different aspects of the work.

When evaluated in an experiment or clinical trial, a particular video configuration used for a particular medical task may not appear to be more effective than audio alone. However, such evidence gives no indication of the suitability of video links for other kinds of medical tasks or in other configurations. Conversely, positive evidence for the value of some technological implementation to support an aspect of medical care does not recommend the deployment of video links implemented in other ways for other tasks. If the technology is to support the task, then the work done in telemedicine must be described. Our research background is in human–computer interaction (HCI), where this is a major preoccupation. In HCI, "task fit" is seen as a major criterion for success and is formalized in the International Standards Organisation's definition of usability (ISO 9241, parts 10 and 11). Task fit can only be achieved through a proper understanding of the tasks, that is, the work the user is trying to achieve.

In this article, we describe findings from three field studies of a particular kind of telemedical consultation, in order to determine something about the nature of the collaborative work involved. It is important to understand that viewing work as a specific set of tasks necessarily restricts the scope of the conclusions drawn: although they may have wider applicability, the method does not underwrite the relevance of findings to wider sets of tasks. Telemedical consultation can cover a variety of activities. The kind of telemedical consultation dealt with here was primarily a collaboration between more than two parties. These included at least a general practitioner (GP) or nurse practitioner (henceforward, primary care practitioner), the patient, and a remote specialist at a hospital. Although there were no formal criteria for selecting cases, telemedical consultations occurred only when it was not clear that a patient should either definitely be referred on, or should definitely be dealt with locally. Thus, these patients in some sense represented "gray areas" of the primary care practitioners' expertise.

Our objective is to draw out some of the characteristics of this work, to examine how these characteristics interacted with the technology provided in the sites we studied, and to suggest some alternative technological solutions. This emphasis on the way the work is organized allows us some confidence in the pertinence of our findings for the design of communications technologies in this deliberately limited context. Indeed, it is likely that the characteristics described have some wider application and so, it is hoped, they will help to inform other kinds of telemedical communications where these characteristics are also to be found. Rather than an implausible cookbook of universal solutions, we intend to provoke the reader to ask about their own situation, the people and resources involved, and whether some form of telemedical consultation might be appropriate in their own setting. This is

Table 2. The Three Sites Visited and Interviewees by Occupation

Site	Linking	Speciality	Staff interviewed
A	Aberdeen Royal Infirmary with Peterhead Community Hospital	Accident & emergency	1 consultant, 4 registrars, 2 GPs, 2 nurses, and the department manager
B	Belfast Royal Infirmary with minor treatment centers in the Westminster area of London	Accident & emergency	1 consultant, 2 nurse practitioners, 1 medical director
C	Two hospitals with GP practices, all in North London	Various	2 researchers, 1 GP

done by presenting a number of issues for design arising from the characteristics we have identified.

THREE SITES VISITED

Three sites were contacted and subsequently visited where video links are in regular use to support telemedical consultation (Table 2). Although site C is specifically a research site (see Harrison et al. [6] for a description of this project and some of their results), all three employ ISDN-2 video links to support the provision of treatment advice in the course of discharging their regular medical responsibilities. For sites A and B, the consultants had agreed to be permanently on call. For the third, the telemedical consultations were arranged by appointment only. The patient would simply come to their local practice rather than traveling to see the consultant. The consultant receives a referral letter in the conventional manner and thus has some idea of the nature of the case prior to the consultation. Site A had a teleradiography system in place, such that the consultant could view a patient's x-ray for a few moments prior to the consultation. Site B was a walk-in clinic staffed by nurse practitioners rather than GPs. Here, the presence of the video link was one of the major factors supporting the existence of this relatively new model of primary care.

DATA COLLECTION

Data were gathered primarily through interviews, variously conducted by the authors, using a specially devised interview schedule (Appendix 1). It was made clear that the interviewers were neither advocates nor detractors of the equipment concerned and in receipt of no material reward on behalf of any supplier of such equipment. It was explained that the purpose of the interview was to try to find out what made systems like the one at the respondent's site easy or hard to use. The schedule was designed to take the informant through a typical consultation, from switching on the equipment through completing any necessary records at the end of the consultation. Elaboration with reference to specific incidents in the informant's experience was encouraged throughout.

Seventeen informants were interviewed in this way (Table 2), including consultants, registrars, GPs, nurse practitioners, and registered nurses. The experience of the informants with the equipment varied from one to over 40 telemedical consultations. Additionally, two managers were interviewed to provide some background on the intended use of the facilities. Whenever possible, informants were interviewed at the place where the relevant equipment was installed and were

asked to indicate specific points with reference to that equipment. The majority of interviews were audiotaped for later review to supplement note-taking. Video recordings were made of these demonstrations. In addition, a video recording of one consultation was made by one of the authors and a further collection of four videotaped consultations was made available by site C.

ANALYSIS

A diagrammatic notation was used to summarize the data obtained from each site. This records the clinical practice followed at that site, and particularly, what communication technologies were used to carry out the component tasks involved. Examples of such communications usage diagrams (CUDs) (11;20) are presented in Appendix 2. The three CUDs included describe site A. The first two columns list the activities carried out at each end of the link with the people present there. A distinction is drawn between primary and peripheral participants, in a similar way that a conversation involves speakers and addressees, on the one hand, and overhearers on the other (15). The primary participants in a particular activity are named with the activity they are doing. Peripheral participants are the people who were also present, who might observe or hear what was going on. They are listed in brackets under the activity. Thus, when the GP and consultant are discussing the patient's history, they are the primary participants and the patient might be considered as a peripheral participant, depending on how the GP and consultant include or exclude them from their discussion. In this case, peripherality seems temporary and perhaps not of any great interest. However, consider the nurse also included in the diagram. Often, this would not be someone whose specific responsibility was to attend the consultation, but someone whose own work would require close physical proximity with the video link. From here, they may be recruited or volunteer to become a part of the consultation.

The activities are divided into task phases by means of horizontal lines. The first three task phases are preliminary to the consultation: a) switching on in the morning; b) initial examination and radiology; and c) transmission of x-ray (Appendix 2: CUD1). There is then a making contact task phase: a call is made, greetings and introductions take place, and the GP and consultant may briefly discuss previous cases. The next task phase, presented as Appendix 2: CUD 2, is one of discussion and diagnosis. The GP, consultant, and patient discuss the problem, the history, and the treatment. The consultant may also view the problem and the GP and consultant may discuss the x-ray. Finally, there is a closure phase (Appendix 2: CUD 3), where the connection is closed and the GP and patient discuss treatment.

Where it was necessary to coordinate activities across the link, the communication medium used and how it was configured are identified in the third column. The last column lists the advantages and disadvantages conferred by using these communication media, with regard to these particular tasks. For example, in the discussion and diagnosis task phase (Appendix 2: CUD 2) it was noted that there are four advantages and two potential disadvantages to using the hands-free audio that allows peripheral parties to overhear. These potential advantages and disadvantages are the main result of the analysis. They are mostly reported directly by our informants; some are inferred by observation of the taped sessions. In each case the "+" indicates a reported or inferred advantage and the "–" a disadvantage. In each case, who is affected is indicated, e.g., "+ for GP." Some of these advantages

and disadvantages are associated with very specific activities, and some are more generally applicable.

The CUD notation makes it possible to integrate all the disparate information gleaned from a particular site and to reason about the consistency of the accounts given. The findings described below were abstracted from the CUDs built from the data obtained at each of the three sites.

FINDINGS

Findings are presented in two forms in this section. Six task characteristics were identified and are each described with reference to the field studies. The implications of these task characteristics are then postulated as a series of issues and suggestions for any practitioner to consider for the design of such a facility to support their own work.

Task Characteristic 1: Consultation Is Mainly About Talking

Seeing one another is compelling, but a consultation involves parties communicating primarily by talking. The consultant wants to know the patient's history and the patient's view of the problem; the primary care practitioner and patient want to be sure that the consultant has all the relevant information. At the end of the consultation, the patient wants to have a clear idea of what is going to happen next, and the consultant and primary care practitioner want to know that the patient understands what he or she has to do.

All three sites included the use of telephone handsets as an alternative to hands-free (loud speaker and microphone) operation. Handsets allowed conversation between pairs of people to be carried out reasonably well. However, the audio quality for hands-free operation varied from poor to unacceptable. Quality is highly sensitive to the relative position of the contributing parties in the room, to the speaker and microphone, and to the volume of speech. Echoing, and technological attempts at dealing with it, render much of the speech stilted and prone to break-down. Users of the link have adapted their speech styles to cope, speaking slowly and with longer pauses between speakers, and report that doing so requires effort and concentration.

Task Characteristic 2: Consultation Often Involves Several People

As discussed earlier, the nature of telemedical consultation as studied here was inherently collaborative. There are some important consequences of having more than two parties. Again, careful consideration should be given to who might be around and thereby become legitimately involved with a telemedical consultation. Overhearing the primary participants in conversation is a tremendously efficient way of understanding what is going on and securing the best exchange and contribution to a consultation. It relieves the participants of any requirement for repetition to the other interested parties and simultaneously guarantees that all concerned have been in receipt of the same information during the consultation. One task recorded in CUD 2 is for the GP and consultant to discuss the patient's history. At this time, the patient and the nurse, who are also present in the treatment room at the Peterhead end, are both peripheral participants (coded as "P, N" in parentheses). The CUD records that the patient may interject, leading to a discussion between consultant and patient, something that is unlikely to happen if the GP and consultant are talking over the phone.

Despite the poor sound quality that resulted, all three sites normally used the hands-free sound, which makes overhearing and interruption possible. A good example of timely interjection arising from overhearing occurred during one of the video-recorded consultations at site C. Here, a GP had booked a consultation with a pediatrician to discuss dizzy spells experienced by an adolescent girl. The girl's mother was also in attendance. One of the lines of questioning pursued by the consultant concerned the girl's eating habits: "and you're a pretty good eater?" The girl replied in the affirmative. Her mother, having overheard the consultant's question, was able to contradict the girl. Had the girl been using the telephone handset, her mother would not have been able to contribute in this way. She would have heard the girl's reply alone, i.e. "yeh," without the conversational context to interpret this reply. It may be that the mother planned to volunteer information of this kind. However, the indirect opportunity to do so made the contribution easy and highly appropriate.

Such contributions can be spoken or signaled visually. In the example, the girl's mother spoke to the consultant. However, the audio transmission equipment at the GP end of the link failed to register her speech. The consultant could see her head shake and failed attempt at speech, and followed it up with a direct question. Here, then, the video link was used to recover and carry forward an abortive attempt at speech.

Task Characteristic 3: One Needs To Know Who Is Listening

Effective speech is "designed" for its expected recipients (14). As individuals speak, they choose words appropriate for their audience. For familiar listeners, the selection process is practically automatic: we know who they are, the kinds of ideas they are familiar with, and so on. In this instance, for example, the consultant must estimate the degree of medical knowledge of the primary care practitioner and the kind of language the patient will understand. Furthermore, experience in dealing with people over successive encounters builds up and the sophistication of the common ground (3) they share is correspondingly amplified.

Should a consultant remember that the primary care practitioner concerned has seen a similar case previously, it is possible to avoid much of the ground work otherwise necessary to establish baseline knowledge levels, or confidence and competence, in these "gray area" cases. This issue is particularly important where novel technologies are concerned, since there is little in the way of specialist knowledge or descriptive language that can be assumed for coordinating the consultation process. So the history shared between consultant and primary care practitioner can be drawn upon to deal with the new situation more efficiently. Seeing someone is a very powerful memory aid for previous encounters with a person, far more so than the person's name (2).

Patient, consultant, and primary care practitioner need to know who else can see and hear. Simply being present can have an effect on the kinds of things discussed. For example, in a sensitive case, the consultant may wish to discuss particulars with the primary care practitioner "off-line." Alternatively, if a nonmedically trained third party such as a technician were present, there may be some reticence on the part of the patient to discuss intimate matters, or it may be that the consultant wishes to ask the patient something that might not reflect well on a relative who is present.

More commonly, it is advantageous for peripheral parties to overhear as in the example described above, where the mother of a patient intervened in a conversation

between patient and consultant. Similarly, a nurse overhearing the discussion between GP, patient, and consultant may more easily carry out and explain treatment at a later stage. Peripheral participants are more likely to benefit from overhearing the primary participants if the people conversing know they are there and design their utterances appropriately.

Task Characteristic 4: Understanding Must Be Monitored To Ensure Effective Communication

In tandem with the selection of words and phrases (Task Characteristic 3) is a two-way monitoring process to check that the words used have been effective. Over the course of a consultation, the picture of what is known and what can be understood by listeners is clarified.

Implications for Design: Issues 1–4

Issue 1: High-quality Multiparty Sound Is a Primary Requirement in Teleconsultation. Although the salient characteristic of a video link is, of course, the video component, the implications of Task Characteristic 1 is that much more work is carried out through the audio component than by video. Task Characteristic 2 further suggests a requirement for multiparty audio, and this is technically difficult to achieve. Guidance in the positioning of participants with respect to the video link's audio equipment may well pay dividends. Also, the effective use of sound-deadening material may reduce false-switching and break-up of speech. Alternatively, each participant could be given a separate radio microphone. In general, more resources should be directed at the audio side of the link, in terms of the computing power and development work, especially on echo canceling.

Issue 2: The Remote Consultant Will Benefit from a View of the Faces of the Patient and the Primary Care Practitioner. When several people take part in a conversation (Task Characteristic 3), coordinating who will speak next becomes a significant issue (4). While taking turns in two-party conversations by audio alone is not problematic, not being able to see those with whom one is conversing may hamper a three-party conversation. A view of the faces of the patient and the primary care practitioner may also facilitate the monitoring of understanding (Task Characteristic 4). While it is perfectly possible to achieve this monitoring process just by sound alone (listening for verbal confirmations, etc.), there may well be a case to be made for the appropriateness of visual monitoring in some sensitive medical contexts and when difficult decisions have to be made.

Issue 3: The Remote Consultant Will Benefit from a Wide-Angle View of the Whole Treatment Room. If peripheral participants are to overhear, then it is important that the remote party knows who they are (Task Characteristics 2 and 3). Current facilities are more than adequate for the visual identification of the parties concerned, provided they are within camera shot. Unfortunately, the video links are often placed in small spaces where it is difficult to arrange for all concerned to be within the range of the camera. For this purpose, a suitably positioned wide-angle camera is needed. A very slow image update would possibly suffice for this purpose, or even a still from the beginning of the consultation.

Task Characteristic 5: There Are Points Where Participants Need To Share Visual Information

Despite what has been said about the importance of speech, there are points in the consultation where participants need to make use of and share visual information. Site A's video link was provided in conjunction with a teleradiography link.

The primary care practitioner and consultant could talk effectively about an x-ray visible to both. The other sites used roving cameras to provide an image of the injury. The teleradiography worked well, the roving cameras did not. The reasons for this are instructive.

The x-ray was prepared by conventional means and then scanned to transmit it. When discussing the x-ray, the medics at each end of the link both viewed the same electronic representation. For the mobile cameras, the digitizing process used was very sensitive to camera movement. Movement of the camera or the patient resulted in significant break-up of the image seen by the consultant. This problem was compounded as the image provided by the camera was visible locally but in an undegraded form. Because the person manipulating the camera could not see the problems caused by small movements, it was very difficult to learn to avoid them.

Implications for Design: Issues 4 and 5

Issue 4: Parties at Each End of the Link Need To Have the Same Image of the Problem. To diagnose effectively, both the consultant and primary care practitioner need to see the object of discussion clearly. In addition, to communicate they must have access to relevantly comparable images. The teleradiography worked well because the GP and consultant were presented with the same digitized x-ray image. The remote camera was less effective because the image was often poor and was not the same at the two ends of the link. The use of a camera tripod and stable rests to keep the patient still are essential if a usable image is to be transmitted to the consultant. Freeze frame or slow scan may be quite adequate in this instance, although full movement may be needed for remote observation of manipulation and palpation. If the image is subject to transmission problems, there may be an argument for simulating the same problems at the local end. If the local image had been subject to the same problems of breakup as the remote one, it would have been easier to avoid them and to coordinate on providing the best possible image.

Issue 5: Facilities for Remote Pointing Will Be Valuable. Where there is not a common language for describing things, gestures and particularly pointing are very useful. McCarthy and Monk (7;8) argue that the ability to point to a shared visible artifact accounts for the extreme efficiency of many utterances in everyday communication (also see reference 18). It can be very difficult to consult about some visible feature using only words. Specialist training equips medics very well with the ability to describe with precision. However, for the kind of consultation considered here, the level of uncertainty can tax powers of verbal description into the extreme. Being able to refer by pointing or to use figural gesture provides a great opportunity for easy and efficient communication.

Task Characteristic 6: Patients Need To Be Confident in the Result of the Consultation

A visit to the doctor is primarily about dealing with a problem that the patient has, namely getting well again. When patients leave their primary care practitioner, they want to feel as if they have been dealth with appropriately and that they are on the road to recovery. This is an issue of confidence in the system of care that they have experienced. Confidence is not just for the benefit of the patient, since if they are not happy that they have been dealt with properly, they will almost certainly return at a later date, entailing additional costs for the health service concerned.

Implications for Design: Issue 6

Issue 6: Allowing the Patient To Hear the Voice and See the Face of a Remote Consultant Bolsters Patient Confidence. All those interviewed reported very positive patient reaction to telemedical consultation. Though no patients were interviewed in these field studies, a questionnaire study of 43 patients at site C, reported by Harrison et al. (6), revealed that 86% questioned after a teleconsultation agreed with the statement, "I felt the consultant could understand my problem" (10% disagreed, 4% neither agreed nor disagreed). A similar number of patients agreed with the statement, "I was able to say all I wanted" (86% agreed, 12% disagreed), and given the statement, "After using the television link this is how I would feel about using it again," they responded "positive" (84%) rather than "neutral" (16%) or "negative" (none). Taken together, these figures back up the view of the medics interviewed in our study.

Although a medical consultation involves much more than inspection and manipulation, the notion of "being seen" by a doctor may be far more closely identified with proper treatment by the lay person. The visibility of the consultant was repeatedly said to be instrumental in securing patient confidence by those interviewed. Whether this is a consequence of seeing the consultant or seeing the consultant seeing them, or indeed of being a party to the consultation between primary care practitioner and consultant, the overall value of the communication link in securing patient confidence in the care they receive would appear to be high. Our findings suggest that three-way sound may also foster confidence by helping the patient understand what is going on.

GENERAL CONCLUSIONS

Wootton (23), a leading proponent of telemedicine, has pointed out that equipment is often implemented in the vague hope of some technological panacea. Rather, it must be implemented with a clear idea of why it is being used. To quote him: "purchasing the equipment will not guarantee success, any more than buying a scalpel will turn you into a surgeon" (23, 1377). This article offers a way of thinking about the aims of telemedicine. Teleconsultation is viewed as a set of tasks carried out jointly by a number of people with different levels of medical and technological experience and subtly different objectives. The aim of the analysis carried out is to design equipment that facilitates effective and efficient transfer of information for the purposes of building a common understanding, in pursuance of getting some job done.

From this analysis, six possible ways in which the current technology could be used more effectively are suggested as issues 1–6 above. The first, and probably most important, is the need for better multiparty sound. In the long term the technological work and computing power required to achieve this may be expensive, but in the short term much may be done by adjusting the position of speakers and microphones and by changing the sound-absorbing properties of the rooms used.

Taken together, issues 2, 3, and 4 suggest the transmission of multiple images: a) an image of the faces of the patient and doctor; b) a wide-angle view of the whole room, and c) a view of the problem. This raises several interesting human factors and technological problems. Transmitting full-motion, high-definition video from three cameras would require a larger communications bandwidth than is likely to be economically viable in the immediate future. However, the rate of information transfer can be reduced by using either slowly updated or low-definition images.

As was suggested in Table 1, low refresh rates may be sufficient for many tasks; indeed, an image of a skin problem or a wound may be better transmitted as a single high-resolution still image. That way primary care practitioners could capture such an image and manipulate it to their satisfaction before sending it. They could also then be reasonably sure that both they and the remote consultant were looking at the same image and that it was of sufficient quality for the job. There may be a call for full-motion video when viewing a patient manipulating a joint for example, but then one can probably get away with a low-definition image. Turning to the context view, it is possible to determine who is there and what they are doing from a relatively low-definition, very slow scan, wide-angle view of the room. The only view that would seem at first sight to require both high definition and full motion is the view of the faces of the patient and primary care practitioner. Bruce (2) reviews experimental work on the image quality needed for person identification, recognizing emotional expressions, and supplementing speech perception. Experiments on the intelligibility of speech, when it is listened to through noise, show that poor audio quality can be compensated for by an image of the face. However, this benefit is very sensitive to delay, especially if the video lags behind the audio. Of course, if the audio quality is good, an image of the face will not be necessary for this purpose. When bandwidth problems arise, it may be better to devote more of the channel capacity to audio than to try to provide delay-free, full-motion video.

Assuming that bandwidth problems can be overcome in this way, there remain the technical problems of transmitting multiple images of varying refresh rates and resolution and the human factor problems of providing simple controls for combining or switching between views. Should one cycle through the images or combine them on one screen so that the consultant is always aware of the images available, or should one give over control of what is displayed so that the whole screen may be devoted to displaying the image needed for the current task? A lot more experience of combined images and research on their use is required before these questions can be answered. The video facilities encountered in the field studies were just adequate for the task. Given the centrality of the audio facilities to the consultation process and the inevitably high cost of high-quality video, these improvements must be seen to be of secondary importance to hands-free audio at this stage.

The qualitative approach used to derive the conclusions reported here is not offered as an alternative to proper clinical trials. It is better thought of as a necessary precursor. As observed in the introduction, a trial must be a test of a particular configuration of equipment applied to a particular medical task. Understanding the clinical context is necessary not only to select the configuration of equipment most likely to succeed (the main concern of this paper) but also to delimit the focus of the trial. This point can be illustrated by considering two large quantitative trials in the literature. In the study by Dunn et al. (5), a patient with an attendant nurse consulted with a remote GP. They concluded that there was no advantage of video over audio alone. However, the patient knew that they were in any case going to see a regular doctor, face to face, after the experimental session. There was no account of how well the patient understood the GP's recommendations, since in this trial no recommendations were made. As Dunn et al. admit, this means that they could only make conclusions about issues such as accuracy of diagnosis. The issues of comprehension and confidence identified in this article were simply not addressed. This is criticism of a trial concluding against video-based telemedicine on the basis that it had inappropriate scope. One can also criticize another trial concluding in favor of video on the basis that the equipment configurations used

were not comparable. Moore et al. (12) compared two-way telephone conversations with video and audio conversations for remote diagnosis. However, the video condition had multiparty audio and the telephone condition did not. Our field study suggests that multiparty audio was one of the most valuable aspects of the available facilities. This difference in audio facilities could have produced all of the effects observed and attributed by Moore et al. to the video. Wyatt (24) makes the additional points that trials of telemedicine should include relevant control groups to show that the electronic transfer of information is superior to alternative means of transferring the same data, e.g., mailed photographs; also, the doctors taking part should be randomly sampled rather than being volunteers and enthusiasts, as is often the case.

It is important to note, in the spirit of the task focus promoted here, that this article does not specifically address many other kinds of telemedical activity, for example, peer-to-peer consultations or situations of extreme need, such as the remote surgery envisaged by Siderfin et al. for the British Antarctic Survey (16). It is also important to note another limitation in the scope of this research. The description of the concerns of physicians and patients has been at the level of task, e.g., treatment, diagnosis, or communication. There are also important organizational and political concerns that need to be considered in the design and implementation of any technological innovation. It is possible to design facilities that are unacceptable to an organization as a whole, even though they support a particular view of the work extremely well. If that view of the work is not shared by some key player and the technology forces them to adopt it, then the technology will not be used. More positively, the very existence of some technology may make possible some new organizational initiative, irrespective of its general effectiveness. For example, the possibility of having a video link at site B was reported as being an important aspect in justifying the setting up of minor treatment centers staffed by nurse practitioners at this location. This was before anything was known of its effectiveness.

Despite these qualifications and cautions, our work indicates that a video link, when configured appropriately, has potential value as a resource for telemedical consultation, both as a diagnostic aid and as a facilitator for multiparty interaction. More generally, we hope to have demonstrated the value of striving to fit new technology to the task, instead of expecting the users to pick up the pieces and adapt their practices to new technology.

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APPENDIX 1

Interview Schedule

We are conducting some research on behalf of the ESRC (Economic and Social Research Council). It's about the use of video systems in medicine. We are trying to find out what makes systems like the one here easy or hard to use.

1. This information is purely for our own research purposes. I would like to tape record this interview. The tapes will not be passed to anyone at your place of work, and only to others with your express permission. If we quote you in report, it will be anonymous and we will make sure no one could tell who it is.

(Background)

2. So you are . . .?
   and your job is to . . .?
3. How would you describe your responsibilities?
4. Who are you responsible to?
5. How much have you used the facilities ?
   So how many times a week would that be?
6. Did you have much to do with setting it up in the first place?
   What were your expectations?
   What kind of training?
7. (Establishing link)
   Perhaps you could take me through from the beginning, do you have to switch it on, get the links up, etc.?
   Does that involve anyone else?
   Could that be easier?
   How does the patient fit into all this?
8. (Therapist talking with Consultant)
   Consider the GP talking to the consultant over the link. What kind of things are talked about?
   Does the fact the discussion is over a video link have any effect on the conversation?
   What is the most difficult thing to explain/get over in this situation?
   Is it useful if the patient overhears?
   Is it sometimes difficult if the patient overhears?

9a. (Therapist talking with Patient)
   So let us say the GP/sister is talking to the patient. Do you think the presence of the video link has any effect on what they say?
   Is it useful for the conversation to be overheard on the link?
   Are there sometimes difficulties because you overhear something?

9b. (Supplementary-Consultant talking with Patient)
   How much does the consultant talk to the patient?
   Do the patients ask questions?
   Does the fact they are talking over a video link have any effect on the conversation?
   Have you noticed any problems/misunderstandings arising here?
   What do you think about the patients having a picture of the consultant?

10. (Use of cameras/views)
   What views are used with the link? What tends to get looked at?
   Is/are the camera(s) moved around much? Without asking or under instruction?
   Is it easy to explain what needs to be seen? Is it easy to tell when the required view has been obtained?
   What do you think about having a picture of the other medic?
   What do you think about having a picture of the patient?
   Is there another view you would like to have?
   What do you think about having a portable camera?

11. (Disengaging) OK, so the consultation is finished.
   What happens next?
   Do you have to do anything with the equipment?
   Does that involve anyone else?

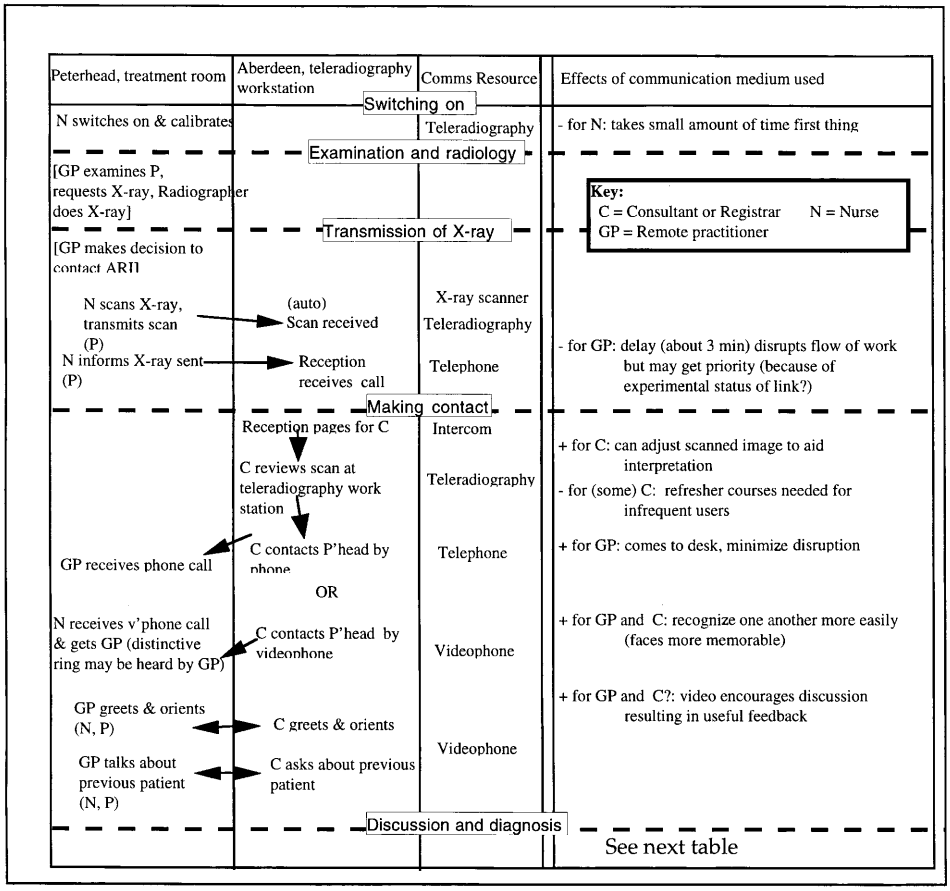
12. (Else) Is there anything else you can tell me about using the . . .
   We talked about your expectations of the link at the beginning. How have these been borne out?
   What is the best thing about it?
   What is the worst thing about it?

Daily routine/Other people

Another thing we want to know about is how the system fits into your daily work.

13. Can you describe an ideal day?
    So that was an ideal day. What can go wrong?
    Can you think of any way that the system could fit your daily work better?
14. You have mentioned [write list of people]
    Is there anyone else who is important in your work (receptionist?)
    Would it be possible to talk to them?
    Do you think the fact there is a video link here affects their work at all?
    Has the video link affected your relationship with any of these people?

Appendix 2. CUD1: Startup and Making Contact



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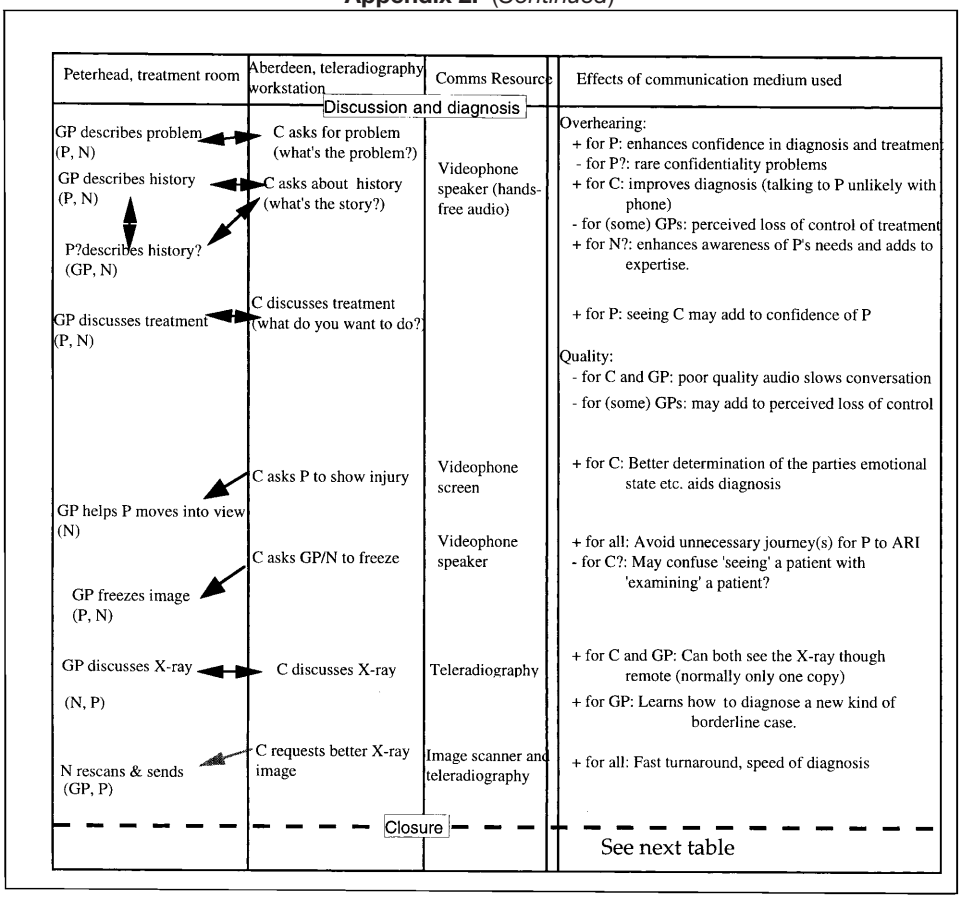
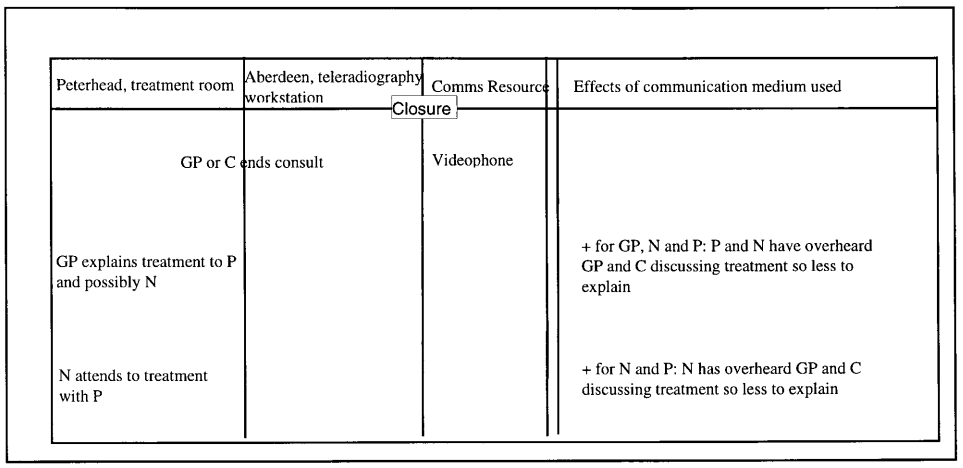
Appendix 2. (*Continued*)



CUD2: Discussion and Diagnosis



CUD3: Closure

https://doi.org/10.1017/S0266462399015330 Published online by Cambridge University Press