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Published in:
Proceedings of OzCHI 2008

DOI (link to publication from Publisher):
10.1145/1517744.1517766

Publication date:
2008

Document Version
Early version, also known as pre-print

Multidisciplinary Medical Team Meetings: A Field Study of Collaboration in Health Care

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ABSTRACT
We present an observational study that was conducted to guide the design of an enhanced collaboration platform to support distributed multidisciplinary team meetings between two hospitals. Our goal was to find out how the breast cancer multidisciplinary team collaborates in their face-to-face meetings and in their discussions using an existing video-conferencing system and to identify obstacles and issues to their primary tasks. We identified a set of concerns around the way visibility and audibility affect the social cohesion of the group and impede communication and situation awareness between the distributed team. We also identified a parallel set of concerns around the difficulty of preparing and interacting around the medical images used in the meetings. These issues exposed a complex matrix of technical, social, procedural and organisational factors that affect the collaboration. We suggest potential directions for technical interventions in this setting.

Categories and Subject Descriptors
H5.3. Information interfaces and presentation (e.g., HCI): *Computer-supported cooperative work, Synchronous interaction.* H4.3 Information systems applications: Communications applications - *videoconferencing*

General Terms
Design, Human Factors

Keywords
Distributed collaboration, multidisciplinary team, field study.

1. INTRODUCTION
Cancer care involves a range of services including screening, diagnosis, treatment (surgery, chemotherapy and radiotherapy), rehabilitation and supportive care. Multidisciplinary care is an integrated team approach to health care in which relevant health care professionals collaboratively develop a treatment plan for individual cancer patients. There is increasing evidence that multidisciplinary care improves cancer patient outcomes [1].

Regular multidisciplinary team meetings have been considered an integral component of multidisciplinary care. A central theme of the meetings is for clinicians from different disciplines to get together to review patient cases, establish diagnosis, and decide upon the management of cancer patients. The meeting also provides an education environment for medical students and junior doctors.

Australia has a complex health system, with patients treated in both the public and private sectors and in urban, regional, rural and remote areas. There is a shortage of highly specialized medical experts. Some of the medical professionals work at multiple sectors and sometimes they may have to travel to attend case discussion sessions at different hospitals. Telemedicine technology has been used as a solution for this problem by using a networked environment to support the case discussion across sites [2]. Multidisciplinary team meetings using video-conferencing technology are increasingly being deployed to allow distributed team members to work together.

These drivers led to our project of designing an enhanced collaboration platform to support distributed multidisciplinary team meetings. We have been working closely with a large group of breast cancer care professionals from two hospitals in Sydney, a large public and teaching hospital (hospital A) and a private hospital (hospital B). There is a mix of public and private service provision between these two hospitals. Some of the surgeons and radiologists in hospital A also have patients at hospital B. The two hospitals hold weekly multidisciplinary team meetings. At each hospital, the meeting begins with cases in which all data and discussions are held locally. Followed by this are case discussions where the patient data are distributed between two hospitals using video-conferencing. The patient history, radiology images and pathology images are displayed and discussed in the meeting. Similar to many other telemedicine applications in Australian hospitals, the meeting is held in a multi-purpose meeting room at each hospital and uses a standard commercial video-conferencing system.

This paper describes a field study investigating how the breast cancer multidisciplinary team collaborates in face-to-face meetings and in discussions using existing video-conferencing technology. We present an analysis of the social-technical problems of the interaction between the distributed teams. We also discuss some challenges in designing a collaboration platform to support the multidisciplinary team meeting.

OZCHI 2008 Proceedings ISBN: 0-9803063-4-5

2. RELATED WORK

It has been shown that good communication and interaction are essential to enhance the quality of collaboration among members of a cancer care team and facilities such as video-conferencing systems can enhance the effectiveness of this collaboration [3]. A significant body of work in the area of computer supported collaboration in the distributed multidisciplinary team meetings has centred on investigating the feasibility of video-conferencing meetings by comparing them to the face-to-face meetings (e.g. [4] [5] [6] [7]). It has shown that it is feasible to facilitate the multidisciplinary case discussion using video-conferencing. The actual use of video-conferencing is found to affect negotiating style and perception of status and power since it is formal and regimented compared to face-to-face meetings [4]. The value of seeing artefacts during a case presentation is held high [5]. Video-conferencing meetings are somewhat "less efficient" and take longer than face-to-face meetings. Difficulties related to coordination and awareness in this video-mediated communication environment are caused by technical as well as social-emotional and organizational factors [5] [6].

There has been a wide range of collaboration systems providing remote situation awareness and shared artifacts explored in a variety of settings. The early work on media spaces was to provide awareness to distributed workgroups through video, audio and shared computing resources [8]. It has been emphasized that there is a need for the participants interacting to be aware of what other people are doing, and of the artifacts in the workspace. Additionally, this awareness requirement should be "explicitly and deliberately" supported in a collaborative system [9]. The study of how the video and audio technology behaves and functions and the analyses emphasizes social and culture influences are important to explore the "affordance" of the technology [10]. Within the health domain, there have been systems providing social and spatial awareness features for clinicians in medical settings about their colleagues' current work and whereabouts [11]. Also there is a demonstration of an immersive interactive tele-guidance system focusing on supporting the "space" setup and interaction with medical images [12].

Supporting a geographically distributed medical team requires appropriate collaboration technologies tailored to their work environment to enable the team to accomplish their work. It has become increasingly clear that the success of any collaboration technology supporting distributed medical team relies on an understanding of the human computer interaction entailed in the technology [13] and a social-technical approach in the design process [14] [15].

In the field of computer-supported cooperative work (CSCW) in healthcare, there is a stream of research (e.g.[16][17][18]) which identify not just that there are social-techical issues but specifically what they are. Importantly, every workspace setting is unique and this is reflected in the interpretations of social and technical issues manifested in their specific context [19].

3. METHOD

As the first step in the design process, we conducted a three-month field study in the two hospitals. The field study helped us understand multidisciplinary team meetings in order to guide the subsequent design. Our research focused on understanding the group behaviour and function, the task and the interaction on shared artifacts in the collaboration.

Workplace studies within CSCW can be broadly characterised as research which aims to study work as it occurs [19]. Our field study combined interviews of key participants, with observations and video recordings of the meetings. A similar approach has been used in a study of timing and teleconferencing of multidisciplinary team meeting and has been shown to be effective in understanding the mechanics in this environment [5].

Since the meetings were held on every Wednesday morning only, we arranged the interviews and observations as two parallel processes. The use of different methods, conducted in parallel, was intended to enable us to quickly review items of interest from the observations and, if needed, to provides evidence to interview participants of their exhibited behaviours. A debrief session for the observers was held after each meeting to share initial understandings and perceptions of the meeting. The debrief session was helpful to maintain research focus, reflect on findings and direct further stages of work. In order to match the pace of the design cycle, "rapid ethnography" [20] techniques were used, such as focusing on interviewing the key participants at the initial stage of the study to quickly identify the basic requirements.

3.1 Participants

At each meeting there were around twenty to thirty participants at hospital A and around ten to fifteen participants at hospital B. We interviewed eleven meeting participants. They were from both hospitals and from each of the key clinical disciplines represented in the team (See Table 1 below). It was important to build up good relationship with the meeting participants and to obtain their trust as the meeting content was sensitive and confidential and we wanted to get best quality data we could. We designed the study with the help of key participants. We attended the weekly meetings and communicated actively with these participants both at the meetings and via telephone and email at other time. Concerns regarding patient privacy and video recordings were addressed by anonymising the data. All participants were provided with an information sheet explaining that their and their patients' identities would be protected and the data would be used only for the purpose of the study.

Table 1 Participants interviewed.

Role	Hospital A	Hospital B
Surgeon	1	1
Medical oncologist	0	1
Radiation oncologist	1	1
Pathologist	1	1
Radiologist	2	0
Coordinator (nurse)	1	1

The participants came from several departments and the attendances were flexible (some of them were transferred to

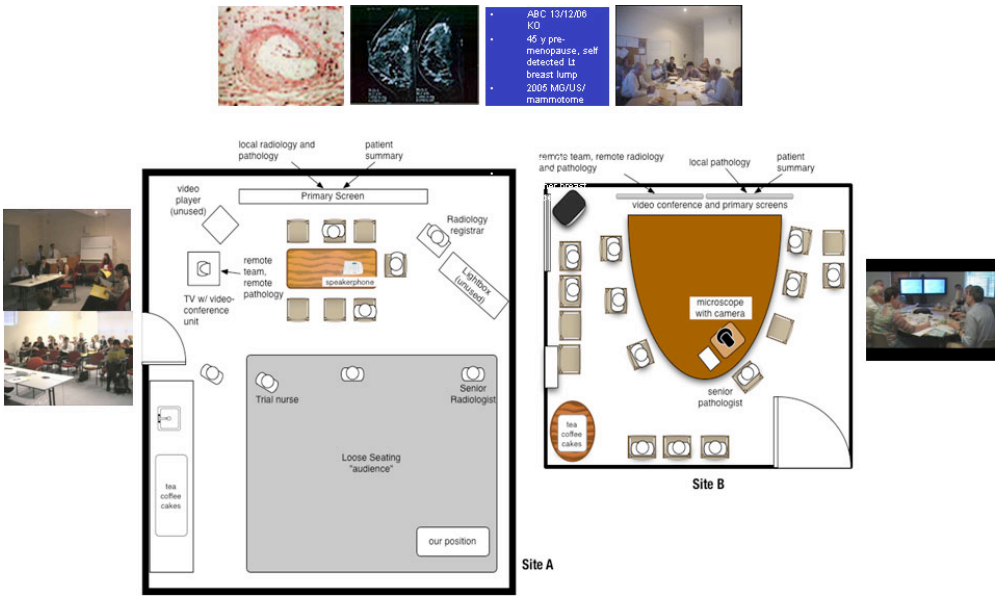

Figure 1 Site plans of two rooms in the two hospitals

different departments and some of them were new to the meeting). It was very useful to get the support from the hospital project officer who was a clinical nurse consultant to maintain the list and help to get the contacts for interviews.

3.2 Data collection

Three to four observers split up at two sites to observe the meetings and met after the observation to debrief. Observations notes were taken by each of the researchers. These notes also included interesting issues discovered during the informal talk with the clinicians before and after the multidisciplinary team meetings.

Audio and video recordings were collected in some of the meetings. We were able to directly record the video stream from the video-conferencing system and used one or two video cameras in each of the meeting rooms. The recording equipment was set up and tested one hour before the meetings. The positions of the room cameras were arranged to obtain the best views while minimising the intrusiveness to the meetings.

Semi-structured interviews focused on participants' perspectives on their work in general and specifically their comments on the meetings, the functioning of the group and how these might be better supported. Interviewing medical staff in hospital is not trivial, therefore several interview strategies were employed:

- Participants in this study are busy clinicians and work under constant time constraints. So the interview questions were prioritised to ensure that the most important information, generally individual practices and routines, was captured in even the shortest interview.
- Some of the participants might be on-call when we conducted interviews, for example the interview with a pathologist was stopped several times since she had to work on an urgent diagnosis request from a surgeon waiting at the operating theatre. So it also required the flexibility of keeping interview consistency to deal with work related interruptions during the interviews.
- Interviews with the radiologists and pathologists were held in their departments. This provided us with an opportunity to see their work environment and appreciate the difficulties and complexity of their preparation work before the meetings.
- Interviews were held after the meeting if possible because clinicians usually had some time available after the meetings and had a fresher memory about their experience of the meeting.
- Snapshots taken from the video recordings of the meetings have been found helpful to prompt participants to discuss their experiences in the meetings.
- As part of the interviews, participants were encouraged to create draft layout diagrams of the new collaboration system based on their expectations.

3.3 Data analysis

Interview transcriptions and observation notes were read by all of the observers and interesting issues were indentified and discussed. One of the observers worked on the data category based on the interview structure and issues identified. Since this is an initial study in the design process, the categorization was deliberately loose.

The recordings of the meetings were synchronized and annotated using the Vegas software. Snapshots taken from the video recordings showing the team's interactions in the meetings were used to prompt participants in the interviews. The formal video analysis was not involved in the initial analysis phase.

4. RESULTS OF THE INITIAL ANALYSIS

The focus of our research was to investigate current practice to identify problems and possible design issues. We will present our findings of the meeting setup and results related to social-technical issues below.

4.1 Meeting setup

The total meeting time is between one to two hours in each hospital every Wednesday morning. Typically between five to fifteen cases are reviewed during the local face-to-face discussion at the start and the video-conferencing meeting follows. Each case begins with the patients' details being read out to the group, followed by the presentation of relevant medical images and pathology images. The clinician in-charge (usually a surgeon) discusses the proposed treatment, and radiation oncologists and medical oncologists contribute their points of view about clinical trials or options. Nurses, psychologists and community visitors contribute other relevant information. Eventually a decision is made about future care and treatment.

The local face-to-face multidisciplinary team meeting started six years ago at two hospitals individually. The video-conferencing meeting was introduced two years ago. The two sites are connected by a standard, commercial video-conferencing unit using ISDN connection at 256 kbit/s. Hospital A has a much larger group of participants than hospital B (Figure 1). The meeting at hospital A is held in a very large room with majority of the people sitting in the back of the "lecture" room which is not captured by the video-conferencing camera and cannot be easily seen by hospital B people (shown at the left of Figure 1). The microphone is placed on a conference table where four or five key people sit in front of the video-conferencing TV screen. A projector screen is set up at the front of the room. Hospital B has smaller room with seven or eight key people sitting at a round table and facing two TV screens.

At hospital A, radiology images, pathology images and a de-identified patient summary are incorporated in a PowerPoint presentation before the meeting and shared to both sites via the video-conferencing unit. However at hospital B pathology images are directly shown and explained from a digital microscope camera by a senior pathologist and transmitted to hospital A during the meeting. At hospital A when discussing images locally, laser pointers are used by radiologists to point at the PowerPoint images on the primary projector screen.

4.2 Context and aims of the meeting

The multidisciplinary team meeting has several functions. The main outcome of the meeting is to reach a decision on the patient management which allows patients to start treatment more quickly and effectively. For clinicians working in different departments, the meeting provides an opportunity to discuss their recommendations with the rest of the team and to get patient referrals. It is also an important venue for recruiting cancer patients for clinical trials. The meeting serves a social function to support the development of collegial relationships. The social component also includes the before and after meeting informal interactions which provide opportunities for clinicians to talk about non-meeting related work. It also has an education component, for medical students, for different discipline clinicians and for peers in the same discipline.

We asked interview participants about what constituted an effective meeting. We found that they had similar expectations in these aspects: all relevant patient issues have been well presented; everyone has the opportunity to provide input to the management of patients; work as a team to make decisions and support each other; learn something from the meeting; and patients are actually effectively treated. Three of them also felt that the measure of the effectiveness of the meeting was not easy to establish.

Some of surgeons in hospital A work partly at hospital B; the radiology test of a hospital B patient may be reviewed by a senior radiologist at hospital A; the pathology test of a hospital B patient is reviewed by a senior pathologist at hospital B when a hospital A surgeon operates on that patient. Private hospital clinicians usually work in a controlled and efficient time schedule and some of them only work as part-time staff. The work pattern difference between private and public hospitals affects the way of preparation for the meeting (described in 4.3). Some of the social-technical problems we will present are due to this mixed nature of private and public practice.

4.3 Meeting preparation

The preparation required for the meetings, particularly for the radiologists and pathologists, is incredibly time-consuming. This represents one of the problems with the current situation. The meeting preparation required is outlined below.

4.3.1 Patient history

Surgeons initiate the list of patients to be discussed and inform breast cancer nurses. The nurses at each of the hospitals coordinate with their respective surgeons and circulate the list to the relevant radiologists and pathologists by Friday early afternoon. Since radiology and pathology examinations of the patient might be performed at different institutes, the nurses need to assist in ordering appropriate materials. The nurses also need to look for patient records to generate patient summaries. At hospital A the summary is put into a PowerPoint presentation and at hospital B a patient summary cover sheet is filled in (Figure 2).

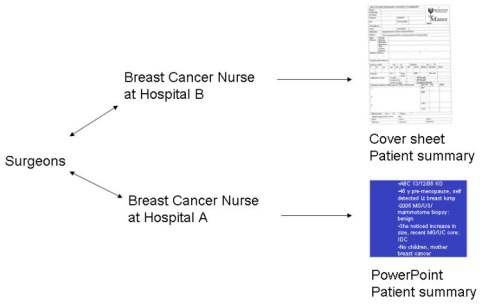

Figure 2. Preparation of patient history

4.3.2 Radiology images

At hospital A, it takes six to eight hours sometimes after work hours, for a radiologist to prepare medial images in a PowerPoint presentation before the meeting. Since the digital medical image database - PACS (Picture Archiving and Communication System) is not used in either of the hospitals, films need to be located from physical storages, reports need to found or faxed from institutes where the films were taken. Then the radiologist analyses the films and reports, finds right images for illustration, captures images by digital camera, uploads the camera images to a computer, uses Photoshop to produce the best quality images and to annotate the area of interest (AOI), and puts images into a PowerPoint presentation (Figure 3). At hospital B, radiologists are only involved in the local case discussions and bring films with them to present directly on the light box during the meeting.

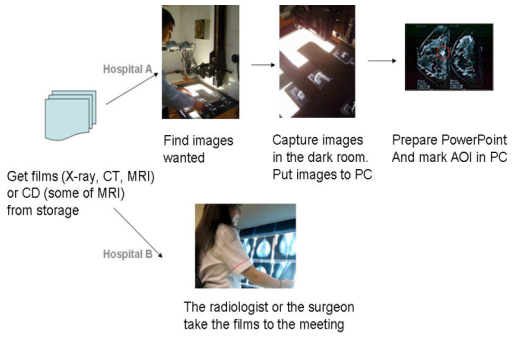

Figure 3. Preparation of radiology images

4.3.3 Pathology images

Before the meeting, the pathologists locate the slides and reports required from various storage places, and find the best slides and areas of interest for the demonstration. As with the radiology images, each of the two hospitals have different ways of preparing and presenting pathology images. Similar to the preparation of radiology images, a pathologist works full-time at hospital A captures the pathology images by a camera attached to a microscope, uploads images to a computer, inserts the images and summary of the diagnosis into PowerPoint (Figure 4). The total process takes around two to three hours. At hospital B, a part-time pathologist spends around ten to twenty minutes per case to review the pathology slides and may mark the area of interest directly on the slides, brings the pathology slides to the meeting and presents them directly from a digital microscope which is integrated with the video-conferencing system.

The preparation is a burden which falls on pathologists and radiologists who review the images and prepare the deck of slides and films. Some of them even need to participate in other multidisciplinary team meetings, e.g. the lung cancer multidisciplinary team meeting.

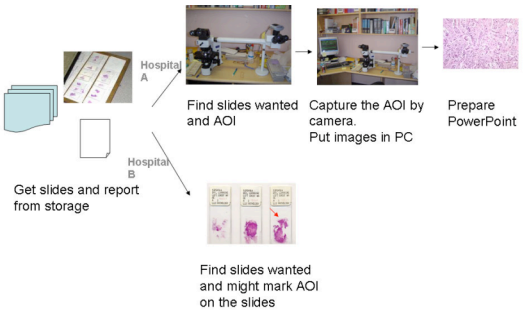

Figure 4. Preparation of pathology images

4.4 Interaction and communication of the participants

The overall atmosphere of the meetings is professional and cooperative. However, in comparison to the local meetings, video-conferencing meetings appear to be more formal and categorical. The communication in the local meeting we have observed displays more social meaning, particularly in hospital B where a smaller amount of people sit around a circular table with good eye contact. The discussions in the local meetings are open and informal. People openly express their uncertainties or disagreements and explore issues of interest in a relaxed way. They share jokes, leave their seats to get drinks and lean backward/forward to gossip to the people surrounding them. All of our interview participants indicated that they were satisfied with the interactions during local meetings and the large majority of the interview participants (ten out of eleven) expressed negative sentiments about the interactions in the video-conferencing meetings. The comments below exemplify these sentiments expressed by the participants:

"In the local meeting, I think people feel that they have the opportunity to express their views…everyone's views are listened to and valued. I think any disagreements about management can usually be appropriately resolved without any aggravation….people who attend our meeting actually get on well with each other and get on in a cooperative manner that's in the interests of the patient…there is much less cross-interaction between the two groups than there should be."

"The meetings are pretty efficient until you go to the video link and then their efficiency drops off dramatically and people disengage at that point."

Although the inter-personal relationships between some of the clinicians at the two hospitals contributes to this difference as pointed out by some of our interview participants, another reason for the disssatisfaction is the lack of physical "presence" experienced and the "gap" felt due to the current setup of the room and the video-conferencing audio and video quality. These remote awareness issues are explored in more detail below.

Being able to see everyone in the remote room. The issue of lack of social and spatial awareness due to the limited visual information is evident from the instances of unawareness of individual people's presence, such as asking "Is X there or not?" "Is Y sitting in the background?". This problem can be due to the seating arrangement in the room of hospital A, the size and position of the displays and the quality of the videos. The majority of the people at hospital A sit in the back of the "lecture" room and are outside the camera capture area. Also at hospital A, the video-conferencing system requires a person to manually switch between the views of hospital B and medical images to be displayed on the front projector screen, such that if nobody takes the responsibility or if someone forgets to switch the views, people in hospital A sitting in the back rows can not see the people in hospital B. Interview participants expressed their desire to see the whole room of the remote site. They value being able to see not only the people talking but also people not directly engaged in conversation. Being able to see remote people's gestures and having good eye contact were also mentioned as important criteria by some of interview participants. One participant described the problem of visibility this way:

"it certainly does limit… The body language is not often seen on a video link, particularly if not everyone in the room is able to be seen on the screen, and that could be part of why one end doesn't talk so much because people can't see you know somebody on the screen"

Being able to hear everyone in the remote room. The audio problems also cause the "distance" felt in the video-conferencing meetings. Clinicians sitting at the back of the room in hospital A are out of microphone range and can therefore not be heard by hospital B. This has contributed to the lack of satisfaction experienced by hospital B - who would like to be able to hear all of the people at hospital A. Although the room in hospital B is relatively small, clinicians not sitting on the circular table also need to raise their voice to be heard by hospital A. The pathologists at hospital B are sometimes inaudible due to the microscope being situated between

themselves and the microphone. Another issue affecting the audio quality at both sites is the occasional rustling of paper situated near the microphones overwhelming the speech. This suggests that microphone coverage needs to be carefully designed to prevent such occurrences.

4.5 Interaction with radiology images and pathology images

Interview questions addressing clinicians' interactions with images fell into three broad categories: the importance, understanding and following the content, and the image preparation. These are explored below in more detail under their respective headings.

4.5.1 The importance

The importance of reviewing radiology images and pathology images at the meetings was appreciated by majority of the participants interviewed. During the meeting, the presentation of these images "sits in the middle" of the discussion which leads the agreement on the diagnosis and the disease stage and is critical for the choice of the patient management. The central role that the images play is captured in the following interview comment:

"To read about it is not as good as to see it and hear about it at the same time. Essential for the people that are going to be involved in the direct management."

The presentation of the images serves two purposes: providing evidence to support diagnosis; for the education function. Radiologists and pathologists begin their presentation by summarising reports and then use images as a completeness of their demonstration. A senior radiologist interviewed commented that the presentation of such images provide the opportunity to let other clinicians such as surgeons to appreciate the difficulties associated with making their diagnosis. As a teaching tool, the images are used to educate clinicians from the other disciplines and medical students about the radiology and pathology aspects of the patients' case. In the interviews, a few senior clinicians commented that complex cases were of the greatest interest to them and straightforward cases were less important.

4.5.2 Understanding and following the content

The majority of the interview participants responded that the audience could understand what radiologists and pathologists explained on the images since they all had training in medical school and the more frequently they attended meetings the easier they could understand. However, radiology and pathology are highly specialised areas. The diagnosis provided by the radiologists and pathologists are usually not questioned in the meeting. Rather, images in the meeting are used for illustration purposes and support for decisions. The required quality of the image is therefore not as high as that required for diagnostic purposes.

The ability to point to certain areas on an image is considered important for both the radiologists and pathologists. This finding was observed in the field study and mentioned by some of the clinicians in the interviews. Radiologists at hospital A put marks in the presentation images and pathologists put area of interest in the centre of the images before the meetings to assist the audience following their presentations. At hospital A, laser pointers are used by radiologists sitting in the audience to point to certain parts of the PowerPoint images on the front projector screen. However, during the video-conferencing meeting a radiology registrar standing at the console has to follow the presenter's laser activity by controlling a computer mouse cursor to show it to the team at hospital B. At hospital B laser pointers are available but are not used because they do not work on the TV display, so the pathologist presenting has to verbally indicate area of interest. The image lag described in 4.5.3 makes the process of following the presentation and explanation of images more difficult, particularly for clinicians located at hospital A who can experience extensive delays in image transmission across the video-conferencing.

4.5.3 Prepared images and real-time captured images

There are different ways of sharing radiology images and pathology images between the two hospitals during the meetings: prepared images in a PowerPoint file from hospital A and real-time captured images from hospital B.

A couple of interview participants at hospital B prefer the way of moving slides around to look area of interest during the meeting as it provided the opportunity of accessing images that are not prepared previously and therefore better positioning the pathologist to address unanticipated questions at the meeting. However the PowerPoint presentation method has been highly valued by interview participants of hospital A since it is a more cohesive and straightforward way to present, particularly in a meeting which might have more than ten patient cases to be discussed in one hour. The record of the images also serves as a good database for other teaching purposes later. Hospital A participants' preference is exemplified by the following comment:

"it's much better to be able to just show – even though it's a lot more work for us to do it like that it's much better for the meeting… a few select areas photographed and you can just demonstrate it straight away. It's a much more cohesive way to present a meeting."

The pathology image lag has been identified as a major technical problem by the majority of interview participants (nine out of eleven). Microscopy images are detailed and take some time to be fully transmitted from hospital B to hospital A. The pathologist moves the slides quickly while talking. As a result, the pathologist may be describing the next image before the prior image has had a chance to display properly. This is a source of great frustration for participants at hospital A, as stated by one interview participant:

"They relay down to us the pathology which they're looking down a microscope… then they move the slide and it goes all out of focus and it takes two or three seconds to come back into focus…"

We have described the structural differences between the two hospitals and the preparation workflow in 4.2 and 4.3. The interview participants pointed out that they did not have a mechanism at the moment for hospital B to present prepared images to hospital A since it requires a support group input like hospital A has which is too expensive to obtain in a private hospital.

PACS was not used in either of the hospitals at the time of our study although there is funding by the government to implement it. There is a desire by the two radiologists we interviewed at hospital A to access to a PACS system which they believe will make their work around the meetings easier. However, a radiologist at hospital B mentioned in a multidisciplinary team

meeting that PACS would introduce some technical problems and there would be a long learning curve.

4.6 Design ideas from users

Interview participants were encouraged during the interviews to think of solutions to the current problems. It appeared that a quarter of the interview participants thought that there would be a need to train one or two people at each hospital to operate the video-conferencing unit properly and to troubleshoot minor technical difficulties during the meetings. Some of them also suggested that it would require streamlining the preparation work, improving the flow of the meeting, and encouraging the back row people to be more interactive.

Two of the interview participants drew their designs based on their experience and expectations. A medical oncologist from hospital B generated a sketching of a new layout arrangement at hospital A (shown at the left in Figure 5). Another example was drawn by a senior radiologist at hospital A who explained an advanced system supporting the multidisciplinary team meeting he saw in Swiss (shown at the right in Figure 5). It shows a ramp-seat room with a good setup of microphones and displays, access to digital imaging, and a seamless way of presenting the material.

Figure 5. Examples of users' design sketching.

5. DISCUSSION

The field study revealed a number of issues relating to collaboration in a multidisciplinary team meeting context. Our study participants referred to each issue mostly as a technical problem with the current situation. Further investigation revealed that the nature of these problems extended beyond the technology itself. In this section we discuss the challenges of designing a system to support the collaboration of a multidisciplinary team meeting both technically and socially.

The first issue relates to the social cohesion of the group and remote situation awareness of participants, task status and interaction process. There are problems of visibility and identity of remote participants and audibility of remote participants especially at the peripheral of meeting rooms. This problem is caused by the inappropriate setups of the seating and the audio-video devices and the limitation of the audio-video quality. Our analysis shows that in the video-conferencing meetings, the lack of awareness of remote situation could affect the spontaneous interactions and open discussions which are important features of an effectiveness meeting. There is also a social aspect of the communication process that is not "publicly available" [9] and interrupted in this computer-mediated scenario [5] and this in turn produces a distance between the distributed group and alters their interaction. One of our research foci is how the technology can help to achieve better awareness of remote situation. It requires not only the high quality audio and video, but also the "physics" of media space [10], such as optimum location, size of the devices and a built-for-purpose configuration in this specific context.

The second issue relates to the shared artifacts, the medical images, in the multidisciplinary team meeting setting. There are two different ways of presenting medical images over video-conferencing: prepared PowerPoint still images which require a large amount of preparation time before the meeting, and real-time captured images during the meeting which cause an image lag problem at the remote side. There is a trade-off between these two methods and it is linked to different hospital work structures. There are four primary components to our discussion of the issue: the trade-off between these two methods of presenting, the constraints of different health service structures, the PACS system, and the interaction tools required.

The pre-meeting selection of radiology images and pathology samples to be discussed at the multidisciplinary team meeting takes hours. Due to the limited time for the meeting, most of the clinicians we have spoken to prefer the prepared PowerPoint because it is smoother, faster and easier to follow, but the preparation of the PowerPoint also consumes hours of time prior to the meeting. Use of a static presentation for pathology images (rather than a "live" presentation from the microscope) also limits the ability of the pathologist to answer unanticipated questions during the meeting.

This is a procedural issue links to different health service structures rather than technical problems. Australia presents a challenge for the implementation of multidisciplinary team meetings, given its geography, the mix of private and public service provision, and differences in resource availability and access. Private hospital doctors have different work patterns and time pressures to that of public hospital doctors. There is a preference to keep the way it works by hospital participants since there is not a mechanism can change the current practice. Technical researchers need to consider a flexible system which is able to accommodate and integrate requirements from different organizations in the sharing of medical images.

There is a clear interest from radiologists in introducing PACS to the multidisciplinary team meeting. The implementation of a shared PACS image storage system might help the meeting preparation and importantly allow sharing high quality medical images. Although PACS could provide easy access to digital images, there are issues of common interface, boundary between different hospitals, network latency to deal with the "image lag" problem and the tensions between static and live presentation.

There have been studies investigating pointing and annotation tools in remote collaborations, however only a few relate to collaboration in the health domain [11]. The laser pointer, currently used as a preferred remote pointing tool, is not visible to the remote participants. A tabletop type of pointing tool, such as a mouse or tablet, is not shareable for multiple participants, especially in the large scattered room of hospital A. As such, there appears to be the need for multiple pointing devices that can be used standing or sitting, such as a 3D mouse. However further research is needed to ensure that a chosen solution serves the needs of the diverse community in the multidisciplinary team meeting.

6. CONCLUSION

The goal of the field study was to find out how the breast cancer multidisciplinary team collaborates in their face-to-face meetings and in their discussions using an existing video-conferencing technology and to identify obstacles and issues to their primary tasks. We found a set of issues around the way visibility and audibility affect the social cohesion of the group and impede communication and situation awareness and a parallel set of concerns around the difficulty of preparing and interacting around the medical images used in the meeting. The latter issue exposed a complex matrix of technical, social, procedural and organisational factors that affect the collaboration.

We believe that appropriate configuration and setup of video-conferencing technologies has the potential to enhance the remote situation awareness and social cohesion which are critical to the effectiveness of the multidisciplinary team meetings. It also requires suitable interaction tools and convenient access to the digital medical image database at hospitals to support the information sharing during the meetings. A careful consideration of the social and procedure aspects affected by different health service structures is also important in the design. Our future work intends to address these social-technical challenges which require further investigation along the process of design collaboration technologies.

7. ACKNOWLEDGMENTS

The authors would like to thank for the cooperation from Dr. Katrina Moore, Dr. Fran Boyle, Ms Kerrie Andrews and all the members of the breast cancer multidisciplinary team at Royal North Shore Hospital and Mater Hospital, Sydney. Thanks also to Dr. Bruce Barraclough at CSIRO ICT centre and the members of the HxI initiative for their support to this project.

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