

Information Sharing at Multidisciplinary Medical Team Meetings

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Abstract Results of a study of multidisciplinary medical team meetings (MDTMs) are presented, with focus on information presentation, collaboration, sharing and decision-making issues. The MDTM forum is shown to be an important juncture in the patient care pathway where prior work is reviewed, future work is planned, and decisions are made by consensus. It is shown that while all participants perceive that they benefit from their attendance, the benefit for most active participants is directly proportional to their contribution. Record keeping of the decision agreed and the basis for that decision poses a challenge, particularly in the context of electronic patient record (EPR) keeping. This study also reveals the multi-faceted nature of the event and the fact that new knowledge is generated during the meetings. In addition to its main function in patient management, the MDTM has an educational role and fulfils hospital functions in planning and co-ordination of service delivery. These findings are analysed in terms of their implications for the information sharing needs of participants according to their roles; and requirements for technology support at individual, group and organisational levels are discussed.

Keywords Information sharing · Information generation · Interaction · Team meeting

1 Introduction

Collaborative work in the domain of healthcare is extremely dynamic in nature, taking multiple forms and modes, each supported by different mechanisms and practices.

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This variety and flexibility makes health care work an ideal and challenging object of study for collaborative work and decision-making.

A multidisciplinary medical team meeting (MDTM) is an example of collaborative working in healthcare. It is a practice historically associated with university teaching hospitals, but has become an important event in patient care pathways in modern health systems. All of the individual specialist teams involved in patient care meet and consider their patient cases. Each patient has their details reviewed within the group of specialists: the physician reports on the clinical findings; the radiologist shows the radiological image features; the pathologist illustrates the cells in tissue samples. Following the correlation of all the data, the diagnosis is clarified and recommendations are agreed on the management plan for the patient. Nursing and allied health professionals are also involved in the discussion. While most of the business of the meeting is conducted through talk, images are also used that were gathered in work conducted by individuals outside of the meeting. These images might be from the out-patient clinics, or procedures undertaken, such as, for example, physical features e.g. rashes, and videos/images taken during endoscopic or surgical procedures. Each of the specialities participating at the meeting has a team comprising a number of staff of varying status and experience. So, as well as serving its patient management function, the MDTM is a forum for education and professional development.

MDTMs offer a unique opportunity to examine synchronous collaboration through dynamic interaction, and the use of artefacts, among a number of different professional roles. The MDTM serves as a co-ordination mechanism (Schmidt and Simonee 1996), and therefore can be studied from the perspective of the artefacts and distinct protocols they embody and the particular articulation of co-operative work they stipulate. In addition, the MDTM is a synchronous activity to which many collaborative processes (synchronous and asynchronous) converge, and from which a number of other processes emanate. These features enable us to conduct focussed empirical studies of greater reach and generality within the healthcare environment than would otherwise be possible if the investigation were restricted to any particular set of auxiliary processes.

The method adopted in this study is based on ethnomethodologically informed fieldwork followed by more focussed investigation. Ethnomethodology has been increasingly employed in the analysis of the negotiation process (Martinovski et al. 2007) and in system design (Viller and Sommerville 2000; Randall et al. 2007), particularly in the healthcare domain (Hartswood et al. 2008). The study reported in this paper is part of a larger project in the area of computer supported cooperative work (CSCW). Therefore, following the ethnomethodological approach, we avoided pre-imposing categories to the fieldwork data. A combination of methods were employed as follows. First, an extensive ethnomethodologically informed fieldwork (over 3 years) was undertaken (phase 1). Following the identification of “significant events” in the fieldwork study, focussed observation was undertaken accompanied by questionnaires and semi-structured interviews (phase 2). Finally, aspects of dialogue and multi-modal interaction in selected MDTM-related tasks were analysed quantitatively to a greater level of detail (phase 3). Phases 2 and 3 often prompt re-examination and further analysis of the fieldwork data or more detailed empirical investigation. We believe

this iterative strategy adds reliability to our findings through a process of triangulation (Mackay and Fayard 1997). While the study reported in this paper forms part of phase 2, both phases 1 and 2 are reflected in it.

Most research on how to support collaboration in this area either focus on artefacts that support general tasks, such as patient records (Hardstone et al. 2004) and their plasticity (or lack of it) in face of the complexities of medical work, or on more localised support for specific tasks and processes (Berg 1999; Munkvold et al. 2007). From a theoretical perspective, the expectation is that these lines of research will eventually converge so as to allow the resulting conceptualisations to be tested empirically. However, spacial and temporal constraints usually stand in the way of such unified empirical studies, which has led some researchers to argue for frameworks that privilege the analysis of work rhythms (Reddy and Dourish 2002). The theory of time, interaction and performance (TIP theory) (McGrath 1991) emphasises the temporal patterning of interaction and performance in small groups, in the context of the individual, the group, and the organisational perspectives on the group activity. While we acknowledge the importance of analysing such temporal aspects, and report on the results of our analysis of temporality in MDTM work elsewhere (Kane and Luz 2006; Kane et al. 2007), the present study analyses interaction and the artefacts which mediate it through a focussed study of a specific event. Temporal aspects are introduced as necessary in order to contextualise the analysis.

The nature, causes and consequences of the group interaction process in complex settings are of interest in group research (McGrath 1984), and our research on MDTMs encompasses different facets of the group activities, from different perspectives. By focussing on the acting group in its behavioural setting and, more specifically, on how the interaction that takes place at MDTMs benefits different professional roles in their pre- and post-MDTM tasks and responsibilities, we aim to identify areas that might be amenable to technological support so as to make the overall work processes more effective.

Following a long-term study complemented by questionnaires and interviews, in order to elucidate information and organisational needs of participants, we (i) establish the fact that new information is generated at MDTMs which leads us to identify a need for better support to activities such as documentation and explicit articulation of agreed outcomes; (ii) identify the value of clinical images as an aid to the patient case discussion (PCD) and establish requirements with respect to which information sources should be better supported; (iii) identify potential miscommunication risks which might pose threats to patient safety, highlighting the need for an information-rich record that would be consistent, reproducible, could be referenced as needed, providing the safeguards not currently embodied within the written record; (iv) identify asymmetries as well as qualitative differences across the information and presentation needs of the various MDTM stakeholders and (v) show that all members perceive a benefit from their attendance at the MDTM, regardless of their role, hierarchical position or work experience.

This paper is structured as follows. The general aim of the study and the methods used are explained. The results are presented and discussed through a description of the MDTM event, the information presented during discussion and evaluation of contributions, with particular attention to the information generated and learning that

occurs. The use of radiology and pathology images is given special mention as is the basis of the decision taken and the decision outcome that is regularly sought by participants afterwards, i.e. post-MDTM. The paper concludes with an extensive discussion of the main findings, and their implications with respect to technology support and process co-ordination mechanisms, which might improve collaboration in MDTM settings.

2 Objectives

The primary aim of this study was to identify roles, that may contribute information toward the decisions being made at the meeting, and/or receive information that enables later individual clinical decisions in routine hospital work. The purpose of the PCD is ultimately to determine the best course of treatment for the patient in the circumstances. For all the information contributed in discussion, each data item is available independently in text form in distributed records. This suggests two questions which we investigate in this paper:

- Does the need for a particular role's involvement in PCDs reflect a deficiency with information flow within the usual channels in the hospital?
- How much do participants and contributors of information feel that the MDTM benefits them in the performance of their duties, given that they would have access to all of the information by other means at a later time?

The pathologist, for instance, demonstrates the tissue findings during the PCD and the formal pathology report on the findings is sent from the pathology department to the requesting clinician, is eventually filed in the patient's (paper) chart and is also available electronically on the EPR system. Thus, an individual clinician could make a clinical decision, alone, with information available within patient and hospital records, without any need to attend a meeting. Theoretically, the decisions made at the MDTM could be made automatically, since the decisions are based on clinical practice guidelines and individual specialist assessments, and there would be no need for a meeting.

We also aimed to identify if there is any particular specialist role that is critical, or makes a unique contribution, to the discussion and if there is a particular role that benefits more than others from being party to the discussion. How well individual contributions to the group are regarded by their team colleagues is also evaluated.

Determining the availability, accessibility and ease at which specialists' information needs post-MDTM are met is also an objective, since it might point to weaknesses within the information flows and exchange during discussions. We asked individuals if they have a requirement to refer back to items discussed at the MDTM in the conduct of their respective duties afterwards, what items of information they access and how this requirement is met. Participants were asked also to indicate the level of difficulty normally experienced in satisfying these information needs post-MDTM.

3 The MDTM Event

The form of collaborative work done at MDTMs is considered to reduce health-care system error (Øvretveit 1999) by improving co-ordination and communication among MDT members. For example, modern cancer treatment can involve chemotherapy, and/or radiation therapy, and/or surgery, administered sequentially, concurrently, or in combination, depending on tumour variables, within a particular timeframe. Determining the best combination of treatment(s) for a particular patient, as well as co-ordinating the treatment can be problematic. Instead of an individual clinician making these decisions, a group model of care has developed through multidisciplinary team (MDT) working, and meetings of this group have evolved as the main decision-making forum for MDT activities. The MDTM, represented in Fig. 1, is proving itself as a useful mechanism to determine and co-ordinate appropriate treatment, and the practice of having MDTMs is becoming increasingly necessary and more widespread.

The usual specialities represented in a multi-disciplinary team are physicians, surgeons, radiologists, pathologists, radiation and medical oncologists, a physiotherapist (or dietician, or speech and language therapist, or other paramedical speciality, depending on the nature of the group), and nurses as well as a data manager and administrator. Medical and surgical staff in-training are also part of the MDT and attend MDTMs. Each specialist brings items of information to the MDTM and pools it into the discussion. Some specialities may describe findings augmented by images, such as radiologists who contribute in the diagnosis; others bring expertise and contribute more to the discussion of the management decision, such as oncologists.

An analysis of the MDTM process reveals that it starts with pre-MDTM tasks conducted independently by some particular roles within the team, and continues post-MDTM into the completion of assigned tasks and responsibilities, (often by a

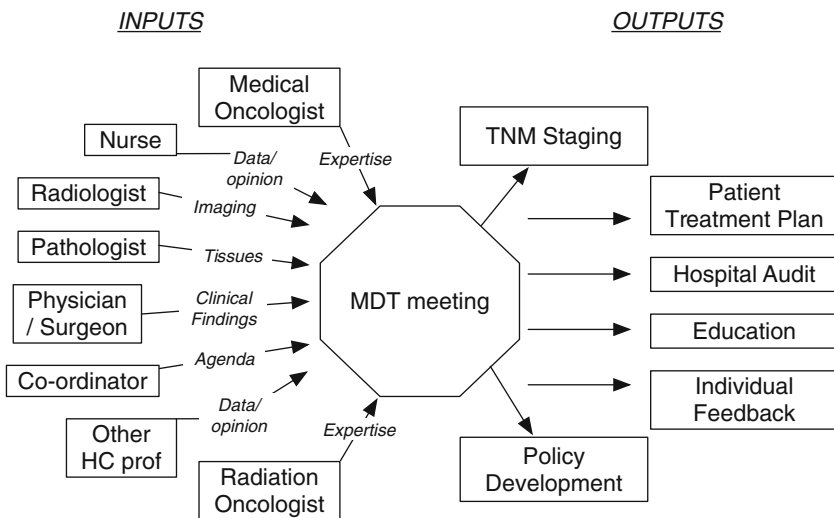


Fig. 1 The MDT Meeting where a number of clinical specialists meet and review patient case details

different set of team members). The MDTM itself, when all the team members come together, is discussion-based and examination shows it to be highly structured and comprised of two important parts. A description of the MDTM in the context of its function to improve dependability in the patient care pathway is given in [Kane and Luz \(2006\)](#). In this paper, some detail of a typical discussion is given to put the exercise reported here in context. A more detailed account is given in [Kane and Luz \(2009a\)](#).

In the first part of a PCD, the unit of activity at an MDTM, the clinical findings (signs and symptoms), including endoscopy, are reviewed in conjunction with the radiology and pathology findings. Typically, the clinician who examined the patient opens the discussion by summarising the presenting symptoms and the clinical findings on examination. Depending on the nature of the speciality, endoscopic or surgical findings may be reported. The radiologist continues the investigative story by illustrating relevant features in any images undertaken, such as chest radiographs, CT (Computed Tomography)/PET (Positron Emission Tomography)/MRI (Magnetic Resonance Imaging) scans, followed by the pathologist who demonstrates the microscopic tissue structures in the biopsy samples, or surgical specimens. The definitive diagnosis and disease stage is agreed by the MDTM, following presentation and correlation of the clinical, radiological and pathological findings.

The MDTM is the only place in the patient care pathway where the three-way correlation of clinical, radiology and pathology findings occurs. Correlation allows for the revision and reinterpretation of results, the resolution of any inconsistencies, prompts investigations to be repeated or draws attention to unsatisfactory work practices within the organisation. Typically in the first part of the discussion, when the patients definitive diagnosis is being established, diagnosis is often not straightforward ([Symon et al. 1996](#)). Discussion on the facts presented allows for individual specialists, such as radiologists, to refine, or explain the basis, of their professional judgement to the group ([Kane and Luz 2009a](#)).

The process of preparation for this first part of a PCD takes place pre-MDTM ([Kane et al. 2007](#)) when independent investigations are conducted, and individual team members review the information that they will present to the group at the meeting. The interaction through discussion in the first phase of the PCD essentially reviews the independent work conducted prior to the meeting. Through this interaction, a 'measure' of the patient's disease is generated, called 'staging', and this information serves as the basis for planning of the future work processes, to be engaged following the meeting.

The establishment of the definitive diagnosis (as distinct from the clinical, or pathological diagnosis), including the disease stage (called the TNM stage), is a critical element of the meeting, and this decision is achieved by consensus, as explained in [Kane and Luz \(2009a\)](#). The TNM (Tumour, Nodes, Metastases) staging represents the tumour type and size, the location and number of nodes involved (a measure of spread of disease) and if there is evidence of distant metastases, (a measure of disease extent). Together, the combination of tumour type, size and pattern of spread form a characterisation of the disease. While the pathologist contributes information on the tumour *type* from a biopsy sample, the radiologist can give an estimate of the *size* and *spread* of the tumour from imaging undertaken, and the clinicians often contribute information not available on imaging or tissues samples, which assists in determining

the extent of the disease from the patient's presenting signs and symptoms. Thus, no single speciality alone can estimate the TNM disease stage in a living patient as it requires collaboration from a number of specialities. At the MDTM, the TNM staging is generated through the interaction of specialities during the first part of the PCD.

The TNM stage is the key determinant in the choice of treatment and is the main input for the second part of the PCD when senior staff consider the treatment options and the most appropriate management for the patient in the circumstances, (taking current clinical practice guidelines into account). While the first part of a case discussion can be characterised by the use of radiological, pathological and sometimes other images to support the presentation of patient findings, the latter part has more interaction among specialities who engage in speculative appraisal of the options and achieve consensus on the most appropriate course of action to recommend to the patient. The patient's general state of health and co-morbidity (such as heart disease) are important factors, in conjunction with the TNM stage, in determining the most suitable treatment for an individual patient. More individuals will have information that influences the patient's general suitability for any treatment option being considered, and individual specialists contribute their opinion in the process. For example, a patient with an early stage non-small cell lung cancer (T1N0M0) may be best treated by surgical removal of the segment of affected lung, unless s/he is determined to be a very poor candidate for surgery. It is likely that this patient will initially present to the respiratory physician, and his/her care will be transferred during discussion to the cardio-thoracic team who will conduct the segmentectomy procedure and continue the care of the patient. Some negotiation may be observed in this part of the PCD as risks of treatment are weighed against potential benefits for the patient. For example, a surgeon might say:

Sounds like he isn't fit for surgery. You say he's confined to bed at the moment — that doesn't augur well for his prospects with surgery . . . even though its a T1N0M0

to which the physician might respond:

I think you'll find him suitable. He's highly motivated, and he's a hill-walker — he cycled a lot up until recently too, so he's good for his age . . .

and a nurse might add:

He told me its over 6 years since he gave up smoking
[supporting his transfer to the surgeon]

and the medical oncologist might contribute:

. . . surgery is his best chance. We can review him after that and see if chemotherapy has anything to offer
[further encouraging the surgeon to take over this case]

and the surgeon acknowledges:

OK, then, I'll take him over. Include him on my next round and we'll assess him.

By the end of the PCD each individual role has been party to the discussion of pooled information, whether contributors to the first part of the discussion, such as

radiology or pathology, or to the latter part, such as oncology or surgery. The information giving role of many of these specialists is recognised by their colleagues (Catt et al. 2005) and although some role contributions seem to be predominantly in one or other part of the PCD, all roles are observed to participate in both parts of the discussion from time to time. For example, in the latter part of the discussion the decision on the benefits of chemotherapy or surgery may not be clear-cut and participants might ask to review a particular feature in a radiological image, that might have been already mentioned in the first part of the PCD. Or the pathologist might remind the group in the second part of the discussion about subtle tumour features that will influence the choice of treatment. It is not unusual, during the presentations in the first part of the discussion for a surgeon or oncologist to interrupt the presenter and clarify a detail, in anticipation of later discussion that will involve their judgement on the matter. Several studies have found that the additional clinical information provided at MDTMs often alters the diagnosis and affects patient care (Newman et al. 2006).

MDTMs also serve important organisation and education functions and are useful fora for policy development. From time to time policy on protocols for investigation and treatment are revised through discussion; research ideas are considered and publications that impact on the domain are announced and discussed. The forum is an important organisational learning resource. Participation in MDTMs is a requirement in post-graduate specialist training and provides an opportunity for continuing professional development for hospital staff. In addition to promoting learning by making thinking visible (Collins 1996), verbal articulation and dialogue are recognised to have considerable promise as support mechanisms for problem-formulation and problem-solving (Schein 2003). Organisational effectiveness is dependent on valid communication. It increasingly hinges on the development of a common language, and any form of organisational learning requires the evolution of shared mental models. Dialogue is a necessary first step in the development of those shared mental models (Schein 2003).

Despite the acknowledgement that the MDTM adds dependability to the overall patient care pathway, and the recognised potential for technological support, the MDTM utilises relatively little technology during proceedings. Other than access to the picture archiving and communication system (PACS), a PC, document reader, microscope and an overhead large screen display (all of which are used in the first part of the discussion) technological support is not employed. *No* technologies are currently available to support the second part of a PCD where the treatment decision is made and the care plan is agreed.

4 Assessing Perceptions of Contribution and Gain

Following extensive ethnographic observation, reported elsewhere (Kane and Luz 2006), a questionnaire was devised to enquire of the information provision and information requirements of MDTM participants, including post-MDTM information needs, and the degree to which those information needs are satisfied through their attendance at MDTMs. Since each multidisciplinary medical team is comprised of several separate clinical teams, each of which has an internal hierarchy, with varying

levels of experience, the analysis of questionnaire responses sought to establish if there are differences in information requirements due to the nature of the speciality, team role, rank or amount of clinical experience, of team members. Furthermore, observation of the MDTM setting suggests that there are some roles that are key providers of information, while some other roles rely on the MDTM forum to provide them with information to use in their individual professional roles, post-MDTM (see description of the MDTM event, Sect. 3). Questions aimed to identify roles that were contributors of information and those who attended the MDTM to gain information from colleagues.

4.1 Method

A set of questions was developed in collaboration with members of one of the teams (respiratory). The set was tested with a sample of participants and was issued at a meetings of each of the main MDTs at a large teaching hospital and tertiary referral centre. The questions were distributed at meetings of eight MDTs, namely, respiratory, head and neck, urology, gynaecology, gastro-intestinal, lymphoma, breast and dermatology MDTs. In total, 140 questionnaires were distributed among the eight MDTs. Completed response sheets were collected at the end of each meeting.

Although the respondent's speciality, role and level of experience were recorded, individual responses were submitted anonymously. Follow-up interviews were conducted with team members who volunteered to discuss the questionnaire findings at a later date. Ten such interviews were conducted, lasting from 10 to 20 min, and each of the main roles in an MDT was represented.

4.1.1 Participants

Participants at each meeting, and subjects in this exercise, were all hospital staff and members of the team concerned. Within each of the eight MDTs, the members range from the most senior team members (consultants) through to the most junior members (interns) of the team. Other intermediate roles on the teams are registrars and house officers. Depending on the speciality, the multidisciplinary medical teams consist of various medical and surgical specialists. For example, the respiratory MDT has four consultant respiratory physicians and two consultant cardio-thoracic surgeons as well as registrars, house officers and interns working with each of the consultants. There are also radiologists, pathologists, oncologists, a chest physiotherapist and specialist nurse members of the team. An MDT can typically have approximately 40 members in a large teaching hospital.

4.1.2 Questions

Team members were invited to quantify the amount of information that they perceived they contributed to the MDTM as well as their perception of the new information they gained as a result of the discussion.

The terms ‘gain’ and ‘contribution’ are used here to describe the self-reported information contribution or gain respectively, that were perceived to pertain as a result of the respondents participation in PCDs at the MDTM. Participants were explicitly asked to assess their contribution and gain in terms of the *amount of information* provided and received during the discussion.

No attempt was made to quantify the information in terms of specific data items. Instead, self-reported measures were collected on a 5-point Likert scale. This allowed for the comparison of the relative differences perceived between an individual’s contribution versus gain.

While one can argue that perception of contribution and gain thus defined is essentially subjective, we took care that the criteria against which such assessment was made were clear and unambiguous to respondents. Since the questions were presented together, in the same questionnaire, and referred to the same variable (amount of information) it is reasonable to assume that the Likert scales used in the questionnaires have very similar properties and were interpreted as such by the respondents. We also verified, by interviewing a representative set of respondents that their interpretation of the questions matched their intended meaning.

Since the questionnaire was distributed among several MDTs of different specialities (e.g. gynaecology, respiratory, etc.), and participants were asked to describe their clinical speciality (e.g. radiologist, surgeon, etc.), status (e.g. consultant, house officer, etc.) and number of years experience, it is possible to investigate statistical relationships between these role factors and reported contribution and gain.

MDT members were also asked if they are generally satisfied with their own contribution to the team, the nature of the information they provide and of any difficulties they experience in making their contribution to the MDTMs. As well as enquiring of their role contribution, team members were invited to say from which role (if any) they would like to receive more information.

A separate question invited details of enquiries that team members might make of records *after* MDTMs, to fulfil their individual role needs. This question aimed to identify particular items of information that a MDTM record might incorporate, to facilitate team members in their work following the MDTM, and identify areas of difficulty. Team members were asked with regard to reviewing notes, or looking up detail, after the meeting to indicate the type of information currently consulted, the level of difficulty experienced, and information they would like to be able to access. Reported difficulty was indicated on an 11-point scale.

Prior to the issue of the set of questions described here, evaluations of different elements of the MDTM were collected over a series of MDTMs. The description of the patient’s clinical presentation and findings, the results of their radiology and pathology as well as an assessment of the amount of discussion about the patients management were evaluated by the attendees. Attendees were asked to rate contributions and indicate if they would have liked more, or if too much time was given to a particular aspect. Responses were collected on a 5-point Likert scale. The results of the evaluations are reported in [Kane and Luz \(2006\)](#) but were re-examined in the light of the findings of the set of questions designed for this study.

5 Results

A total of 104 completed questionnaires were returned which represents a response rate of approximately 80%. The vast majority of responses were submitted from senior members of the team (91, or 88%). Responses were also received from eight junior doctors and five medical students. A breakdown of the respondents' roles in the MDT is given in Table 1. All roles who normally participate in PCDs were represented in the submitted questionnaires.

The non-responders were generally junior members of the team, who said afterwards that they felt inadequate and were concerned that 'poor scores' might be reported to their seniors, despite being assured to the contrary. These junior team members reported that they feel they contribute nothing to the discussion but gain a lot. They regard the MDTM as a tutorial. Since they did not submit paper-based responses, their views are not incorporated into the quantitative data reported here. However, their views are taken into account in the interpretation of results, and discussed in the conclusion, when we refer to the separate groups identified that demonstrate different information needs. Results presented within Tables and Figures are confined to the data submitted.

Of the 104 respondents, 39 are consultants (and the most senior members of the MDT). These 39 responses represent 100% of the consultant participants among the eight teams with which this exercise was conducted. A total of 20 specialist registrars and 12 registrars responded (who are next in seniority to consultants). Most of the respondents were experienced in their role; the breakdown of experience is summarised in Table 2.

Almost all the senior members of the teams completed the questionnaire, which allows for analysis and inferences for active participants at MDTMs. Exercises that

Table 1 Respondents' roles at the MDTM

Role	No.	Role	No.
Physician	15	Surgeon	26
Pathologist	16	Radiologist	10
Nurse	9	Med. oncologist	9
Dietician	1	Rad. oncologist	4
MDT Co-ordinator	3	Physiotherapist	1
Researcher	1	Data manager	3
Speech/Language		Medical student	5
Therapist	1		
		Total	104

Table 2 Respondents' levels of work experience

Experience	Frequency	Experience	Frequency
>20 years	11	<1 year	12
11–20 years	28	None	2
6–10 years	20		
1–5	29	No response	2

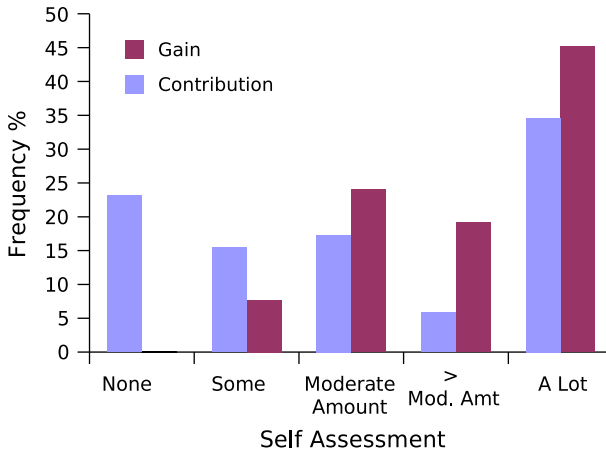


Fig. 2 Information contribution and gain

involved the observers only are reported elsewhere (Kane and Luz 2009b). With respect to individual contribution to the PCD, two groups are distinguishable: those who are active contributors (76) and non-contributors (28).

Given the similarities between the different MDTs the analysis of results reported in the following sections are generalisable and can be expected to apply to other teams and situations.¹

5.1 Providing and Receiving Information

Respondents' perceived contribution and gain is illustrated in Fig. 2. 40% of the respondents feel they contribute little or nothing to the proceedings. (16% do not consider that they have much to contribute and 24% claim to be non-contributors.) Over one-third (34.6%) feel they 'contribute a lot' to the MDTM, while 17% consider they contribute a 'moderate' amount to the discussion. 5.8% value their contribution as 'more than moderate amount'.

With respect to individual gain, as an outcome of the case presentation and discussion at the MDTM, all respondents perceive at least some information gain. 19% report a gain of 'more than a moderate amount' and 45% claim to 'gain a lot' from the proceedings. While 24% consider their information gain to be 'moderate', 8% consider there is 'some' gain. Thus, over 90% say that the gain 'at least a moderate amount' from their attendance at MDTMs. There were four non-respondents.

There is no significant difference in the amount of reported gain between the active and passive participants to the PCD. Seniority and experience did not have any effect on the reported gain from the PCD and experienced members of the MDT were equally

¹ In different parts of the world terminology differs with respect to these types of meetings. 'Tumour boards', 'surgical risk management meetings', 'clinical pathology conferences', 'surgical pathology meetings' and 'consensus meetings' are among other terms used. Meeting behaviour can be expected to be similar for all of these meetings with some local variability.

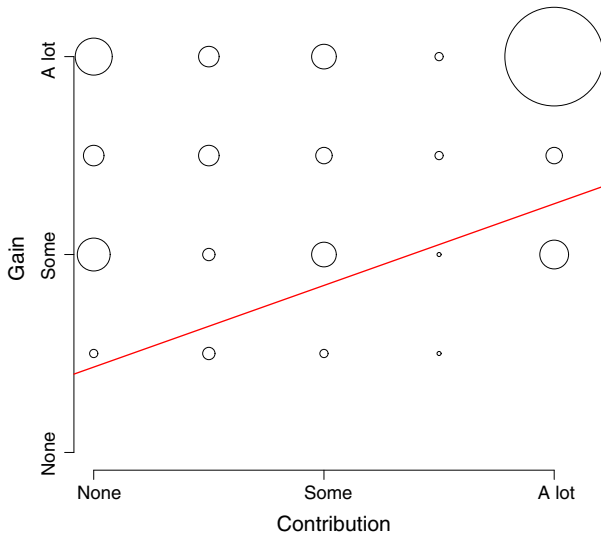


Fig. 3 Individual contribution and gain

likely to report a benefit from the discussion as their less experienced colleagues. When a ‘net gain’ calculation is taken into account, a significant difference is evident between active and passive participants. *Net gain* is calculated from the differences between the self-reported contribution and gain from discussions, $t = -9.847$, $df = 49$, $p = 0.000$.

The vast majority the respondents (86%) claim to experience at least as much gain as the contribution they provide, while over half (52%) experience a net gain from their participation. In other words, they consider that they gain more than they contribute from their attendance. Interestingly, there is also a significant correlation between the self-reported estimations of contribution and gain (Spearman’s correlation coefficient $\rho = 0.262$, $p = 0.008$). This is clearly shown in Fig. 3, where perceived contribution is plotted against perceived gain, and the diameter of a circle is directly proportional, on a logarithmic scale, to the number of responses (data points) for a particular pair of answers. The large circle on the top right-hand corner of the graph, for instance, represents the fact that a large number of respondents claimed that they contribute a lot to the MDTM and gain a lot from it, whereas the small circle on the bottom left means that few people thought they contribute nothing and gain little from the MDTM.

At interview, following analysis of the questionnaire responses, when participants were asked to describe the nature of their experienced information gain, they consistently reported that they ‘learned’ from their participation at MDTMs. Following one participant’s explicit description of the learning he experienced through articulation of his contribution, a sample was asked if the learning, or gain, they reported was because of their own contribution, or that of their colleagues. All those questioned reported that when completing the questionnaire they had in mind the gain they received from listening to a colleague’s contribution, rather than articulation of their own. They added that, on reflection, they learn from their own contribution too. As one participant described it:

when you're trying to explain to others the basis of your opinion . . . and justify it, . . . it makes you think about the detail . . . and things becomes clearer . . .

Thus, it is likely that the information gain for participants at MDTMs is actually greater than that expressed in the written questionnaires and that our analysis here of information gain at MDTMs is conservative.

There is no role identified that can be considered as a 'contributor only' of information. For those respondents (15) who claim to make greater contributions than their gain, 11 consider they contribute 'A lot' and gain a moderate (7), or more than moderate, amount (4). The majority (67%) of these 15 individuals are either pathologists or radiologists (10) and among the remaining 5 are physicians (2), medical oncologists (2) and a surgeon. It is noteworthy that 35 (34%) claim to make contributions equal to their gains, and that 24 of this group (69%) categorise the quantity as 'a lot'. When the data are examined with respect to the individual contribution and gain, they suggest that there are two distinct groups: active participants and passive observers. Passive observers can gain a lot of benefit from their attendance. When correlation between contribution and gain is examined for the active participants only, we find that the more an individual contributes to the discussion, the more they gain as a result (Spearman's correlation coefficient $\rho = 0.3342$, $p = 0.003$).

5.2 Information Presentation

Participants were asked to describe the specific type and form of information provided by their role to the MDTM. The information contributed to the MDTM can be categorised as: information provided initially by the patient (symptoms), observations by clinicians (findings on examination), images, and experience/knowledge of the participant. Team members emphasised in text and at interview, that while the information may be contained in pictures or images they bring to the MDTM, they also contribute their interpretation of the data and *diagnosis* to the MDTM. It would be wrong to interpret the image data in itself to contain all the information that it represents. It is the interpretation of the image data in conjunction with the other findings that provides the knowledge necessary for the definitive diagnosis and effective treatment of the patient. For example, the radiologist interprets the radiological image in the light of the clinical information provided at the time of the imaging request. Through further interaction at the MDTM with the pathologist and clinical colleagues, the interpretation of the image is refined in the light of new information received at the MDTM (Wong and Birks 2004; Santoso et al. 2004; Newman et al. 2006). Radiologist and pathologists usually present images when making a contribution. Physicians and surgeons sometimes present images from clinical procedures.

An issue was raised at interviews that needs to be highlighted. Pathologists and radiologists are consistent contributors to MDTMs, regardless of speciality (i.e. gynaecology, lymphoma, lung). Both these specialities issue formal written reports on the material being presented as well as demonstrating the significant image features at the MDTM. In other words, participants at MDTMs also have available to them written reports that are filed in the patient's chart (or record) and although available, team members find it important to have the radiologist and, or, the pathologist articulate

their findings verbally. Disquiet was expressed by both radiologists and pathologists during interviews that while they know what the formal record says, because they would have overseen the issue of the written record, they have a concern that they may be misunderstood when they articulate image findings at MDTMs. While they aim to emphasise features and add nuance to help in the differentiation and interpretation of findings, they have a concern that their manner of delivery may be misinterpreted by listeners. For example, some image features may be attributed to an inflammatory, or malignant, process and while the presenter may feel that the weight of evidence is in favour of it being one process more than another and might say

... its probably benign ... ,

a listener may wrongly over-interpret this statement to mean that the finding *is* benign. Or a radiologist may outline an area of suspicion in the patient's left upper lobe of the lung with a pointer, which will appear on the right side of the image displayed. Mistakes in marking left or right sided lesions is a known source of error (Seiden and Barach 2006; Gormley et al. 2009). Another example is when a tumour is described as

... a typical carcinoid ...

it could be wrongly noted as

... an atypical carcinoid ... ,

which changes the nature of the patient's condition dramatically and has treatment implications. Another concern is the use of acronyms. S.C.C. is commonly used for Small Cell Carcinoma of the lung, but some people use the acronym for Squamous Cell Carcinoma of the lung, which is an entirely different category of lung tumour, with a different treatment approach. In the former, chemotherapy is the most common strategy, while surgery is preferred for squamous cell tumours (depending on the fitness assessment and other co-morbidity factors). These examples are evidence in support of the need for interactive visual annotation of images during the PCD, and/or the collaborative creation of a record visible to all MDTM participants.

The potential for these sorts of errors is a cause for concern. Presenters of information do not have any way of knowing what personal notes any individual listener may have taken for later use, and if these notes might contradict the written formal report. Several clinicians expressed concern that misinterpretation of nuances, or misattribution of expression, might mislead another clinician and ultimately affect the management of the patient. Presenters of information have an interest in receiving feedback that their message was received and understood as they intended. This concern was also articulated by surgeons when they give their opinion on a patient's suitability for surgery. If an error in understanding results in a patient being referred to the surgical out-patient clinic, the error can be corrected and the patient will not proceed for surgery. However, if the misunderstanding results in the patient *not* being referred when they are, in fact, a suitable candidate, then there is potential for the patient to be adversely affected by the mistake. This issue highlights the need for a technological solution to facilitate an information-rich record that would be consistent, reproducible, could be referenced as needed and would provide the added value

needed that is not currently embodied within the written record. This record proposed would satisfy the sender, be available for checking, and provide clarity for the receiver. Ideally a mechanism would be developed to facilitate a 'return message' to confirm that the understanding of the receiver was that intended by the sender. This could potentially be achieved through a single record agreed during PCDs, visible to the information provider, and available for individuals on personal devices, if required. A large interactive display that would support visual annotation and allow preservation of record of MDTM discussion, as discussed earlier, is indicated.

5.3 Evaluation of MDTM Contribution

Generally speaking, team members are satisfied with the presentation of information from their own role to the MDTM (64.4%) with a minority (21.2%) dissatisfied. Among the reasons for dissatisfaction are: (a) that more *time* is needed for preparation beforehand, and for discussion at the MDTM; (b) that their contribution would be more valuable if all surgical patients were *always* discussed prior to their surgery (which doesn't always happen due to time constraints), (c) the equipment at the MDTM is not user friendly in allowing to make the most of the image they wish to show and (d) there is no facility (currently) to demonstrate electronic images from the endoscopic unit to the MDTM. Items (a) and (b) listed here are process and scheduling issues (Kane et al. 2007); item (c) refers to the technology currently used at the MDTM. The system in use was generously donated to support a teleconferencing initiative and was not designed for this particular setting that involves multiple users at the same time. Item (d) above refers to a limitation of the current endoscopy system to be networked and available to the MDTM. This constraint has since been rectified. With regard to the information provided by other members of the team, almost 20% (19) of respondents indicated that they would like more information from some of their colleagues. Over 50% (11) of these respondents would like to get more information from the clinicians, particularly the lead clinician (3). Other sources identified, from which information would be appreciated, are images from procedures, charts, radiation oncology, radiology, pathology and from management with respect to how the MDTMs might be better supported.

Both pathologists and radiologists express a strong need for detailed clinical information on request forms beforehand to enable them to better prepare for the MDTM. The problem of adequate clinical information being provided to radiologists and pathologists at the time of service request is a common problem and is also identified in other studies (Symon et al. 1996). When a patient is being tabled for discussion at the MDTM, information is again requested by radiologists and pathologists to facilitate more efficient review of the relevant materials prior to the discussion. For example, a patient may be tabled for discussion because of a special interest in the review of a PET scan that was not available during an earlier discussion. In these cases, the pathologist need not make a prolonged review of the material since the focus of the discussion will be on the PET scan images to be presented by the radiologist. Such practices prompts that the co-ordination of artefacts, information and procedures deserves particular attention in efforts to design systems that will maximise efficiency across a

multitude of users and specialities. Supporting the pre-MDTM coordination and data gathering processes, and dissemination of relevant material among the group prior to the discussion, has been identified as an area of key importance (Kane and Luz 2006).

Another need expressed by many participants is the explicit articulation of the agreed outcome, or management plan for the patient, from the lead clinician. Historically, patient management decisions were made by the clinician responsible for the patient, in conjunction with the patient. Nowadays, with more specialisation and complexity in diagnostic and treatment approaches, multidisciplinary input is advised and a recommendation on a treatment plan is agreed by group consensus, rather than an individual clinician. (The recommendation is currently relayed to the patient who ultimately makes the final decision.) The development of a meeting record, that would explicitly summarise the recommended action and responsibilities, would serve as a useful method for the coordination of post-MDTM tasks and responsibilities and facilitate audit.

In the discourse given on p. 443, the surgeon in closing the discussion gives a direction to one of the team to “include him in my next [ward] round”. Although it is not apparent to a casual observer who this individual might be, it is a designated responsibility of one of the team to organise information necessary for the ward rounds. Furthermore, in saying that “we’ll assess him”, conveys a signal to the team that he expects to be reminded of this decision when making the ward round. The transfer of formal responsibility for this case from the physician to the surgeon during the MDTM, which was also indicated on closing the discussion, is the responsibility of another member of the team. These roles and responsibilities should be clear to the individuals concerned, but there is no easy mechanism to clarify that the relevant members of the team are aware of their responsibilities, nor is there an easy mechanism to audit that the tasks were satisfactorily completed.

Results to the question on participants’ contributions were reviewed in conjunction with MDTM evaluations over a series of MDTMs. A summary of participants evaluations is given in Fig. 4. Participants are most satisfied with those contributors to MDTMs who articulate their findings through use of artefacts, i.e. radiological and pathology contributions are rated more highly than those who present information through voice alone.

Figure 4 shows that over one-third of MDTM participants would like to have more discussion on the patient management and clinical aspects of the discussion. Both these aspects of PCDs are conducted through vocal interaction without the support of artefacts. The greatest satisfaction ratings (>90%) are for radiology and pathology, who demonstrate relevant features using images. Endoscopy features are given in a verbal report to the MDTM. The visual appearance of the airways (or gastrointestinal tract, or other accessible anatomical structure) is described and sometimes the description is supplemented with an image and shown to participants. Figure 4 illustrates that those contributions that utilise artefacts to supplement their presentation are rated more favourably than the aspects of the MDTM that involve talk alone, again reinforcing the requirement for better support for shared and interactive presentation of information at MDTMs, or ‘situation awareness’ support, identified in the previous section.

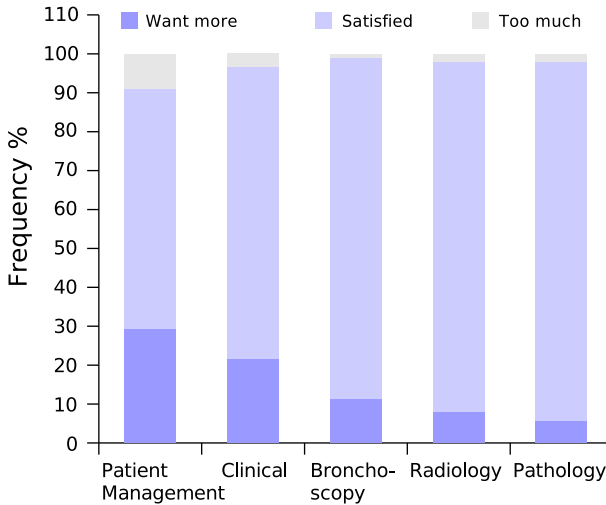


Fig. 4 Evaluation of contributions

5.4 Post-MDTM Needs

Participants were asked to indicate the type of information they currently consult, the level of difficulty experienced, and information they would like to access after the MDTM. Results are summarised in Fig. 5. When respondents indicate that they currently access an item, they expect to have continued access. In Fig. 5 those expressing a wish to access an item, represent MDT members who do *not* currently have access to that information.

The levels of reported difficulty in accessing items of information after the MDTM is summarised in Fig. 6. The level of difficulty reported for radiology images is unexpectedly high, because of difficulties following the introduction of a Picture Archiving and Communication System (PACS) in the hospital. The system was oversubscribed and there were a number of recent failures prior to the issue of the questionnaire. Issues around the access of pathology reports include criticisms of the turnaround time needed in pathology and are not solely due to lack of electronic access. Access to view pathology reports (text) has been made available through the electronic patient record (EPR) system that was introduced in conjunction with the PACS project.

For each of the items identified in Fig. 5 for which there is a wish to have access, there is a correlation (significant at 0.05 level), with the level of difficulty in accessing the corresponding item in Fig. 6, *except* for the ‘decision agreed’ and the ‘personal action point’. Spearman’s Correlation ρ and statistical significance p for the correlations calculated is given in Table 3. These items which team members wish to have but report difficulty in accessing relate to organisational/hospital information. Individuals tend to rely on personal notes as reminders of personal professional tasks and responsibilities, rather than rely on the systems available which are considered weak.

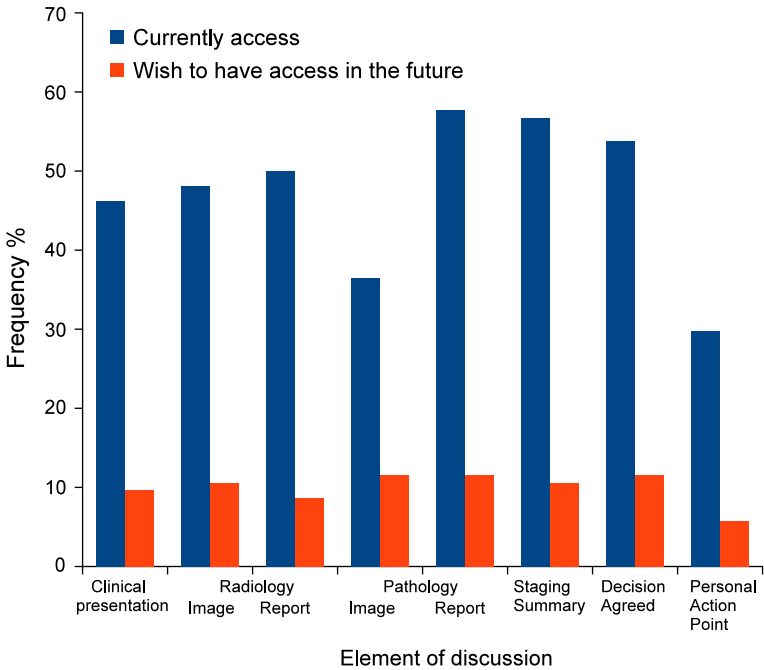


Fig. 5 Information needs post MDTMs

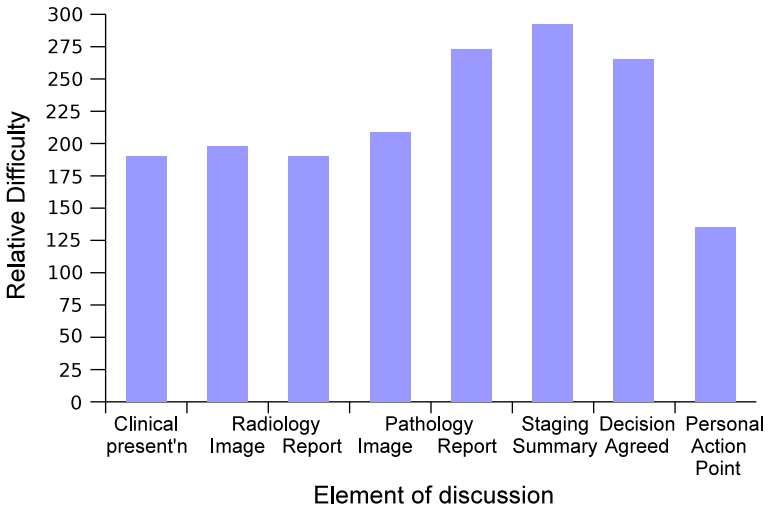


Fig. 6 Relative difficulty in accessing information

For the ‘decision agreed’, many respondents expect one of their juniors to take note of this decision and do not have a personal need to access this information on the decision in many cases. Furthermore, an individual clinician is not bound by the group decision (in current practice). So, for some clinicians there may not be the same necessity to record the decision, and access to the original data will facilitate reflection

Table 3 Correlation between the wish to access an item of information and the level of reported difficulty in accessing that information

Information item required	Spearman's correlation coefficient ρ with difficulty with access	Significance p
Clinical details	0.203	0.039
Radiology images	0.402	0.000
Radiology report	0.333	0.001
Pathology images	0.339	0.000
Pathology report	0.318	0.001
TNM staging summary	0.241	0.014
MDT decision agreed	0.149	0.132
Personal action point	0.106	0.283

and recall of the PCD. Similarly for personal note-taking, many senior clinicians rely on junior staff to record notes during the MDTMs. These explanations account for the lack of correlation for these items. Nonetheless, it is considered that easy access to the advice of the MDTM and decision agreed, as well as tools to facilitate personal note-taking would be welcomed. Technological support to facilitate easier access to formal pathology reports, radiology images and reports, and summaries of the TNM disease stage, is considered a necessity.

There remains a significant issue with regard to the format of a formal record of the latter parts of a PCD, namely, the TNM disease staging summary, the decision agreed and the consequent action that needs to be taken. While many respondents report that they sometimes experience difficulty locating the clinical findings in patient charts, more people said that the outcomes of the discussion are more difficult to establish afterwards (than clinical details). Currently, a member of the team records the decision made on a form which is later filed in the patient's chart. Although this practice is the current standard, patient charts with filed forms may not be available to all clinicians when needed. Many clinicians tend to take personal notes during MDTMs, for reference afterwards. While personal notes are useful, the official record is the one that has medico-legal validity with respect to the MDTM decision. If members of the team have differences in their understanding of what was agreed and decided, the current formal record can prove weak in resolving and establishing the true facts afterwards. This seems to indicate a need for post-MDTM validation of the formal record in addition to (or perhaps in coordination with) support for individual notetaking and shared information display during the meeting as discussed above.

6 Discussion

In this section the main findings are reviewed and the challenges with regard to providing support for MDTM-type activities, are identified. Where possible we make suggestions that would improve on known problems in terms of technical support and better co-ordination of work processes.

It was postulated at the outset that some roles might attend the MDTM for the sole purpose of imparting information. If a particular role could be identified to be

critical to the proceedings, or if information could be specifically identified that could be provided independently of a clinician, then technology could be proposed to target the provision of those specific information needs. But no particular speciality was identified as ‘critical’ to a successful MDTM; all specialities need to be present for the PCD to be a success. Harmonising and synchronising work rhythms (Reddy and Dourish 2002) offers the best solution to enable all participants and information to be available together. Emphasis is given to the importance of radiology and pathology to the establishment of a definitive diagnosis and the medical oncologist and radiation oncologist to the discussion on appropriate treatment options. These four specialities (radiology, pathology, medical oncology and radiation oncology) are core members of several MDTs, (compared to specialists such as a respiratory physician who belongs to one team), and spend a lot of their time in preparation for, or in attendance at MDTMs. Technologies that might support pre-MDTM preparation for radiology and pathology, or customised note-taking for oncologists have potential to positively impact on work practices for those specialities.

Participants’ contributions vary on the amount of knowledge, experience, views and interpretations of data that they bring to the discussions, but all members experience gain regardless of their rank or experience, even though the MDTM is not the only source of the data (which are available through distributed records). Contributions are more highly valued when they are supplemented with image artefacts (Fig. 4), and participants would like to have more time for discussion. Figure 3 shows that while some people may gain a lot with little contribution, there is a correlation between higher contributions and high gains from participation, suggesting that efforts to support increased interaction among the participants will yield important gains. Tools that would support the use of multiple images at once could potentially save presenters’ time that is currently spent locating, loading and referring back and forth among different image sets, and allow more time for interaction and discussion.

The aspects of the discussion that rely on vocal interaction, and rate less favourably, are difficult to support technologically. However, if the talk processes were better understood through deeper analysis of how knowledge is shared, grounding achieved and the role of interplay between speech and actions that take place (Clark and Krych 2004), the information needs of clinicians at MDTMs might be better facilitated. The development of a MDTM skills taxonomy to support communication, situation awareness, teamwork, decision-making and leadership such as those identified for surgeons in the operating room (Flin et al. 2006) has the potential to help understanding of the interactions that take place at the MDTM and develop technological supports to enhance those interactions.

6.1 Information, Knowledge and Learning

The “community of interaction” demonstrated in the MDTM contributes to the amplification and development of new knowledge and can be regarded as an important mechanism for the organisational learning. As noted by Nonaka (1994), organisational knowledge is created through a continuous dialogue between tacit and explicit

knowledge, and the group interactions at MDTMs provide a valuable forum for knowledge development. The MDTM as a community can be considered as a ‘hidden fountainhead of knowledge development and therefore the key to the challenge of the knowledge economy’ (Wenger and Snyder 2000, p. 145). While describing communities of practice as the new frontier in organisations and predicting that in the future they may be as common to discussions about organisations as business units and teams are today, Wenger and Snyder (2000) emphasise that such practices need to be nurtured by management to reach their full potential.

In this paper, the term ‘information’ has been used mainly to refer to patient data items and disease processes. There are other levels of information processing that are evident at MDTMs, namely the internalisation and feedback that is embedded in the exchanges at individual, group and at hospital organisation level that should be noted. There are many facets to the MDTM and the development of any tools that might support the activities must understand, and take account of, the multi-dimensional nature of the activities. Activities to be supported need to be considered from the perspective of an individual member of the team, the interactions that occur between its members and the knowledge-capture need for the organisation, i.e. solutions should be sought at the individual, group and organisation levels.

It is understandable that a surgeon listening to a radiologist articulate significant image findings will represent additional knowledge for the surgeon, but the benefit to the contributor of information, in this example the radiologist, must not be overlooked. The articulation of thought, and connecting new experiences to existing knowledge, enhances the development of clinical reasoning (Murphy 2004; Koschmann 2002). People learn through dialogue with one another and, in the process, transform their understanding (Collins 1996). Individuals tend to overlook this self-benefit and consider others as the sole providers of gain. However on reflection, participants acknowledge and agree that the articulation of information develops their own knowledge and understanding. Thus, the person presenting the information to the group benefits through the articulation of the information. We see the MDTM as a ‘knowledge-building community’ in the respect that knowledge and learning are a by-product of the social processes (Hoadley and Kilner 2005): knowledge is generated and shared where there is purposeful conversation around content in context. Elements can be identified in MDTMs that occur in communities of practices: content, conversation, connections, (information) context and purposes. *Content* refers to explicit tacit knowledge objects, *conversation* refers to discussions, *connections* refer to interpersonal contacts between community members; *context* provides the rich details that makes information meaningful and *purpose* is the reason for the community. The greater these elements are present in any community, the more likely and effective the knowledge generation and transfer will be (Hoadley and Kilner 2005).

Extending this description of the MDTM as a community, and rather than seeing knowledge as a thing that belongs to an individual, it is more useful to adopt Koschmann’s view that knowledge is better described as “meaning-making in the context of joint activity” (Koschmann 2002). Knowledge is generated through discussion at the MDTM. Although contributed by the individuals present, the body of information belongs to the group. Stahl in his outline of learning models described how groups

are believed to construct knowledge by a synergistic effect that merges ideas from different perspectives (Stahl 2002). He says:

In collaborating, people typically establish conventional dialogic patterns of proposing, questioning, augmenting, mutually completing, repairing, and confirming each others expressions of knowledge. Knowledge here is not so much the ownership by individuals of mental representations in their heads as it is the ability to engage in appropriate displays within the social world (Stahl 2002, p. 177).

In this example of the MDT, the group knowledge is achieved through group discourse, is spread across people and artefacts and persists in physical artefacts. This group knowledge generated for a PCD could potentially be captured in a persistent MDTM record that would eventually be filed in the patient's (electronic) chart. Sets of records could be used for educational benefit and a record would also serve as a resource for audit and practice reflection.

6.2 How does the MDTM Provide Feedback?

Feedback is provided to both clinicians and the organisation through the group activity. The product of the group work is ultimately evidenced in how well patients are managed and feedback is provided through regular audit reports and physical artefacts such as the attendance record. Having satisfying MDTMs with all attendees is an important feedback mechanism for the continuance of the MDTM practice. As long as individuals experience personal benefit, the team benefits and the MDTM practice is reinforced. Should it happen that members experience dissatisfaction, then the practice of MDTMs can be predicted to become vulnerable. Attendance at the MDTM is voluntary, so user involvement and acceptance of any technological support is critical for successful continuance of the MDTM practice. Any initiative to enhance the participants' experience would be welcomed.

For individual level feedback, consider the work of any of the clinical specialists who participate in the MDTM. Each individual works relatively independently outside of the meeting time. For roles to be effective, work tasks must have feedback mechanisms to provide the individual with information about their job performance. Feedback is identified as critical to effective work performance (Hackman and Oldham 1980). For many of the roles at the MDTM, the MDTM itself provides feedback on their performance, as well as providing a context to their individual contribution. For the radiologist, pathologist and clinicians, their opinions and observations are correlated with one another. Tissues removed by surgeons are shown in images by the pathologist and margins are discussed: confirmation is provided that the targeted tissue was satisfactorily removed. Thus, as well as being a forum for patient management and professional training, the information sharing and interaction at MDTMs serves important functions with respect to performance feedback for team members. Pathology demonstrates the material removed by the surgeon and sample quality in pathology is an indicator of the skill of the biopsy taker. The investigations requested (and results of those tests) serve as feedback to the clinicians'

investigative skills. If the physician requests inappropriate tests, for example, it will become apparent in discussion. Correlation between radiology and pathology provides feedback on interpretation for radiology. Correlation between radiology/pathology and clinical findings provides feedback for each of these investigative modalities. Findings should always concur and spurious opinions (formed prior to the MDTM) will be made visible in discussion. Facilitating the comparison of images from independent data sources on a large screen display, and to support multi-modal annotation, and saving, of the collaboration would greatly enhance productivity in MDTM work.

6.3 Radiology and Pathology

Radiology and pathology images and reports, are regularly accessed outside of the MDTM by team members and there are levels of difficulty associated (Figs. 5, 6). While radiological images are more frequently accessed than radiology reports, the reverse is true for pathology. There are several possible reasons for this imbalance. One reported reason is the amount of time MDT members 'seek' the pathology report while the sample is in process. The turnaround time for pathology can be 5 days or longer, depending on the level of disease complexity. There are occasions when the final pathology report has not been concluded by the time the MDTM takes place and MDT members will afterwards seek the final report. Closer examination of information seeking behaviour, utilising the concept of work rhythms (Reddy and Dourish 2002), will identify potential solutions, such as alert mechanisms, to advise when information is available to requesting clinicians.

The need to access radiology images, but not reports on those images, is sometimes interpreted by radiologists that other clinicians (mistakenly) believe that they are competent to interpret a radiology image, but not a pathology image, and may explain why radiology reports are less often read than pathology reports. Radiological images are more widely accessed also because images can have different meaning for different specialities and individuals may feel that they can satisfy a personal need by reviewing an image, even with their limited knowledge of radiology. For example, a surgeon may have a need to use the image to help conceptualise the surgical setting and 'see for himself, or herself', with a view to removal of a tumour. An oncologist's interest may be the status of lymph nodes and the tumour volume rather than the precise location of a tumour and its adjacent structures. Thus, a record generated will need to serve multiple needs, or multiple forms of a record will be needed to accommodate different perspectives. Radiological and pathology images are part of the knowledge infrastructure whose depths of interdependence and their role in knowledge production needs to be recognised (Bowker and Star 1999).

The correlation between the wish to see an item and the difficulty experienced in trying to access it (Figs. 5, 6) suggests that reducing the level of difficulty will satisfy some of the current needs of team members. Increasing the number of access points, investigating rhythms in the seeking behaviour as well as alert mechanisms, note-taking tools and a MDTM record all have potential to reduce difficulties in satisfying these information needs post-MDTM.

6.4 Decision Basis and Outcome

Almost half of all comments from respondents about their post-MDTM information needs concern items directly associated with the patient management decision and the underlying rationale (clinical findings and disease stage), or basis, for that decision. Harmonising MDTM work rhythms with intersecting rhythms where team members frequently have a need to access clinical presentation, disease stage and the decision agreed at the MDTM, will make the processes more efficient. Less frequent needs to refer to personal action plans were reported. This observation is explained in the fact that tasks relating to appointments and follow-up details are delegated to only one or two roles within a team. Observer participants at the MDTM are shown to have a greater need for personal note-taking than the vocal participants (Kane and Luz 2006).

Without doubt there is information gain for MDT members at the MDTM but it can be difficult to refer back to that information afterwards, particularly concerning decisions made, and the underlying basis for those decisions (Fig. 6). The decisions made at the MDTM form the basis of the patient care plan, or the material resources for action (Suchman 1987) on which the process depends. In an effort to improve the process, formal articulation of the summary decision was introduced to make explicit the patient management plan, allow for checking agreement and make it easier for those who wished to write notes. Current paper methods for recording the decision of the PCD remain to be improved.

Long term ambitions to implement a full electronic medical record system will need to incorporate a summary of the decision, as minimum, into the patient's record. A case can be made that as well as incorporating the decision, that the underlying basis for the decision, the specific images and artefacts reviewed as well as the options that were considered, will need to be included. The form that any potential record should take, i.e. text-based, still images, audio and, or, video will need to be agreed with users. Just as the need for PCDs has slowly been growing in popularity, so we can expect that the detail that users will wish to include in the formal record will grow as practices become even more established. A taxonomy of non-technical skills for surgeons, made up of four skill categories to improve communication among professionals in the operating room (Flin et al. 2006) could potentially be adopted to provide a framework and common terminology that allows team members to communicate effectively with each other. These categories of 'situation awareness', 'decision-making', 'communication and teamwork' and 'leadership' could be applied in situations such as PCDs to improve communication at the MDTM. A MDTM skills taxonomy modelled on the work of Flin et al. (2006) is currently under development.

In summary, there are different levels at which design interventions would make the process of MDTMs more satisfactory. At a basic level, the design of instrument controls could be implemented, at other levels support for articulation of ideas through facilitation of a greater use of images would enhance proceedings. Given that current patient records do not meet user needs, evidenced in the need for an MDTM, suggests that current paper (and electronic) record systems have not managed to embody all the information needed for health professionals to carry out their role responsibilities.

Supporting interaction among participants rather than the static storage of data will prove more satisfactory in the longer term. Technology that will allow pre-MDTM work to be more easily transferred into the MDTM setting; devices for pointing and annotation would facilitate greater interaction and personal notetaking devices would serve to support post-MDTM work. MDTM records, designed with user involvement would potentially satisfy several longer term needs and goals and be linked with more traditional patient records. Improvements in the MDTM will likely be achieved through a combination of behavioural interventions, including work process harmonisation, and technological innovation.

7 Conclusion

Information exchange at MDTMs is more than simply a sharing of patient data items. The decisions agreed by consensus at the MDTM, are achieved by pooling information, exchanging opinion and negotiating, through talk among team members. All participants gain information and more information is generated for the group than the individual contributions would suggest. The articulation and interaction through conversation yields benefits, not only for the patient, but also for individual practitioners, the group (MDT) and at the hospital (or organisation) level. The decision record from the interactions at the meeting serves as a reference tool on which future individual clinical decisions are made and has the potential to become a central, or key, item of information in any EPR.

Supporting interaction and exchange of information through the use of image artefacts will enhance the collaboration and exchange. The provision of a large shared interactive display area that would allow for multimodal annotation and saving of the interactive activity would provide a record that would support individual team members in their post-MDTM tasks and responsibilities. Such a record would allow for audit, which would facilitate the development of improved clinical practice guidelines on which modern healthcare services depend. Records of the case discussions would also provide a valuable learning repository for on-going training and development. Acknowledging the multiple facets to the information needs and sharing practices at MDTMs provides insight into what might be required to support activities at MDTMs.

As the practice of MDTMs become incorporated into clinical work, with growing evidence of the patient benefit that results, it is incumbent on designers of information communication technologies to address the challenges that such changes in work practices bring to IT practitioners. Furthermore as this research demonstrates, the more we understand of the multiple functions that forums such as the MDTM fulfil, and the complexities of interaction among collaborators in such settings, then we realise that more sophisticated mechanisms need to be created to capture the rich data generated through human interaction. By developing technologies to support such fora, then benefits will be experienced at the organisation, group and individual team member levels, as well as for individual patients or clients.

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