



ELSEVIER

journal homepage: www.ijmijournal.com

“Do no harm”: Fortifying MDT collaboration in changing technological times

Bridget Kane^{a,b,*},¹ Saturnino Luz^b

^a St. James's Hospital, Trinity College Dublin, Ireland

^b School of Computer Science and Statistics, Trinity College Dublin, Ireland

ARTICLE INFO

Article history:

Received 4 May 2012

Received in revised form

18 March 2013

Accepted 20 March 2013

Keywords:

Collaborative work

Teamwork

Medical decision-making

ABSTRACT

Purpose: To examine the changes in multidisciplinary medical team activity and practices, with respect to the amount of patient cases, the information needs and technology used, with up to 10 multidisciplinary teams (MDTs) in a large teaching hospital over a 10-year period.

Methods: An investigation of MDT meeting activity was undertaken in November 2005 and repeated in November 2012 for the MDTs at a large university teaching hospital. Analysis of data from 8 MDTs was informed through long-term ethnographical study, and supplemented with 38 semi-structured interviews and a survey from 182 staff members of MDTs. **Results:** Work rhythms change over time as a function of the volume of work and technology changes, such as the use of a picture archive and communication system (PACS), videoconferencing and an electronic patient record (EPR). Maintaining cohesive teamwork, system dependability, and patient safety in the context of rapid change is challenging.

Conclusions: Benefits of MDT work are in evidence, but the causes are not fully understood. Instead of asking ‘how can technology support more MDT activity?’, we ask ‘how can we preserve the benefits of human–human interaction in an increasingly technological environment?’ and ‘how can we ensure that we do no harm?’ when introducing technology to support an increasingly demanding collaborative work setting.

Introducing technology to streamline work might instead threaten the experienced improvement in patient services.

© 2013 Elsevier Ireland Ltd. All rights reserved.

1. Introduction

Multidisciplinary medical team meetings (MDTMs) are an example of synchronous collaboration, with asynchronous components, among medical specialties for a specific purpose. MDTMs were introduced over 25 years ago as a mechanism of collaborative diagnosis and patient management. Intuitively they are good practice because all of the professional groups are involved in the clinical decisions affecting individual

patients [1,2]. However, the system is increasingly under pressure from technological developments, legislative requirements and economic challenges.

Over the past 10 years in particular, in Ireland and in the UK, we have witnessed a dramatic increase in the development of multidisciplinary team (MDT) work in healthcare. St. James's Hospital in Dublin experienced an uptake from 20% of patients being managed by an MDT in the mid-1990s compared with over 80% in 2004, and a 50% increase in the number of MDTMs between 2003 and 2005 [3], for example. A number of

* Corresponding author. Tel.: +353 18962381; fax: +353 16772204.

E-mail address: kaneb@tcd.ie (B. Kane).

¹ B. Kane is a Marie Curie (ERCIM) Fellow and was an IRCSET Fellow under the Enterprise Partnership Scheme with St. James's Hospital Board at the time of this study.

1386-5056/\$ – see front matter © 2013 Elsevier Ireland Ltd. All rights reserved.

<http://dx.doi.org/10.1016/j.ijmedinf.2013.03.003>

developments has led to this increase in the routine use of MDTMs: (i) clinical practice guidelines (CPGs) that specify that MDTMs should be used [4], (ii) increasingly specialised healthcare [5], (iii) recognition that diagnostic accuracy can be improved through clinical, radiological and pathology collaboration in the decision [6,2], and (iv) more complex treatment protocols that require high levels of coordination between specialist services [2]. Despite their popularity, it is acknowledged that there is little concrete evidence that patient outcomes benefit from MDT collaboration [7,8]. Guidelines from the National Institute for Health and Clinical Excellence (NICE) in the United Kingdom, for instance, recommend MDT work but categorise the evidence for this recommendation as Level III, or Level IV evidence [9], that is, evidence based on quasi-experimental, or observational studies with narrow population spectra, or non-blinded studies (which are considered weak) and professional consensus. NICE was set up in 1999 to provide independent, authoritative and evidence-based guidance to the UK National Health Service (NHS) on the most effective ways to prevent, diagnose and treat disease and ill health, reducing inequalities and variation, to ensure quality and value for money [10]. In providing advice, NICE grades its recommendation depending on the strength of the evidence of efficacy (based on the research design), and the quality and quantity of evidence. The most reliable evidence is derived from randomised controlled trials or systematic reviews of randomised trials [10].

The mandatory MDTM has been described as one of those initiatives causing a split in the medical profession, into those who believe it can improve patient safety, and those who believe it may be indirectly affecting patient outcomes by reducing continuity of care and training opportunities [11,8]. Some argue about the adoption of mandatory 'guidelines' by the professions and question the validity of some of the recommendations in practice. On one hand a guideline is only a guide or suggestion, but once published it can assume an authority on evidence, which is often lacking. Indeed in some cases it is argued that strict adherence to a guideline can be counterproductive [12,13].

From a medical perspective, it is difficult to substantiate improvements in patient outcomes as a result of MDT working because of confounding factors such as socioeconomic status [14], or concurrent changes in cancer care over the last 10 years [2]. However, there is a growing body of evidence that MDTs are associated with improved clinical decision making [15], clinical outcomes [16], patient experience, and working lives of MDT members [8]. We ask 'what is it that improves clinical decision making, or provides benefits for patients?' Could it be that the preparation work of gathering, aggregating and structuring information from diverse sources, which needs to take place in order for the MDTM to take place, yields the benefit? Or that such pre-work acts as an additional quality control, dependability enhancing mechanism [17]? Or perhaps the reason for the experienced benefits of these meetings comes from the explicit management plan records that are generated as an outcome of the discussion to direct patient care afterwards? Or is there something about the face-to-face, real-time nature of the meetings, where attention is drawn, in a natural and effective way, to essential aspects of the data being presented by the very specialists (radiologists, pathologists,

clinicians) who originate the relevant data? The differences in information presentation modalities in the patient case (speech, images, and gestures in MDTMs versus text and perhaps images, in individual assessments) might have a decisive bearing in the assimilation and processing of information. Furthermore, there is evidence that new knowledge is generated during the discussions within the MDT which goes beyond the aggregation of individual contributions [18]. What is the nature of the (presumably) collaborative processes that give rise to this new knowledge? We do not presume to settle all these questions here; rather we highlight the issues implied.

We are not alone in recognising that the need to understand how the multidisciplinary team approach affects specific elements of patient care. Kesson et al. [16] controlled for differences in age, tumour stage and health deprivation and found that multidisciplinary care had a significant initial positive effect on 5-year breast cancer specific survival for patients with incident cancers in 1996, and an on-going positive effect on breast cancer survival, but acknowledges that the reason for the observed benefit particularly in older patients, is unexplained and advocates more research to identify those aspects that are most associated with survival benefits [16]. As long as the reasons for the measurable improvements in patient outcomes are not entirely understood, it is possible that technological changes might threaten the experienced improvement in patient services. No matter how well meaning, we must acknowledge that technology that improves one aspect of the process could have a detrimental effect on another element of it. An analysis of how the changes that happened over the past 5 years affected the MDTM system might shed some light on these issues, and help us ensure that the gains brought about by the introduction of MDTMs can be preserved in the face of changing technological, organisational (including economic) constraints.

We examine the main developments in the largest teaching hospital in Ireland and identify changes in MDT collaboration as the work volume increased. Our study provides insights into the nature of medical teamwork, meetings and the use of technology. Changes are shown in the dynamics of the interaction among the MDT members, the modes and the choices of medium for communication at MDTM following the implementation of a PACS, an EPR system, as well as an increase in the numbers of patients being managed by the MDT system. Deeper understanding of the nature of the collaboration and coordination involved in MDT work may reveal insights that can be usefully applied in other computer-supported collaborative work (CSCW) settings.

1.1. Development of MDT working

Hospital structures have been changing from an individual consultant-led service, to grouped structures and multidisciplinary team based services. Consultant-led teams are grouped into cogent administrative structures, or directorates. A respiratory team, for example, may be grouped with cardiology and cardio-thoracic surgery. Patient services involve interaction and coordination between specialists in the same directorate and between directorates. For example, a lung cancer patient will have dealings with respiratory physicians, cardio-thoracic surgeons, oncologists, pathologists, radiologists, and likely

palliative care, whose services will be delivered through at least 5 directorates in a typical teaching hospital. The MDTM is, in fact, a coordinating mechanism between individual teams and specialist services [17]. With changed structures, decision-making practices have changed too. MDTMs are now the forum where all of the main decisions are taken that affect an individual patient's care, and the forum through which hospital policy is developed in caring for particular diseases. Because the MDTM forum has become a key facilitator of health service delivery, it has become critically important that such fora are supported by information communication technology (ICT) to provide dependable work systems to sustain patient care, and facilitate the functions that the MDTM forum needs to fulfil [2]. We recognise that many MDTMs currently function satisfactorily with minimal help of ICT, and that many rely on paper records alone. However, it is our view that given (a) the developments in electronic patient medical record systems, (b) the prominent role of MDTMs in patient care, (c) the recognition that communication errors underly many adverse patient events and (d) increasing demands of society to apply the highest quality standards, we have a responsibility to design ICT solutions that can make our health systems more dependable. It is generally accepted that carefully selected technology, designed and used appropriately has the potential to enable more effective service delivery, across a variety of organisational settings.

1.2. Traditional vs. MDT work systems

The old-style care pathway is explained in this case example. BW, aged 45 years, noticed a lump in her breast and went to her local doctor (general practitioner, or GP). She was sent for a mammogram. A week later she got a call to return for more imaging. After another week her GP was notified that she should now have her lump investigated by a surgeon. A few more weeks passed before BW met the surgeon who took a biopsy and asked her to return to the clinic for review once the result was complete. Another week passed and BW was told she had cancer and advised to have a lumpectomy, which was scheduled for 2 weeks later. After recovering from surgery, BW returned for follow-up and was advised to consult with an oncologist. Within a few days treatment commenced which was to continue over the following 5 years. The point in this story is that several weeks pass and the patient is 'processed' through a series of sequential steps, one by one. No more than one clinician was involved in her care at any stage. If one of her tests had been a false negative, the process would have been discontinued and the patient would have been discharged to her GP, who would have likely waited to observe if symptoms deteriorated (in which case she would be referred through the same process once again).

In contrast, once an MDT process is in place, a patient is managed differently. On referral of a lump, BW would attend a MDT Breast Clinic where a physical examination, radiology imaging and pathology tests would be performed in the same session with different specialists (at the same clinic). At the following weekly MDTM all of BW's results would be correlated, a definitive diagnosis made, and a recommendation for treatment would be agreed among the MDT of specialists, which include surgeons, radiation and medical oncologists,

pathologists, radiologists and nurses (who will often contribute social and/or family circumstances that may influence the treatment plan). Chemotherapy, radiation and surgery are modes of cancer treatment and may be given in sequence or concurrently depending on the tumour type, disease stage and co-morbidities. It is important that these treatments are carefully coordinated to ensure the best (clinical) outcome for the patient. Geneticists may also be present, at the weekly MDT meeting, who will advise if screening is needed for other family members. This latter MDT process is faster, and recognises that the diagnosis and management of a cancer relies on a system that is an interdependent group of items, people and processes that add dependability to the overall patient management system [17]. As well as having patient management functions, MDTMs are recognised as having professional development, educational and organisational functions, and providing socioemotional support for MDT members [19,17].

2. Analysis of the effects of MDTMs

It is generally accepted that MDTMs bring benefits [4]. They facilitate three-way correlation of radiology imaging, pathology results and clinical findings, which is expected to improve the overall quality of the diagnostic work system [2,6]. The probability of having a wrong result when three independent work processes are correlated is much reduced, and there is an increase in the sensitivity and specificity of the investigative process. Most of the quantitative research into the benefits of the MDTM has aimed to demonstrate patient benefits, usually through the application of more treatments and higher levels of coordinated care. Although numbers of cases may be small in individual studies, there is growing evidence to justify the benefits being attributed to MDTMs [16,15,7,8,20]. But there is also an acknowledgement that all of the necessary information must be present, and all of the required roles available for a good discussion. Otherwise the case will need to be rescheduled, which can lead to delays for the patient starting treatment [21], and wastes time for those who are in attendance [22]. One physician put it: "it [MDT discussion] is either great ... or a waste of time ...".

The reconfiguration of cancer services following recommendation for MDT working [4] is attributed, at least in part, to an increase in staff stress [23]. Patients clearly benefit from being treated by a surgeon with a high workload [24], but the impact of the stress and emotional exhaustion identified in MDTs [25] has yet to be measured, and [26] suggests that quality assurance measures are needed. While several have sought to identify the factors that help MDTMs work better [27–29] a general formula for success remains elusive.

3. Methodology

Long-term study, since 2001, provides the data for this paper. Unobtrusive data gathering through observation of several MDTs at work, their MDTMs and the artefacts they each use, provide the main material for analysis. Interviews, questionnaires and group exercises were also used to probe specific research questions that arose, and to clarify findings. We are

privileged to have the opportunity to observe several MDTs at work over an extended period of time. Each MDT meets weekly, differs in workload and has been affected in different ways by external factors such as CPGs and health service restructuring. The hospital is a specialist referral centre for prostate, lung, breast, head and neck and oesophagus cancers. Some of these designations were awarded since 2005.

Our approach in this study borrowed concepts from different theoretical perspectives, adapting them to our needs as the research evolved. The initial stages of the work were strongly influenced by ethnomet hodological approaches [30], motivated by the need to be as unobtrusive as possible, given the sensitive nature of the work situation being studied. We were also motivated by the goals of capturing a sense of the context surrounding the activities of the MDT and producing (as far as possible) unbiased accounts of the different perspectives of the specialisms involved. As a clearer picture of 'the MDT system' emerged, we started to explore certain themes or concepts of interest identified in various theoretical frameworks, as suggested by other works in the healthcare domain [17,31]. The study was informed, for instance, by the concept of common information space, as proposed by Bannon and Bødker [32] and elaborated by others in the context of heterogeneous teams in hospital wards [33,34]. These concepts influenced the analyses of information flows into, and at, MDTMs and of the role of different representations and records presented below. Similarly, the concept of temporal rhythms [35] was useful in the investigation of issues such as coordination of pre- and post-meeting actions and the impact of remote meeting scheduling on the activities of the MDT. Following CSCW methodology [36,37] we examined the use of artefacts and their utility in collaboration, coordination and building new knowledge. Organisational learning perspectives [38] were useful in looking at the learning and professional development aspects of the MDTM. Finally, we employed more targeted methods, including interviews, questionnaires, and measurement of vocalisations, and duration, of patient case discussions as a means of triangulating the qualitative findings.

Data provided through targeted data gathering exercises often prompted further research questions to be explored. Specific data used in this paper documents changes in the volume of work, and the new technologies that were introduced over the period. We also report changes in MDT behaviour. We do not suggest that the volume of work is associated with the introduction of the technologies, or vice versa, as these relationships are complex and are outside the scope of our study. However we acknowledge that drivers to implement the PACS and EPR systems were motivated by an expectation that they would facilitate improved management of an increasing workload in the hospital.

For the month of November 2010 the number, timing and duration of MDTMs held, and the numbers of patients discussed were recorded. These data are compared with data from November 2005, a similar month with 22 working days, reported in [3]. November 2010 had 5 Mondays and Tuesdays and 4 of each of the other days. November 2005 had 4 Mondays and 5 Tuesdays and 4 of each of the other meeting days (Thursdays and Fridays). However Monday October 31st 2005 was a Bank Holiday and the work scheduled was deferred to

Monday November 7th 2005 resulting in a double workload for that day. Thus these months were considered comparable for the purposes of this study.

Gathering data in this way allows for the MDTM activity to be examined from the hospital's perspective, and facilitates analysis of the growth and impact of MDTMs over the 5-year period. One-to-one semi-structured recorded interviews lasting 30–60 min, were conducted with over 30 MDT members. These data help verify observations. Themes that emerged at interview provide context for the analysis of data reported here and influence the interpretation of its significance.

4. Results

A typical MDT meets weekly and discusses a number of patients, one at a time. For each patient, their symptoms and findings on examination, together with their radiology and pathology test results are reviewed. A diagnosis and stage of disease are agreed by consensus, and a management plan (recommendation) is also agreed by the specialists present in the context of current CPGs, and the general state of health of the patient. Regardless of the speciality, the general conduct of a discussion follows a pattern, described in detail elsewhere [6]. A significant increase in workload has been recorded across all of the specialist MDTs, but particularly for those for whom new CPGs were introduced, namely breast and cervical cancers, which impacted on the Breast and Gynaecology MDT. The number of MDTMs, the patients discussed and the increase this represents over 2005 figures are given in Table 1. Overall there is an increase of almost 100% which ranges from >20% for the Head and Neck MDT to 261% for the Urology MDT.

The changes observed in the nature of the interactions at MDTMs as a result of an increase in volume of work have forced change in the systems of working. Some limited additional staff resources were allocated in radiology and pathology in recognition of the additional preparation work required by these disciplines. Additional clerical administrative support is also provided, but because of funding limitations the clerical resource is shared between all of the MDTs. Physical space and time are significant constraining factors. Of all of the constraints observed, time and timing are associated with the greatest observable effects on the MDTM, with respect to information communication, co-ordination, synchronous and asynchronous interaction.

Following our discussion on Time that follows, we review the categories where we can identify changes as a consequence of limited time at MDTMs. Those aspects of MDTMs where the impact of time constraints is evident are in (i) function, (ii) the agenda and meeting preparation, (iii) interaction during discussion (including the use of images, case synopsis, role and organisation), (iv) sub-specialisation and (v) record-keeping. Examining these changes contributes to our understanding of the nature of the collaborative work of an MDT and also provides insight into the impact of the picture archive and communication system (PACS), electronic patient record (EPR) and videoconferencing technology on interactions at MDTMs.

Table 1 – Sample of weekly MDTMs held, and number of patients discussed, in November 2005 and 2010.

MDT	Time (min) per MDTM		Patients per hour (mean)		Patients per MDTM (mean)		% increase in MDTM time	% increase in patient cases
	November 2005	November 2010	November 2005	November 2010	November 2005	November 2010		
Urology	45	60	6	16	4.5	16	33	261
Breast	60	105	14	27	14	47	75	237
Gynaecology	60	120	9	14	9	28	100	211
Skin cancer	60	90	47	57	47	86	50	82
Lymphoma	45	60	7.3	9	5.5	9	33	64
Gastro-intestinal (GI)	45	60	20	24	15	24	33	58
Respiratory	120	105	11.5	19.4	23	34	-12.5	50
Head and neck	30 ^a	30	23	28	11.5 ^b	14 ^b	0	>20
Total	465	630	465	630	129.5	258	35.5	99.2%

^a Head, Neck and Thyroid MDTMs were introduced in 2006 (see text). By 2010, weekly Head and Neck, and separate monthly Thyroid MDTMs were scheduled.

^b 2010 figure is Head and Neck only. For 2005, figure includes thyroid cancers.

4.1. Time

Time is a major constraint and is directly responsible for many of the changes observed. Time is limited; schedules are tight, and patient numbers are increasing. An increase in the time spent at MDTMs, in preparation for MDTMs, and time spent following up afterwards (for some roles) has a direct impact on the way in which staff schedule their work, and the amount of time available to discuss an individual patient. MDT members continually complain that they have not enough time, either to attend meetings, or for an individual case discussion. They would like more time to discuss the patients they submit for the agenda, and often see others' discussions having lesser importance. They express frustration if they perceive colleagues wasting time. Patient discussion tends to be highly structured.

Scheduling MDTM time is considered the greatest challenge, especially when many roles and specialities are involved. It is difficult to find time for all of the roles to be free to meet at the same time. Theatre sessions and out-patient clinics need to be synchronised, urgent work and emergencies must be accommodated. For example, in the Urology MDT, there are three surgeons but it has not yet been possible to arrange a time when all of them can be available for a meeting, since they are assigned theatre space and clinic times on different days between two hospitals. A compromise time was agreed that is convenient for the majority of the MDT, most of the time.

There are certain roles such as pathologists, radiologists and oncologists who are members of every MDT. Because of specialisation and limited resources, an individual oncologist, pathologist or radiologist is likely to belong to several MDTs. Indeed, approximately 10% of the clinical staff has reported belonging to between 6 and 10 MDTs [39]. To complicate matters further, there are several highly specialised roles, such as cardio-thoracic surgery that may be appointed to more than one hospital. In this hospital, MDTMs are usually held outside of the 'normal' work hours. This results in obvious disruptions to the work rhythms of certain participants, and some

members are excluded from MDTMs because of scheduled services at other hospitals.

4.2. Changed function of the MDTM

As explained elsewhere that the MDTM serves patient management (including diagnosis), training, education and professional development, organisational and socio-emotional functions [40]. Although initially instituted in teaching hospitals because of their valuable learning opportunity, patient management is now the primary function of MDTMs. Once CPGs specified this process as necessary to providing the greatest benefit to patients, the educational role became secondary. As MDTs have become busier, a further shift is observed: the educational role is demoted due to time constraints, and the organisational functions are promoted to second place. Currently the Lymphoma MDTM is the only meeting where deliberate acts of teaching are conducted. Senior staff asks junior staff their opinions and consider the options in more depth. The consultant might ask the non-consultant hospital doctor (NCHD): 'so what would you do in this case?' Or the MDT leader might hypothesise on a more complex scenario and ask 'what if this patient was a diabetic? Would you still make that recommendation?' Other MDTs also see their MDTMs as having a valuable educational role, but our point is that it has become the norm at MDTMs that the educational function as been reduced in its importance and trainees 'learn' through observation rather than active participation.

In addition to these functions, the MDTM offers an ideal opportunity to capture data for national repositories (e.g. the cancer registry) and for audit. Efforts are ongoing to have specific data gathered at MDTMs, which is a driver to have records maintained. As noted above, there has been a promotion of the hospital's organisational interest in this forum. The hospital today sees itself as having a greater responsibility to ensure that patients are managed according to CPGs than in the past, and MDTMs have become a focus for attention. Record-keeping, for example, has become a real concern, and

is probably being driven as much by the hospital's needs as by the needs of MDTM participants.

Policy development has also become more apparent through the MDTM system. Incremental changes can be introduced relatively easily through a couple of minutes of discussion at the start or end of an MDTM. Problems can be identified through an individual case presentation that can be applied in a general way. For example, a patient might present with a particular finding and be tabled for discussion. The MDTM might suggest that a certain test should be undertaken and the patient discussed again afterwards. So it may be agreed that "... in these cases in future, when we see X we will proceed and have an ultrasound, and then present the patient for discussion".

The socio-emotional function [41] of the meetings is always in the background. Many of the MDTs would likely deny that the socio-emotional function has much importance for them. However, observation suggests that as the work becomes busier, individuals rely more on meeting colleagues at MDTMs and value the support they get through chatting and sharing experiences of the week. When MDTMs are less formal, participants might be reminded during a case discussion about a funny incident, or an unrelated topic and share it with the group. As discussion becomes more formalised these exchanges become more rare. Some groups appear particularly cohesive at MDTMs, but may not meet between one MDTM and the next. The practice of some 'core' members of MDTs, meeting socially on a regular basis, or going on holiday together has been observed. The interpersonal MDT relations have not been a focus in our study, but as this research continues we believe that the dynamics among individuals in an MDT has a greater bearing on the success of an MDTM that we would have ascribed 5 years ago; a fact that appears validated in other work [27].

4.3. The agenda and preparation

As the list of patients on an agenda for discussion at the MDTM increases, so does the burden of pre-MDTM work. For the MDTM to be efficient, MDT members must have prepared in advance. Roles with the burden of preparation, i.e. radiology and pathology, will check the agenda circulated pre-MDTM, and read any formal records from their area. Radiologists and pathologists will review any material in the light of the official report and also in the context of the clinician's concerns, which ideally are expressed when requesting the patient for discussion. They identify features that support their opinion on the images (radiology or pathology) and will present them to the MDTM. (It is likely that another radiologist/pathologist issued the formal report.)

Radiologists and pathologists tend to seek mechanisms to reduce the number of patients being placed on the agenda for MDTM discussion, because of the amount of time that pre-MDTM preparation costs these specialities. They aim to have no more than 25 cases on an agenda, because it is felt that 25 is a reasonable number of cases to prepare in advance, given the available resources. But the GI MDT is the only MDTM that comes close to this target. CPGs generally specify conditions when a patient should be discussed at an MDTM, but the numbers of patients presenting with disease that require

discussion usually exceeds the thresholds agreed. This tension between the numbers agreed and the actual number prompts argument and negotiation. For roles with the burden of preparation for MDTM, information about the context for the discussion can be very helpful, and can make the pre-MDTM work easier. As the number of cases rises above the thresholds agreed, radiologists and pathologists ask for more information that might make their work more manageable.

When radiologists or pathologists are reviewing images prior to the MDTM, the context of the review or reason for discussion is important. For example, a clinician may be most interested in knowing if a suggestion in a written report that there may be an abnormal lymph node in a computed tomography (CT) scan is sustained by the experienced eye of the expert radiologist. Or a surgeon may want to know from a pathologist if the surgical margins are clear, or if there is a need for further surgery. These questions will help the radiologist and pathologist focus their review and save time when reviewing cases for the MDTM.

Typically, surgeons and physicians provide little clinical information to the radiologists and pathologists, who continually request more helpful information. For example, Mary is known to have a lung tumour and her name is submitted for the agenda. The clinician already knows about the tumour, but wants the radiologist to consider distant metastatic deposits, and for the pathologist to say if the surgical margins are clear, (i.e. cancer fully removed) or if there is a need for further surgery. Such questions in the mind of the clinician simplify the pre-MDTM work for the radiologist and pathologist. But the surgeon might only submit a "? cancer" on the request for review (which frustrates the radiologist and pathologist in their preparation). When arguments erupt, the surgeon and physician will agree to provide more information and maintain a 'reasonable' number of patients for review.

So while clinicians agree to try and 'cap' the number of cases that they request on the agenda, they also ask that the pathologists and radiologists review the cases that need to be discussed. This recurring argument is usually resolved with the pathologist and radiologist asking for more relevant information that would help make their review of a case easier, and the clinician agreeing to provide more appropriate information together with a reason for the review, when requesting a case for discussion.

Typically the agreement between the clinicians and the radiologists and pathologists will be observed for a few weeks or so, and the same argument will erupt over again: "too many cases; too little information".

When radiologists are reviewing electronic images in preparation for meetings, it is not easy to annotate the images for later display, so they prefer to take written notes on paper to help them relocate the selected images when presenting to the MDT. Electronic images, or electronic microscopes, in pathology are not in routine use. Pathologists review glass slides with thin slices of the patient's sample when preparing for the MDTM. In the past, pathologists used microscopes to present at the MDTM, but microscope use at an MDTM is now a rare event, as it takes time to find the area of interest under the microscope, focus properly and project the image. Typically nowadays, the pathologist takes a digital image using a camera on a light microscope and inserts the images into

a slide presentation, sometimes adding annotations to the image, and often with a text box summary. The pathologist brings the presentation on a memory stick and loads it onto a personal computer (PC) in the meeting room before the start of the meeting. For some MDTMs, where there is a particularly high case load (breast and skin), practices have further changed, and these changes are discussed in Section 4.4.1. (Unless otherwise stated the practices reported here are the common practices exhibited by most of the MDTs, most of the time, and exceptions are noted where relevant.)

When oncologists are preparing for MDTMs, they tend to check the agenda for patients that might have been treated before, by interrogating the EPR for historical records. As diagnostic and treatment methods have become more sophisticated, more patients who have fully recovered from a cancer are presenting with a subsequent second, or third, or later cancer in the same, or other, organ(s). Once patients have been treated with chemotherapy or radiation, but particularly radiation therapy, the management of subsequent cancers can be complex and more difficult. Thus oncologists query databases to check for any information of note that may apply for a particular patient. We draw attention to this relatively new responsibility for oncologists to review the agenda prior to MDTMs for patients that may have been treated in the past for other cancers. When we commenced our studies, it is unlikely that there was any necessity to conduct such a review prior to the MDTM, as the chances of a patient who was previously cured and discharged presenting with a new cancer were small.

4.4. Interaction at MDTM

We have identified changes in the nature of the interactions both because of the necessity to discuss more cases within the limited time available, and also because of the necessity to have records for later reference. Furthermore, we identify challenges in developing methods of recording that satisfy users needs, protect patient privacy and satisfy hospital governance. Overall, the number of participants in any discussion is reduced, and interactions tend to be more formal as MDTMs become busier and come under greater pressure.

4.4.1. Use of images

We have noticed a marked reduction in the use of images during discussion. Pathologists are now unlikely to bring microscope slides. For breast, gynae and skin, pathology images have almost been completely abandoned in favour of presentation of key items from the pathology report, such as pathological stage of disease (called pTNM). For breast and skin, pathologists have been observed to use tables in their presentation to 'batch' cases, similar to the practice for skin cancer where the pathologists groups cases according to the type of skin tumour. Radiologists too have been reducing the number of images shown at MDTMs. Reviews of more complex imaging takes precedence over first line methods such as chest X-rays or mammograms.

Instead of showing images, radiologists and pathologists tend to describe their findings in talk, sometimes supplemented with gestures. A thumb and forefinger are regularly used to demonstrate size, for example, "about... 2cm... it was

this big", particularly when describing small sizes. Given that a large screen display showing a pathological feature at high magnification of 400×–600× times in size can look overwhelming, gestures can help to put the feature into perspective.

4.4.2. Case synopsis

Case presentations have become shorter. Instead of a 15–20, or even 30-min discussion, as may have happened in 2003, cases now are briskly conducted. Clinical presentation is synopsised and only crucial items of information are presented. The term 'synopsis' is used here rather than 'summary' to convey the influence of the time constraints on the presentation. MDTs seem to be very capable at dividing the time available between the cases on the agenda. It is generally not an issue that a case early on the agenda takes an overly long time at the expense of a case at the end of the agenda, although this can sometimes happen. Describing the effect of having less information available at the MDTM and the reduction in use of pathology images, an interviewee said: "... they've trimmed it down so much now ... and if you ask a question it is hard for them to show it to you because they come with those pre-prepared slides. So I say 'well, what about on the left side?' and they can't tell you because they say they didn't take a picture of the left, only the right, and they don't have the slide with them ... only a selected patch. So, if someone did want to get involved in the discussion that ... kind of ... excludes them ...".

4.4.3. Role

Since there is pressure on clinical staff to present synthesized patient information that conveys the most important and relevant findings, the clinical story is now related by the most senior staff. In the past, NCHDs usually presented the patient's symptoms and findings on examination. NCHDs are less experienced than their consultant seniors and are likely to take more time and provide more information than regarded as necessary (by their seniors).

4.4.4. Organisation

Several teams have now restructured their agenda and have grouped patients. Complicated cases where diagnosis is clear and treatment plan is complex are at the top of the list. This 'batching' of cases is done in different ways by different MDTs, but all methods rely on an individual to make the decision. For skin, the non-medical coordinator captures the HIPE (Hospital In-Patient Experience) coding which will identify all of the patients who have had a diagnosis of skin cancer. The coordinator then structures the list according to the pathology reports on the hospital information system. The Respiratory and Breast MDTs recently implemented an electronic request system that requires the requester to select a 'reason for discussion' from a drop down menu. The agenda is then ordered based on the 'reason', with the most serious cases prioritised. MDTs who use this practice based on tumour type/urgency are very satisfied with it. Prioritising in this way can mean that certain specialities are free to leave once cases that involve them have been discussed, e.g. oncologists at the breast MDTM leave once all the cancers have been discussed to attend to their ward rounds, clinics, or attend to other responsibilities. Discussion will continue with benign tumours or undetermined lesions. If a 'benign' case turns out to have cancer, that case

will be tabled for the following week, or brought to the oncologist's attention outside of the MDTM.

Organisation of the agenda has advantages and disadvantages. It is useful to have similar decisions being made together. In cases where the clinical findings are similar, but the treatment decisions differ, the team is confronted with explaining why they choose different treatment options in what might seem to be similar clinical circumstances. However, the downside is that sometimes there are unexpected results in the 'non-cancer' cases, or a discussion would have benefited from the opinion of someone who has just left the room. There may be a case of a rare disease for which chemotherapy or radiation may be a useful treatment modality, for example. In these instances, when identified, the patient will usually be re-tabled for discussion the following week, and assigned a higher place on the agenda.

4.5. Sub-specialisation

Sub-specialisation is also observed as the volume increases. We reported earlier in [Table 1](#), that the Head, Neck and Thyroid (HNT) team introduced a new monthly Thyroid MDTM. So too, the Urology MDT hold an occasional meeting devoted to renal (kidney) disease; the Skin MDT have special melanoma meetings from time to time, and the GI MDT have a Liver meeting. There has been talk of having a separate Oesophagus MDTM, or a Pancreas MDTM. However finding time in schedules to hold meetings with all of the necessary specialities present is a limiting factor.

4.6. Record keeping

The utility of records (including paper) as coordination mechanisms and part of the social and technological infrastructure supporting cooperative work is clearly recognised [\[42,43\]](#). However, how groups generate records of their collaboration has not gained the same attention. For the MDTs here, generating records during the discussion was raised as a priority, as the volume of work increased and the MDTM system became embedded into the workflow. The greater importance that MDTMs now have with respect to patient management has made it imperative that records of the discussion, and the management plan agreed for the patient, are maintained.

The specific items of information to include in a record were addressed in a survey. The survey is reported detail in [\[22\]](#). Ideally the MDTs would like to know 'who was there' and 'who participated' in a discussion. They would like to know the data discussed, and the opinions of the contributors, particularly of any dissenters. Many of the MDT roles require clear instruction on tasks to be conducted post-MDTM. [Fig. 1](#) represents the records that might be captured from a meeting: (i) details about the MDTM itself (people, time, agenda, place), (ii) the content discussed for each individual case (available afterwards in the patient's EPR for reference), (iii) work lists generated for each role and (iv) data captured for national repositories.

Suggestions have been made to improve record keeping at the MDTM and capture key data for organisational purposes (such as the National Cancer Registry). One of those suggestions is to connect a laptop to the EPR, project the display

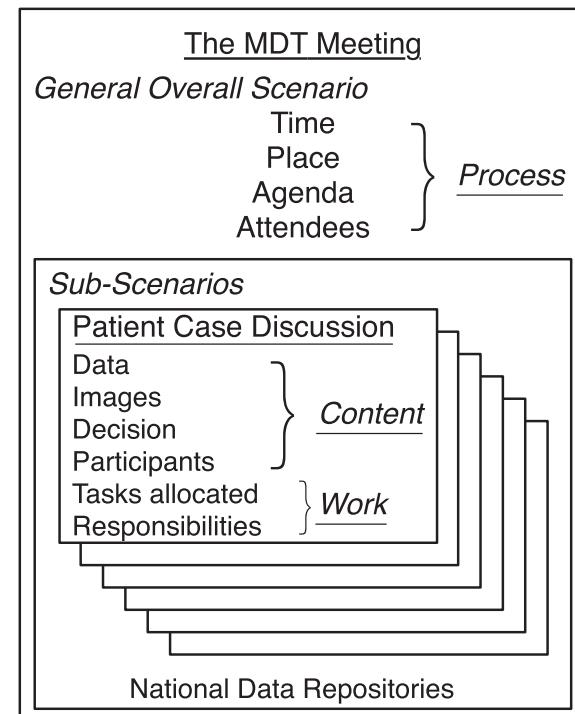


Fig. 1 – Framework for MDTM Records

onto a screen so that all MDTM participants can see. One of the team would enter the data. This initiative is reported in detail in [\[44\]](#). Such a method is also described in [\[45\]](#) and is practiced in the UK. This allows for real time checking of the data entered, since all of the team have the opportunity to have any errors corrected. However, participants have been slow to embrace the suggestion and a number of concerns have been raised. The most common concern is that there is not enough time and that such a practice would slow down the proceedings. However a number of other issues have been raised that concern the content as well as the process of generating a record, some of which are listed in [Table 2](#). Despite reservations it is the intention that at least one of the MDTs will implement real-time validation of a record at MDTMs in the near future.

Table 2 – Opinions expressed on the proposal to implement the practice of real-time data entry, visible for all to see, and available for correction.

- "When I give my opinion, I want to know what's written"
- "I need to be sure my meaning has been understood"
- "We haven't enough time ... that would slow us up ..."
- "Sound great, but what would be recorded?"
- "We would be meeting to ... fill out a form ... a 'group exercise' ... a group form-filling exercise ... is that it?"
- "who will enter the data?"
- "will we take note too of why we made the decision?"
- "yes, I will be interested to hear how others get on with it"
- "... in my view the less said the better ..."
- "I don't want to be tied to the decision ..."
- "... I'll keep my own record anyway ..."
- "it would be nice to know exactly which guideline, or evidence, we are talking about"

Most MDT members take personal notes at MDTMs, for their own use afterwards. Practice varies among the senior clinicians who have ultimate responsibility for their patient's care. Some take notes and file them in the patient's paper chart. Others rely on a team colleague to write notes for the 'record' while maintaining their personal memo. Others demonstrate no interest in maintaining a hospital record (either for the paper chart, or electronic record) and opt for maintaining their personal system of private note-taking instead.

4.7. Technological developments

Over 5 years there have been several technological developments in the hospital, that include the implementation of PACS, videoconferencing and an EPR system. Currently there is a transition to implement a full EPR, and paper charts are being used in conjunction with the electronic system through the transition period.

Picture archive and communication system: A lot of time and energy used to be spent trying to locate hard copy film radiology images and carrying these to the MDTM. It was generally known that up to 20% of patient images went 'missing' [46]. The weight of the film alone warranted a trolley to bring the images to the MDTM. So the implementation of the PACS system over the period 2005–2007 was well received. The system facilitates synchronous viewing by multiple users in different locations, and makes searching for X-ray films unnecessary. It can also cause frustration. Sources of frustration are lack of standards and protocols in different institutions, low-powered PCs, or occasional slow network. Many patients are referred to the hospital with imaging that was conducted elsewhere that needs to be reviewed by a specialist radiologist. Sometimes those images cannot be accessed, or the quality of the image is inferior, or the imaging protocol used is not one with which the specialist radiologist is satisfied, so imaging needs to be repeated. The perceived ready availability of CT, magnetic resonance imaging (MRI) and, more recently positron emission tomography (PET), scanners has led to a large increase in the amount of imaging for a single patient, and more imaging to be reviewed for MDTMs since the introduction of PACS in particular.

Because of the large amount of imaging that is often available on an individual cancer patient, a decision is taken (by the radiologist) to show a selected set. Even with a sub-set of images, it can take more time than an MDTM is prepared to spend to load the images onto the PC. Thus, the radiologist may decide that the image is not worth the trouble of loading onto the PC, and decide to describe it verbally instead, from memory. MDT members have complained that "... radiology slows down the meeting and it's prone to crashing...".

There is always a formal written report on any radiology or pathology discussed, and sometime this may be read out, instead of describing the features more informally. MDT members prefer to hear the radiologists' description while demonstrating the features in the image. As one member said: "I like the nuance that [the radiologist] can put on [the image] ... it means more than reading the report. I can read the report on my own computer anytime ... but I like to hear the radiology ... to get the meaning"

Electronic patient record system (EPR): The electronic record system in the hospital is a modern proprietary system that has not yet been fully implemented. Paper charts are also in use. It is the hospital's objective to implement a full electronic record and management system over time. Currently all demographic patient data are captured. Tests are ordered, and results are reported through this system. Thus, all laboratory and radiology results are available in the EPR, along with other test results and reports. The paper charts are used in coordinating patient management, and are taken to the MDTM by the administrative support staff. Thus both the EPR and the paper chart for each patient are available at the MDTM. Occasionally, a team member might request that the EPR be consulted to check on a laboratory result, or other report, but this is perceived to be a time-consuming activity and is a rare event.

The Breast and Respiratory MDTs recently made a transition to having an electronic record of the discussion in the patient's electronic record (EPR). In the case of the Lung MDT, the lead clinician enters the key data and final recommendation (decision) into the EPR system after the MDTM. The Breast MDT aim to complete their form at their MDTM. Up until this recent initiative for the Breast and Lung MDTs, these data were captured on a paper form by those at the MDTM and there was an official copy (the lead clinician's copy) filed in the patient's paper chart and scanned onto the EPR system. There are mixed views on the effectiveness of the electronic form used by these teams, but the change in practices will not be discussed further at this point as they are still under review.

For the 6 other MDTs, structured meeting notes are recorded on paper during the discussion, usually by the clinician responsible for the patient. This is filed in the paper chart (which has been brought to the meeting) and is made available as a scanned image in the patient's electronic record within a few days. The EPR system has a facility, through a separate utility, to support MDTMs that is not considered ideal at the moment. Staff finds it easier to use the regular workstation view and have workarounds with paper notes.

The implementation of the EPR has its advocates and antagonists. While many embrace the development and ease of locating information, others report difficulty. One user said "I have cut back on ordering tests, ... because I find it hard to remember to look for the results, so I need to keep my own notes of what to watch out for ...". Another said "it's easy, really ... once you look for the result with the same login that made the request. On our team we all use the same login, and we have no problems!". While there may be local configuration issues, what has been brought to light is the workarounds people find to do those things they want to do. In a very large hospital, implementation of an electronic record system can be difficult, particularly when many staff are on short term contracts and do not have the opportunity for formal training in the system.

We have observed a slight reduction in the number of patients being requested for the Respiratory and Breast MDTM agendas since the introduction of the electronic ordering system (which is being explored in future work).

Videoconferencing: The development of videoconferencing has not been as great as one might expect. The first MDTMs in videoconference were arranged between the GI and

Respiratory MDTMs with remote hospitals in 2004. While there were several enthusiasts initially, champions of more connections are rare, and in a recent survey staff were ambivalent about benefits of further development. While over one-third (36%) were interested in more video-mediated initiatives, slightly more (38%) are neutral and over one-fifth (22%) disagree that further development would incur any benefit. Analysis of results so far suggests that if the individual has had experience of videoconferencing they are less likely to promote its development. MDTs who do not currently use videoconferencing seem more enthusiastic. In our earlier work we demonstrated that patient case discussions held in videoconference take more time [40], which is a precious resource for MDTs, and exhibit more rigid interaction (turn-taking) patterns [17]. This may account for some of the negative attitude towards videoconferencing by those with experience of conducting discussion over the video link.

Videoconferencing, and scheduling time with other hospitals, adds additional complications when planning MDTMs. The Respiratory MDT for example connects with 5 rural hospitals at different times to discuss cases from each of those hospitals (separately). Not all 5 hospitals connect in any single MDTM (but they may). Whether or not a connection is arranged will depend on a remote patient's needs. Usually for the Respiratory MDT, a connection is established at the appointed time, if necessary, and the remote hospital disconnects once their case has been discussed. For each of the 5 hospitals there is a designated schedule. So, hospital M connects at 0815, hospital T at 0830, and hospital L at 0900, for example. If all 5 hospitals need to connect at a single MDTM, this can be disruptive for the agenda at the large hospital. The GI MDTM, has a long established relationship with one remote hospital, connects for the entire MDTM, and participates in the discussion of all of the agenda.

Cases from remote hospitals tend to be listed first on the agenda, and are taken in order, once the connections are made. A high level of coordination is required to ensure that radiology and pathology have been reviewed prior to the MDTM, that connections are made on time, the appropriate people are all present and that the discussion is conducted satisfactorily.

Virtual MDTM: Developments in the USA of an electronic medical record (EMR) compatible system to support virtual MDTMs [47] were brought to the attention of staff. We asked "what if there was an on-line MDTM, and you could connect from your office, or phone, or mobile device?" The respondents were strongly against such a development, and defended the practice of co-located MDTMs. Of those asked so far (over 30 MDT members), all have said they would not be interested unless they were unable to attend an MDTM. **Table 3** is a sample of typical responses. Despite the time shortage and difficulties expressed about pressure that the MDTMs impose on team members, there is something about being co-located with colleagues at MDTMs that provides a positive benefit.

5. “Do no harm”

As noted in **Section 1**, MDT work has greatly increased over the last decade placing unprecedented time and efficiency

Table 3 – Responses to query if interested in the development of a Virtual MDTM that would save travel time and allow connection from office or mobile device.

"No. Definitely not ... we have to have MDTMs ... to be there ..."
 "I suppose it would be good if I couldn't make a meeting ...
 ... but only if I couldn't be there - I'd want to be there"
 "maybe ... if I couldn't make it in person ... maybe ..."
 "I would have to be there ... and if I can't, I don't even want my patients discussed"
 "its my only chance to meet with everyone together ..."
 "No. I don't like the sound of that ... at all ..."
 "I often want to catch a word with someone ... before or after the meeting ... its my only chance ..."
 "It would be awful ... only a few people there ... with others connected ... no ..."
 "I like to know I'm going to meet the others ..."
 "that's all fine for those people down the country - they can't be here ..."
 "I like being there ... I actually enjoy MDTMs ... sad life maybe ... [laugh] and I like the camaraderie ..."

demands on team members. It is hoped that the increased use of information technology may help alleviate such demands. The findings reported and analysed in the preceding sections point to the need for guidelines aimed at supporting collaboration in the face of rapid technological and organisational changes, as well as ensuring that the positive aspects of MDTMs are not harmed. We propose that guidelines should take into account the impact of changes introduced by the implementation of technology (summarised in **Table 4**), and should address such detail as (i) the number of patients to be discussed, (ii) time per patient, (iii) the information to be articulated, (iv) participants required, (v) change in nature of learning and professional development, and (vi) hospital responsibilities.

First of all, it is clear that better support could be provided for MDTM preparation. Support at different levels is required, with core medical specialists whose expertise is required in various MDTMs deserving particular attention. Summarisation in presentations by such specialists has become increasingly necessary due to time demands.

Table 4 – Summary of changes observed over 7 years and implications for MDTM and use of technology.

Changes	Implication
Increased no. of cases	Less time for discussion
Less time	Less information, fewer participants Reduction in education function Promotion of hospital governance
PACS	Ease of access, but more images to review Greater dependency on technology
EPR	Increased streamlining Greater need to generate discussion record Greater need to generate task lists
Videoconferencing	Takes more time per case [17] Hinders interaction dynamics (turn-taking) More difficult to coordinate artefacts

However, summaries need to be supported by complete information, and the MDT needs to be made aware that details are available if needed.

The introduction of PACS is a potentially helpful development, which could play an important role in preparation and documentation for MDTMs. Current systems, however, need to be better integrated with support for pre- and post-meeting activities as well as with MDTM records. Abundance and wide accessibility of images should not be seen as a substitute for preparation. In addition, a lack of common standards and agreed protocols, heterogeneous image quality and lack of contextual information (e.g. about the reporting radiologist) will diminish the effectiveness and the efficiency of MDTMs. Furthermore, a high standard of specification in networks and hardware needs to be employed to assure dependability. As our work systems become reliant on electronic systems, such as PACS, and paper and other artefacts, such as radiological film, disappear, we need to guarantee that patient information is available when needed, without undue delay. The scenario of a systems failure with patient test data, or imaging for example, if unavailable poses a real life-or-death risk for patients.

Records and documentation are important requirements, and considerable effort is put into ensuring that records created at MDTMs are dependable and reflect the consensus achieved [6]. Representation for awareness of the status of work is one of the many functions of paper records [48]. However, when an awareness and dependability-enhancing mechanism in the form of a large screen for record creation during the MDTMs was suggested to the MDT, reactions were mostly negative. Objections varied from time issues to its anticipated (negative) effects on the discussion. Interestingly, participants also say that they like to take personal notes. This agrees with Østerlund's finding that a single record is often inadequate for all 'places of collaboration' [49]. One needs to be careful when designing for awareness of records creation under strict time constraints, such as in MDTMs. Awareness support should be unobtrusive and, in particular, not formalised into a prominent meeting structure. It should rather be a 'background' activity that can feed into individual activities, such as note-taking, or support secondary functions of the MDTM, such as audit [18]. One should acknowledge that a single record keeping system would not satisfy all individual role requirements.

Finally, videoconferencing, a technology often discussed in connection with MDTMs [17], and more recently virtual meetings can also be potential sources of harm. As regards time, case discussions over videoconferencing place extra coordination demands, take longer than face-to-face discussions and may disrupt the work rhythms of the specialists involved (see Table 4). In addition, attention should be paid to the impact of socio-emotional factors on the meetings. Camaraderie, consensus and clinical discussion are top the list of positive aspects of MDTMs in the view of MDTM participants [27]. Therefore, in considering videoconferencing and virtual meeting technologies for MDTMs one should not underestimate socio-emotional role of the MDTM that needs to be supported too.

6. Conclusion

In reviewing the changes observed over the past 5 years in particular for MDTMs, we capture a sense of the impact that increase in volume on work rhythms and on interactions. We note that preparation for MDTMs becomes more important, and the collaboration at the MDTM is more formal. Although more information is potentially available at MDTMs, because of PACS, and the EPR implementation in particular, it is not as easy to access the electronic information as it is to review a paper chart.

As meetings become busier, there is less information used in the patient case review: fewer images are shown; fewer participants are involved; there is little discussion or questioning, and there is a greater need for formal records that help direct the work of several roles after the meeting. Although MDTMs seem to be less satisfying for MDT members, they still value being there, being co-located with their MDT colleagues, and having the chance to interact with one another.

Remarks on the importance (and lack of import) of record-keeping allude to other complexities outside the scope of this discussion. It is clear there are factors outside of the MDTM process that temper or modify the MDTM recommendations and have medico-legal and ethical implications that cannot be ignored.

Our research suggests that there is a valuable, but elusive, benefit from the co-located interaction among medical specialists at an MDTM that proves satisfying for individuals, and likely provides direct benefit to patient outcomes in the longer term. Because the process is believed to be a safer way of professional collaboration and coordination of patient services, there is a danger that this might create a false sense of safety when all of the information (data, images or expertise) is not available at the MDTM. At what point, as MDTMs experience increased pressure and utilise less and less patient information, will the risks posed by decisions taken at MDTMs outweigh their benefits?

Author contributions

BrIDGET KANE wrote the initial drafts and developed the ideas in cooperation with Dr SATURNINO LUZ.

Conflict of interest

None declared.

Acknowledgements

A sincere 'thank you' is extended to all of the multidisciplinary teams at St. James's hospital, Dublin, for their on-going co-operation in this study. BRIDGET KANE is a Marie Curie (ERCIM) Fellow and at the time of this study was an IRCSET Fellow, funded through the IRCSET Research Council for Science Engineering and Technology (IRCSET) Enterprise Partnership Scheme with St. James's Hospital Board.

We also appreciate the helpful comments from our anonymous reviewers.

Summary points**What was already known about the topic?**

- Work rhythms are important to examine in an analysis of collaboration in health care work.
- Multidisciplinary team work has become an important feature in modern healthcare.

What this study added to our knowledge?

- Quantitative data from a large teaching hospital on the development of multidisciplinary team working over the past 10 years.
- Elements intrinsic to the interaction in a multidisciplinary medical team constitute a delicate ecosystem.
- As the balance between actors, digital media and paper artefacts fluctuates, so too the nature of the interaction and collaboration changes.
- The MDT Ecosystem contains
 - specialist knowledge
 - radiological samples
 - pathological samples
 - clinical interpretation of patient's findings
 - roles and responsibilities
- Physical space and time are significant constraining factors.
- Time and timing are associated with the greatest observable effects on the MDTM.

REFERENCES

- [1] T. Ruhstaller, H. Roe, B. Thürlimann, J.J. Nicholl, The multidisciplinary meeting: an indispensable aid to communication between different specialities, *Eur. J. Cancer* 42 (2006) 2459–2462.
- [2] A. Fleissig, V. Jenkins, S. Catt, L. Fallowfield, Multidisciplinary teams in cancer care: are they effective in the UK? *Lancet Oncol.* 7 (2006) 935–943.
- [3] B. Kane, S. Luz, D.S. O'Briain, R. McDermott, Multidisciplinary team meetings and their impact on work-flow in radiology and pathology departments, *BMC Med.* 5 (2007).
- [4] K. Calman, D. Hine, *A Policy Framework for Commissioning Cancer Services*, Department of Health, Welsh Office, 1995.
- [5] I. Batchelor, J. McFarlane, Multi-disciplinary clinical teams, Based on Working Papers of the Royal Commission on the NHS, King's Fund, RC12, 1980.
- [6] B. Kane, S. Luz, Achieving diagnosis by consensus, *Comput. Support. Cooper. Work (CSCW)* 18 (2009) 357–392.
- [7] V. Patkar, D. Acosta, T. Davidson, A. Jones, J. Fox, M. Keshtgar, Cancer multidisciplinary team meetings: evidence challenges and the role of clinical decision support technology, *Int. J. Breast Cancer* 2011 (2011), <http://dx.doi.org/10.4061/2011/831605>, Article ID: 831605, 7 pages.
- [8] C. Taylor, A.J. Munro, R. Glynne-Jones, C. Griffith, P. Trevatt, M. Richards, A.J. Ramirez, Multidisciplinary team working in cancer: what is the evidence? *Br. Med. J.* 340 (2010) c951.
- [9] National Collaborating Centre for Acute Care (NICE), *Diagnosis and Treatment of Lung Cancer. Methods, Evidence and Guidance*, London, 2005.
- [10] National Institute for Clinical Excellence (NICE), 2013, About NICE, <http://www.nice.org.uk/aboutnice/whatwedo/> (accessed March 2013).
- [11] A. Alamri, V. Apok, M. Crocker, M. Powell, Sir Victor Horsley (1857–1916): lessons for the modern clinician, *Br. J. Neurosurg.* (2011) 1–5, early on-line.
- [12] J. Collum, J. Harrop, M. Stokes, D. Kendall, Patient safety and quality of care continue to improve in nhs north west following early implementation of the European working time directive, *QJM* 103 (2010) 929–940.
- [13] A. Maxwell, M. Crocker, T. Jones, D. Bhagawati, M. Papadopoulos, B.A. Bell, Implementation of the European working time directive in neurosurgery reduces continuity of care and training opportunities, *Acta Neurochir.* 152 (2010) 1207–1210.
- [14] G. Brown, Specialist multidisciplinary team working in the treatment of cancer, *Brit. Med. J.* 344 (2012) e2780.
- [15] G. Palmer, A. Martling, B. Cederman, T. Holm, Preoperative tumour staging with multidisciplinary team assessment improves the outcome in locally advanced primary rectal cancer, *Colorectal Dis.* 13 (2011) 1361–1369.
- [16] E.M. Kesson, G.M. Allardice, W.D. George, H.J.G. Burns, D.S. Morrison, Effects of multidisciplinary team working on breast cancer survival: retrospective, comparative, interventional cohort study of 13 722 women, *BMJ* 344 (2012).
- [17] B. Kane, S. Luz, Multidisciplinary medical team meetings: an analysis of collaborative working with special attention to timing and teleconferencing, *Comput. Support. Cooper. Work (CSCW)* 15 (2006) 501–535.
- [18] B. Kane, S. Luz, Information sharing at multidisciplinary medical team meetings, *Group Decis. Negot.* 20 (2011) 437–464.
- [19] E.J. Macaskill, S. Thrush, E.M. Walker, J.M. Dixon, Surgeons' views on multi-disciplinary breast meetings, *Eur. J. Cancer* 42 (2006) 905–908.
- [20] S. Bydder, A. Nowak, K. Marion, M. Phillips, R. Atun, The impact of case discussion at a multidisciplinary team meeting on the treatment and survival of patients with inoperable non-small cell lung cancer, *Int. Med. J.* 39 (2009) 838–841.
- [21] T. Goolam-Hossen, C. Metcalfe, A. Cameron, B. Roces, S. Falk, J.M. Blazeb, Waiting times for cancer treatment: the impact of multi-disciplinary team meetings, *J. Behav. Inform. Technol.* 30 (2011) 467–471.
- [22] B. Kane, S. Luz, On record-keeping at multidisciplinary team meetings, in: *24th IEEE International Symposium on Computer-Based Medical Systems (CBMS)*, IEEE, 2011, pp. 1–6.
- [23] C. Taylor, J. Graham, H.W. Potts, M.A. Richards, A.J. Ramirez, Changes in mental health of UK hospital consultants since the mid-1990s, *Lancet* 366 (2005) 742–744.
- [24] J. Stefoski Mikeljevic, R.A. Haward, C. Johnston, R. Sainsbury, D. Forman, Surgeon workload and survival from breast cancer, *Br. J. Cancer* 89 (2003) 487–491.
- [25] S. Catt, L. Fallowfield, V. Jenkins, C. Langridge, A. Cox, The informational roles and psychological health of members of 10 oncology multidisciplinary teams in the UK, *Br. J. Cancer* 93 (2005) 1092–1097.
- [26] J. Stalfors, C. Lundberg, T. Westin, Quality assessment of a multidisciplinary tumour meeting for patients with head and neck cancer, *Acta Oto-laryngol.* 127 (2007) 82–87.
- [27] B. Lamb, N. Sevdalis, S. Arora, A. Pinto, C. Vincent, J. Green, Teamwork and team decision-making at multidisciplinary cancer conferences: barriers facilitators and opportunities for improvement, *World J. Surg.* (2011) 1–7.
- [28] J. Firth-Cozens, Multidisciplinary teamwork: the good, bad, and everything in between, *Qual. Health Care* 10 (2001) 65–66.

- [29] R. Haward, Z. Amir, C. Borrill, J. Dawson, J. Scully, M. West, R. Sainsbury, Breast cancer teams: the impact of constitution, new cancer workload, and methods of operation on their effectiveness, *Br. J. Cancer* 89 (2003) 15–22.
- [30] D. Randall, R. Harper, M. Rouncefield, *Fieldwork for Design*, Springer-Verlag, London, 2007.
- [31] G. Doherty, J. McKnight, S. Luz, Fieldwork for requirements: frameworks for mobile healthcare applications, *Int. J. Human-Comput. Stud.* 68 (2010) 760–776.
- [32] L. Bannon, S. Bødker, Constructing common information spaces, in: Proceedings of the Fifth European Conference on Computer-Supported Co-operative Work, Shared Information Spaces, 1997, pp. 81–86.
- [33] M. Reddy, P. Dourish, W. Pratt, Coordinating heterogeneous work: information and representation in medical care, in: Proceedings of the 7th European Conference on Computer-Supported Cooperative Work (ECSCW'01), 2001, pp. 239–258.
- [34] C. Bossen, The parameters of common information spaces: the heterogeneity of cooperative work at a hospital ward, in: Proceedings of the CSCW'0, 2002.
- [35] M. Reddy, P. Dourish, A finger on the pulse: temporal rhythms and information seeking in medical work, in: Proceedings ACM Conference on Computer-supported Cooperative Work (CSCW'02), ACM Press, 2002, pp. 344–353.
- [36] J.E. Bardram, C. Bossen, A web of coordinative artifacts: collaborative work at a hospital ward, in: Group'05, ACM, Sanibel Island, FL, USA, 2005, pp. 168–176.
- [37] C. Tang, S. Carpendale, An observational study on information flow during nurses' shift change, in: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, ACM, New York, NY, USA, 2007, pp. 219–228.
- [38] E.H. Schein, On dialogue, culture, and organizational learning, *Reflections* 4 (2003) 27–38.
- [39] B. Kane, K. O'Byrne, S. Luz, Assessing support requirements for multidisciplinary team meetings, in: 23rd IEEE International Symposium on Computer-Based Medical Systems, IEEE, Perth, Australia, 2010, pp. 110–115.
- [40] B.T. Kane, An analysis of multidisciplinary medical team meeting and the use of communication technology, Ph.D. thesis, University of Dublin, Trinity College, 2008.
- [41] M. Losada, P. Sanchez, E.E. Noble, Collaborative technology and group process feedback: their impact on interactive sequences in meetings, in: Proceedings ACM Conference on Computer-supported Cooperative Work, CSCW '90, ACM, New York, NY, USA, 1990, pp. 53–64.
- [42] C. Bossen, R. Markussen, Infrastructuring and ordering devices in health care: medication plans and practices on a hospital ward, *Comput. Support. Cooper. Work (CSCW)* 19 (2010) 615–637.
- [43] G. Fitzpatrick, Integrated care and the working record, *Health Inform. J.* 10 (2004) 291–302.
- [44] B. Kane, P.J. Toussaint, S. Luz, Shared decision making needs a communication record, in: CSCW, ACM, 2013, pp. 79–89.
- [45] G. Napolitano, E. Ranaghan, R. Middleton, C. Fox, A. Gavin, Real-time multidisciplinary team meeting management systems. a comparison with paper records for staging completeness and waiting times, *J. Behav. Inform. Technol.* 30 (2011) 473–477.
- [46] N.H. Strickland, Current topic: PACS (picture archiving and communication systems): filmless radiology, *Arch. Dis. Child.* 83 (2000) 82–86.
- [47] University of California, EMR-Compatible Online Virtual Meeting Room for Multidisciplinary Medical Teams, 2011.
- [48] G. Fitzpatrick, Understanding the paper health record in practice: implications for EHRs, in: Health Informatics Conference (HIC'2000) Integrating Information for Health Care, Health Informatics Society of Australia, Adelaide, Australia, 2000.
- [49] C. Østerlund, Documents in place: demarcating places for collaboration in healthcare settings, *Comput. Support. Cooper. Work (CSCW)* 17 (2008) 195–225.