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Multi-disciplinary collaboration during ward rounds: Embodied aspects of electronic medical record usage

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ABSTRACT

Purpose: Hospital medicine necessitates that practitioners from many disciplines collaborate to care for patients with complex illnesses. Much emphasis is placed on multi-disciplinary interaction during the ward round to achieve collaboration, but it can still be difficult to attain. This paper looks at how electronic medical records affect multi-disciplinary collaboration during ward rounds.

Methods: We take an embodied approach, with a specific focus on the spatial and postural patterning of bodies in space. Using F-formation system theory as an analytical starting point, we compare the non-verbal interaction systems that support multi-disciplinary interaction during usage of a paper medical record and an electronic medical record at two points after deployment.

Results: We show that the paper medical record supports a nuanced non-verbal interaction system which is used to negotiate the ward round interaction and facilitate multi-disciplinary communication. We also illustrated how the electronic medical record initially fails to support a similar non-verbal interaction system, but with some adjustments over time, the ward round team re-establishes a functioning non-verbal interaction system and with it, multi-disciplinary communication.

Conclusions: We conclude with a discussion on the effects of electronic medical records on multi-disciplinary interaction and suggest a number of implications for their design: including, considering the social ergonomics of the device, the inclusion of paper in electronic medical records, addressing data fixation, and facilitating practitioners to make social changes to the interaction through the ability to make technical changes to the system.

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1.   Introduction

Hospital medicine is highly collaborative work. This is in part to coordinate care across shifts, but increasingly, to share knowledge across disciplines to care for people with complex cases. In an intensive care unit (ICU) for example, a patient will often have practitioners from many disciplines involved in his or her care, including: surgeons, doctors, nurses, dieticians, pharmacists, microbiologists, and physiotherapists. Effective collaboration between these practitioners is considered essential to good patient care [1], but is known to be difficult to achieve [2]. As electronic medical records (EMR) become an important tool in hospital medicine, it is important to ensure that they are designed to support multi-disciplinary collaboration.

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Multi-disciplinary collaboration can occur at any time in hospital medicine. However, it explicitly happens during the ward round. For the most part, practitioners work within the bounds of their own disciplines and coordinate across these boundaries on an *ad hoc* basis. Only during the ward round does the majority of the team come together to appraise patients' progress. Travelling from bed to bed, the ward round team consults the medical record, talks to the patient, and then collaboratively decides on each patient's care plan. During this process, much emphasis is placed on the value of multi-disciplinary interaction, which is considered an important factor in achieving high quality care. This paper focuses on how an EMR supports or hinders multi-disciplinary interaction during this context of the ward round.

We begin in the related literature section by considering current research on collaboration around EMRs and motivate a focus on embodiment. We then discuss literature on embodiment in health informatics and articulate our choice to focus on non-verbal interaction systems as a way of considering multi-disciplinary interaction during ward rounds, proposing F-formation system theory as the analytical starting point. After summarising this theory and its relevance to this paper, we present the method of analysis and the results of applying it to three situations: paper medical record usage and EMR usage at two points after deployment. We conclude the study with a discussion of how EMRs impact multi-disciplinary communication in the ward round setting and draw implications for the design of EMRs.

2. Related literature

2.1. Collaboration and electronic medical records

A growing body of research has considered how EMRs can support aspects of multi-disciplinary collaboration. Reddy et al. [3] for example, discuss the benefits of multiple, discipline-specific representations of the same data in an EMR for coordinating care across disciplines. Berg et al. [4] consider the structure of data in an electronic medical record, arguing that overly structured data with rationalistic and pre-fixed notions of its organisation can decrease the sharing of decision making between nurses and doctors. Pratt et al. [5] focus on the importance of incorporating awareness mechanisms into an EMR to facilitate the coordination of work between disciplines. This idea is further developed in Cabitza et al. [6] who articulate the coordinative conventions that should exist in an EMR.

The cited research mainly considers asynchronous collaboration through the EMR. Synchronous multi-disciplinary collaboration around medical records has received greater attention in research on remote team meetings. Kane et al. [7] analyse the use of different modes of communication and provide evidence for the usefulness of dual sources of data (audio and text), regardless if the practitioners are co-located or remote. In another paper by the same authors [8], preference for the video link over the display of artefacts, such as medical images, is noted, highlighting the important cues gathered from seeing the other practitioners. Li et al. [9] indicate a similar finding and encourage a focus on the social-emotional space related to awareness and coordination issues.

This research into remote synchronous systems hints at the use, and importance of, *embodied* aspects of interaction that occur in groups. It is embodied, non-verbal mechanisms that require seeing the other practitioners and not just hearing them. These come to light in remote situations where tacit use of the body in communication is lost and therefore noticeable. However, embodied and spatial aspects of interactions also contribute to co-located multi-disciplinary interactions, such as ward rounds. These embodied aspects of co-present interaction often go unnoticed in more routine situations where the challenge of remote collaboration is not involved. In this paper, we aim to make visible the role of the body in interaction during multi-disciplinary ward rounds.

2.2. Embodiment in medical informatics

Some literature in the medical informatics domain has begun to emphasise the importance of considering embodiment, that is, the ramifications of having a physical body with sensory and movement possibilities in a particular space. Tang and Carpendale [10], for example, highlight an ergonomic issue, the difficulty of moving carts containing an EMR and consequent low usage. Others consider the intersection of ergonomic issues with social ones, such as Heath [11], who describes how the tangible properties of the paper record are utilised to facilitate doctor–patient encounters. Fitzpatrick [12] and Wilson et al. [13] touch on the embodied practices of information creation and display.

The above papers look at various aspects of the embodied nature of interacting with a medical record. Other papers complement this perspective by considering the movement of the body during collaborative practices. Bardram and Bossen [14] illustrates how practitioners move around a hospital to gather information and the ramifications this has for collaboration and work practices. Moving from macro movements to micro ones, Hindmarsh and Pilnick [15] consider the minute movements during a surgical procedure, such as orientation of instruments, which help achieve coordination in this complex undertaking; and Koschhmann and LeBaron [16] focuses on how people orient themselves towards each other and the patient during surgical procedures.

When taken in conjunction, the above findings draw attention to a myriad of embodied-related problems that may arise during EMR usage by ward round teams. The tangibility of paper to facilitate interaction is lost; the creation and display of information is different; the ergonomics are possibly a problem, and non-verbal interaction mechanisms require consideration. In order for this study to address both embodied interactions with the medical record and the spatial issues related to mobility, we chose a granularity of analysis in between the macro and micro movement analyses described above. We investigate the patterning of bodies in space interacting around medical records and the routine arrangements that are practically developed over time.

2.3. Non-verbal interaction systems

Social science literature from the field of interaction analysis provides a theoretical and empirical underpinning for investigating the patterns of bodies in space around medical

Fig. 1 – Non-interaction on a crowded underground train.

records. Goffman [17] is a useful starting point in this literature, demonstrating in detail that whenever two or more people are co-present, that is, within each other's perceptual fields, they participate in spatial and postural arrangements of their bodies that reflect the relationships of all involved.

When co-present groups interact, the role of body in the interaction can be difficult to spot. It becomes more obvious when scrutinising groups that do not want to interact, such as crowds of passengers on an underground train. Careful inspection of the postural positions of passengers on an underground train during rush hour will show that no person aligns their orientation or gaze with any stranger in the vicinity. Fig. 1 shows that three people standing next to each other all have different gaze directions. Although often done unconsciously, this is a way of clearly stating that no interaction is desired despite proximity. In contrast, groups intending to interact align themselves spatially and posturally in such a way as to facilitate interaction.

If we consider how Goffman's principle applies to ward rounds, we can conclude that each person will take up a spatial and postural stance that communicates the desired nature of the interaction. This finding is significant because it implies that not only are the spatial and postural relationships of practitioners during ward rounds not random, but that they contribute to, and reflect, the nature of the interaction.

Other research demonstrates that spatial and postural positioning is both systematic and reflexive in nature. Garfinkel [18] in his theory of *reflexive accountability*, shows that all actions towards another are intelligible and accountable. In other words, no matter what action one takes, it will be interpreted, and accounted for, in terms of norms. For example, if a professor greets one of his students in the corridor, the student is drawn into an interaction in which any choice of return action (whether returning or not returning the greeting) will be consequential. If the student chooses to uphold the norm and return the greeting, the interaction will be completed without thought. If the student does not return the greeting, the professor will wonder for what reason this offense was carried out.

The concept of reflexive accountability can also be applied to medical ward rounds. It suggests that spatial and postural

stances people choose during the ward round are accounted for, and reflected, in the choices of others. The ward round team then forms a non-verbal interaction system in which the choices that people make about where and how they stand reflect the relationship between people during the interaction. This conclusion suggests that non-verbal interaction can be studied as a system in itself, and need not be explained in terms of other external systems, such as psychological state or verbal interaction [19]. The following section articulates why and how looking at the systematic patterning of bodies in space is useful for understanding multi-disciplinary interaction during ward rounds.

2.4.   *Multi-disciplinary interaction during ward rounds*

Atkinson and Heritage [1] and Luke [20] both argue that successful multi-disciplinary interaction during the ward round is essential to good patient care. It provides necessary information exchange and the range of expertise needed to interpret that information, i.e. doctors' knowledge of treatment options and the nurses' understanding of the current state of the patient. To achieve productive multi-disciplinary interaction, it is essential that all relevant information is shared to reach appropriate care decisions and inform every one of their daily tasks. It is also important that the discussion of any one patient does not take any longer than necessary, to allow for all expected activities to be completed in the shift.

Ensuring that all necessary information and expertise is shared, but that no time is wasted, is a tenuous balance that requires a significant amount of *negotiation of the interaction* – that is, who speaks and what is spoken about. This negotiation can be problematic in the hierarchical environment of a hospital. Despite the emphasis on, and opportunity for, interaction during the ward round, traditional medical hierarchy can frustrate doctor–nurse verbal interaction [2]. Although some have proposed a need for better assertiveness training in nurses [21] and techniques to help them 'break into the circle' [22], other research, such as Hill [23], indicates that better understanding of the non-verbal interaction system is needed.

Hill [23] demonstrates that nurses can, and do, participate in ward rounds more than thought, through non-verbal interaction mechanisms. She describes nurses' use of gaze and silence as tools to support or disagree with doctors without embarrassing or confronting them, as would be inappropriate in the established hierarchy. Given the findings in the previous section, that non-verbal interaction systems are inherent in group interaction through spatial and postural choices, we would suggest that Hill's findings are part of a larger non-verbal interaction system used to interact during the ward round. The emphasis on the non-verbal as a primary means of negotiating the interaction between disciplines has focused our analysis on this non-verbal interaction system.

3.   **F-formation system theory**

The theoretical perspective that we apply is Kendon's F-formation system theory [24], which was developed to describe the subtle interactions of space and posture between the members of standing groups. In this section we sum-
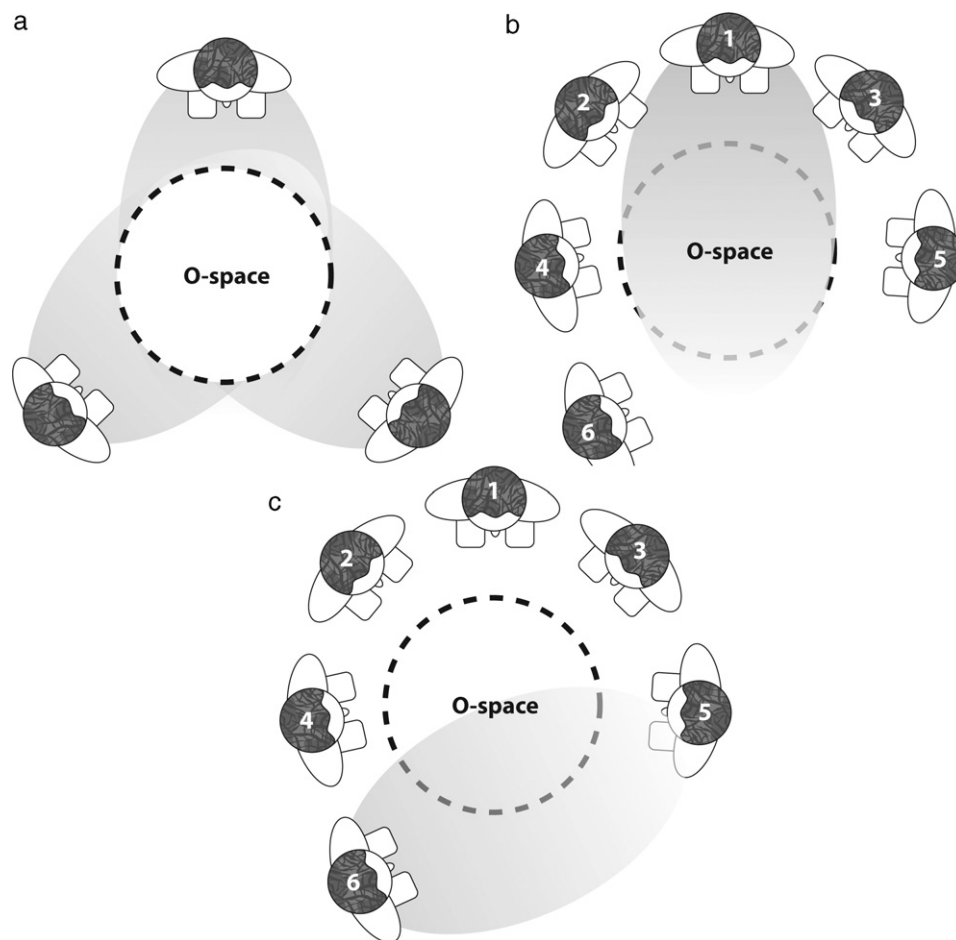
Fig. 2 – (a) Illustration of o-space concept, (b) illustration of overlap between transaction segment of person 1 and the o-space and (c) illustration of overlap between transaction segment of person 6 and the o-space.

marise F-formation system theory, providing an over-view of the structure of group interaction. We also articulate how this informs our analysis of non-verbal interaction systems in the context of ward rounds.

3.1. Group structure

3.1.1. Initial formation

Kendon [24] in his theory of F-formation systems[1], details the spatial organization of social encounters. "An F-formation arises whenever two or more people sustain a spatial and ori-entational relationship in which the space between them is one to which they have equal, direct and exclusive access" (p. 209). There are many possible arrangements, such as: circu-lar, semi-circular, side-by-side, and L-shaped. The formation reached is contingent on the relationships between people in the group, although the spatial arrangement also depends to some extent on the surroundings (i.e. space allocation, num-ber of people, furniture).

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[1] The name derives from the use of the word formation to describe spatial relationships in the military and from their focused (as opposed to unfocused) nature.

It is these relationships between group members that we would like to determine by analysing the non-verbal interac-tion system. We can do this by considering Kendon's concepts of *transactional segment* and *o-space*. Each individual has a transactional segment which is the space that he needs to carry out a particular activity. For example, a man watching TV needs the space between himself and the TV in order to watch TV and will react if somebody stands in that space. A person indicates the space that his transactional segment occupies through his posture. As Kendon says, "the location and the orientation of the transactional segment is limited by how the individual places his body, how he orients it and spreads his limbs" (p. 211).

When people form a group their transaction segments overlap to form an *o-space,* an interaction space in which they can jointly interact as in Fig. 2a. Many situations in which people overlap their transactional segments to form an o-space require some negotiation as the shape of each person's transactional segment will need to change and will affect interaction opportunities. For example, when a ward round team stands in a semi-circle around a paper medical record, the person at the apex of the semi-circle and the person on the tip have different interaction possibilities. Fig. 2b and c visu-alise why this is. Person 1 in Fig. 2b, has the greatest overlap

of his transactional segment and the interaction space, giving him the most opportunity to lead the interaction. Person 6 has the least overlap between his transactional segment and his interaction space as shown in Fig. 2c, giving him less of an opportunity to influence the interaction.

The formation chosen is a reflection of the group's negotiation of the interactional needs of each member of the group, given the spatial possibilities. Analysing the initial formations of a ward round team reflects the perceived interaction needs of the healthcare professionals with each other or the information artefacts to achieve the necessary multi-disciplinary collaboration.

3.1.2. *Adjusting the formation*

Once a group has created a formation, there are many ways in which they can, and do, adjust it throughout an interaction. In particular, there are ways to change speaker or topic. A change of speaker is often initiated by a movement into the formation, which is either accepted by the group who re-adjusts to maintain the formation, or is rejected and the movement reversed. A change of topic is also generally seen by a re-figuring or re-orienting of the formation in this way. The formation of the ward round around the medical record makes it difficult for such large-scale movements. However, Kendon presents empirical work that suggests that other non-verbal interaction mechanisms can play a similar function.

Formation is primarily determined by the placement of the feet. Movement of other parts of the body give people ways to adjust the formation., *upper-body orientation* and *posture* are two ways to react to the non-verbal interactional system. These usually indicate changing connections between people, and we would add information artefacts. Kendon's analysis stops at this point, describing social groups without reference to information artefacts. Heath [11], however, demonstrates the importance of *gesture* and the *object manipulation* (e.g. moving a piece of paper) as ways of inviting attention to an information artefact in a group. In the context of the ward round, adjustments to upper-body orientation, posture, gesture, and objection manipulation can be observed to understand how the interaction is negotiated, in terms of who speaks and what topic is spoken about.

3.2. *Analysing group interaction*

Group formation is the starting point for understanding the non-verbal interaction system, as it reflects the negotiation of the group's interaction needs, and constrains the possibilities of other non-verbal interaction mechanisms. The analysis can be deepened by examining the four non-verbal interaction mechanisms identified in the previous paragraph: upper-body orientation, posture, gesture, and object manipulation, and noting how group members' adjustments are supported or hindered by the formation. Knowing what kinds of relationships can be identified by looking at each type of non-verbal interaction mechanism, and combining that with a general understanding of the ICU context, we have a theoretical basis for observing non-verbal interaction systems.

4. Method

The opportunity to do this case-study arose when a nearby hospital asked for support in monitoring its switch from a paper to an electronic medical record (EMR). The switch was intended to improve record keeping matters such as prescription legibility, as well as encourage adherence to guidelines, and provide research and development opportunities. There was concern however, that work practices might be disturbed, particularly multi-disciplinary interaction.

There was general agreement amongst the staff leading the project that the paper record facilitated multi-disciplinary interaction during the ward round well. We therefore took this as our baseline, probing how it supported the non-verbal interaction system. We then looked at the use of the EMR at two further points, four months and one year after its deployment. We examined this data to see whether it supported the non-verbal interaction system (and multi-disciplinary interaction) in the same way as with the paper record, in a different way, or not at all. The research has been classified as an audit by the Cambridgeshire Research Ethics Committee because it does not contain any patient data or interaction and therefore does not require ethics approval.

4.1. *Setting*

This study took place in the ICU of a cardio-thoracic specialist hospital transitioning from a paper to an electronic medical record. The majority of the patients in this unit have had major, invasive surgery, such as heart transplants or bypass surgery. The nature of the recovery process means that patients are unconscious on their arrival at the ICU and perhaps for some days after. Treatment of patients therefore does not rely on doctor–patient interaction, but rather happens through analysis of such data as heart rate, blood results and urine output coming from the many machines to which the patient is attached. The individual work of the doctors and other nursing and para-medical members of the multi-disciplinary team (MDT) is for the most part information centric, with perhaps the exception of the bed nurses who monitor the comfort of the patients.

The ICU is a relatively large unit consisting of twenty-five beds and approximately two hundred staff who care for the patients. They include: doctors, registrar (junior) and consultant (senior), and other multi-disciplinary team members including three levels of nurse (charge nurse, bay nurse and bed nurse), and paramedical staff including a dietician, a pharmacist, a microbiologist, and a group of physiotherapists. At any given time as many as ten different people might be involved in a patient's care. Due to the rota, they change configuration regularly. To maintain continuity of care, a lot of emphasis is placed on communication between practitioners, the primary vehicles being the medical record and conversation during the daily ward round.

The morning ward round brings together all of the relevant MDT personnel to discuss each patient's progress and decide upon future care. The ward round normally consists of about 8 to 10 people, including the consultant, 2 registrars, charge nurse, bay nurse, bed nurse, dietician, and pharma-

cist. The surgeons attend as needed and the physiotherapists and microbiologist attend once a week. The ward round team travels from bedside to bedside to discuss the daily patient care plan, spending between 5 and 15 min at each bed. The team arranges itself around the nurse's table containing the patient's medical record or after the deployment of the EMR, around the computer trolley. The round begins with one of the registrars presenting the most relevant information about the patient. The consultant then works methodically through a general set of issues leading the discussion.

The head of the ICU is acutely aware of the difficulties of multi-disciplinary interaction, especially during ward rounds, appreciating that although nurses do not have the same degree of formal training as doctors, they often have considerable, possibly superior, practical experience. They also spend the most time with the patient and are the most likely to notice problems in treatment or inconsistencies in doctors' orders. Consequently, the head of the ICU in this study, has attempted to flatten the normal hierarchy in order to increase nurse participation in the ward round. Despite his best efforts, the nursing staff report in interviews that they are intimidated by most of the doctors. Nurse–doctor communication then remains a delicate issue in this ward.

4.2.   Data collection

This investigation took place over a period of 13 months during which the ICU transitioned from a paper medical record to an electronic medical record. The data analysed including video, interviews, and ethnographic observations. Video recordings were obtained at three points throughout the study period: (1) 1 month prior to deployment of the EMR; (2) 4 months after deployment; and, (3) 1 year after deployment. Each time, six separate, randomly selected patient discussions were filmed for a total of 3 h of video. To enable comparison, those patient discussions selected for analysis were always managed by the same consultant. Video footage was complemented by broader observation during the above three periods to ensure that the video lens did not limit the analysis.

To gain further context, observation of the target consultant took place the week after deployment, and of other consultants throughout the duration of the study. Interviews of seven practitioners in the MDT spanning different disciplines were also carried out at each of the three time points mentioned. Informal engagement with practitioners, during lunch or while waiting for the ward round attendees who entered isolation rooms to emerge, complemented the more formal data gathering. Extensive field notes were written up after each day spent in the unit to capture these observations. These notes included verbatim quotes jotted down while on the ward, summaries of interactions seen, a running characterisation of the dynamics of the ward and a list of issues to explore in the next observation session. The observational data focused our attention on key issues during the video analysis.

4.3.   Data analysis

In Section 3, we proposed that non-verbal interaction systems can be analysed by considering the initial formation of the group and the systematic adjustments made throughout the interaction. Video analysis [25] is an appropriate method for close scrutiny of systematic behaviour. As the method is described, however, its use is to articulate a system seen on the video without reference to a larger system. Understanding multi-disciplinary interaction also requires understanding the dynamic of the ICU in which the ward rounds take place. Consequently, we embed video analysis into a wider ethnographic study. We use the ethnographic data to interpret and contextualise the video analysis.

4.3.1.   Video analysis procedure

Each video was watched twenty to thirty times, with a gradually narrowing of focus – from tracing the formation, to drilling down, to finally, noting interdependencies. These steps are described below. This kind of analysis took place for each of the six ward rounds recorded. Notes were made in the form of hypotheses, examples, occasional drawings, and further questions.

Step 1: Tracing the formation. We asked the following questions when watching the video: what was the initial formation? How did the initial formation come about? What changes to the formation occurred during the ward round? How did the formation disband? Tracing the formation through answering these questions gave us a reference frame for all of the other non-verbal interaction mechanisms.

Step 2: Drilling down. After we established a frame of how the formation moved, we looked at each layer of non-verbal behaviour in turn. We took note of the non-verbal interaction mechanisms seen, and looked for why they were used, answering the following questions: Was the non-verbal interaction a reaction to another's non-verbal interaction? Did it have a meaning in the context of events? Did it have a meaning in the social system articulated in the field notes during the observational period? We successively looked at each discipline.

Step 3: Noting interdependencies. Once we had a detailed understanding of one interaction, we looked at the interdependencies between the non-verbal interactions, asking questions such as: What does formation tell us about the relationship of the people in the ward round and does that contribute to an understanding of the negotiation of interaction?

Similarities across the six videos were probed and explanations sought from the context provided by the field notes. Differences were also scrutinised to see whether they came from a change to the way the interaction was negotiated or were adjustments to the surrounding. The aim of this analysis was to find generalisations across the data about the non-verbal interaction system that enabled negotiating interaction, and hence multi-disciplinary collaboration, and how it was supported or hindered by the EMR. We emphasise that we used only *observable* evidence of changes to the ward round interactions. We do not presume any further interpretation about effectiveness or quality from the participants' subjective perspectives, or indeed the quality of the clinical outcome.

Fig. 3 – (a) The ward round with the paper patient record: (1) head nurse; (2) consultant; (3) registrar; (4) bay nurse; (5) dietician; (6) bed nurse and (b) paper patient medical record: (1) binder; (2) drug chart; (3) patient plan of the day; (4) observation chart; (5) personal notes.

4.3.2.   Data analysis presentation

We present the data analysis of each of the three data capture points in turn – the paper record and then the electronic record at 4 months and 1 year respectively – before discussing the implications of the results. The first two sections begin with a description of the record and its set-up. Each section follows with a characterisation of the initial formation. Following this, the analysis is presented by medical position, and within this, by sequence. The latter assists in portraying the flow of events and how they are affected by the two records, while the former points out how the hierarchy affects those events. This analysis depicts events that are representative of what was gleaned from the data and uses examples to illustrate this, but does not detail a specific single episode.

5.   Results

5.1.   Paper medical record

The paper medical record, shown in Fig. 3a, consisted of three specific types of form (the observation chart, the drug chart, and the plan of the day) and a folder or binder for miscellaneous and patient-specific forms and papers. The observation chart was A3-size paper and lay flat on the nurse's table. The nurse plotted vital signs on it regularly, recorded blood test results, wrote other medical notes, and kept non-medical care information on the reverse side. A new chart was used each day and was placed on top of the old one. This chart gave a quick overview of the state of the patient and was usually the first reference for the consultant. The drug chart, a fold-out yellow card stock document, had the prescribed drugs written on it. Specific drugs were crossed out after they were no longer needed. The patient plan of the day had directions for medical procedures, such as extubation, to be carried out that day. Other papers, held in a binder, might contain previous history or be related to specific conditions, and were rarely referenced. This collection of forms and papers was the central focus of the ward round discussion for each patient.

5.1.1.   Formation (with paper records)

The consultant, arriving at the bed first, initiates the group formation around the nurse's table that displays the paper charts by taking the position directly in front of the charts and facing the patient. The rest of the MDT staff stand to either side of the consultant, forming a horseshoe. As shown in Fig. 3b, the registrars take a position on either side of the consultant (only 1 registrar is visible here), slightly behind with their feet angled in to maintain the curve of the formation. The head nurse and bay nurse each stand next to one of the registrars looking sideways onto the charts. The remaining staff, including the dietician, pharmacist, and bed nurse, curve around the table next to the bay nurse, the dietician often slightly behind the formation. The ward round participants begin oriented towards the paper, their bodies slightly leaning inwards.

The team always wait for the consultant's arrival in order to form the group. This indicates that each person is taking a place in the formation in relation to him and their expected interaction needs. The orientation of the group towards the charts contrasts with that when participants are free standing (usually before the ward round). At this time, they orient themselves towards the bend of the horseshoe shape (often where the consultant is standing) rather than to the space in the middle (where the charts are during the ward round). It seems that this is done by cue of the consultant as will be seen later.

5.1.2.   Consultant

The consultant's central position in the formation gives him a number of resources for leading. His prominent position makes his magnified postures and gestures visible to everyone in the group as he follows the information relevant to the conversation on the charts. His success in guiding the focus of the group was demonstrated by all of the staff following his gaze throughout the presentation of the patient. There were very few turns of head and when they did occur there was an immediate focus back to the charts rather than a straying of eyes which would happen if the person found it difficult to re-join the conversation. The consultant's reactions to the presenta-

tion of the patient and associated data were also available to the other staff (but not the registrars) a phenomenon that will be discussed later.

The consultant uses gesture and object manipulation to guide the content development of the conversation. As the registrar presented the patient information, the consultant followed the relevant data by pointing to it on the chart with his finger. The registrar adapted his presentation to suit the indicated data; the most notable example was a very rapid change of focus of the registrar from the distant space in front of him to the hand of the consultant. At this time the recorded audio indicated a shift in topic. The charts provide a similar resource for the consultant to indicate a change in topic. For example, while the consultant was talking to the head nurse, he began to draw the drug chart over the vital signs and the nurse quickly brought the topic to a close and the discussion switched to drugs.

Body-orientation and posture also play an important role in the consultant's ability to regulate who speaks. His forward leaning posture during the presentation of the patient makes it difficult for anybody to catch his eye to indicate a desire to speak. Frequently, however, after the presentation is complete, he straightens up slightly (not completely) making non-verbal requests feasible. We observed several times the head nurse lean inward and tilt her head towards the consultant, causing him to re-orient both his head and upper-body to her and start a conversation. This approach worked better than nurse interjection. For example, a bay nurse who spoke without going through the process of requesting the floor, was not acknowledged even after several attempts.

5.1.3. Registrars

The registrars have a seemingly contradictory set of communication possibilities. Theoretically, the registrar can present the patient and develop the topic of conversation as s/he would like. As was shown above, however, the consultant can regulate this talk. The registrar has few counter-measures since the posture of the consultant with his hands spread across the charts makes it difficult to point at data or reach for a chart without asking for it. This does happen on occasion, but not easily. Moreover, it is rare that the other staff orient towards a registrar when she/he speaks. They tend to keep their focus on the charts or the consultant.

Interestingly, the registrars' position facing the data from the same angle as the consultant seems to give them an advantage in that they interject in ways the medical staff do not. It is not clear whether this is a matter of their position in the formation or their status. As Lindley and Monk [26] noted, when people reminisce about photos that they have all the information about, they are less likely to need the face-to-face contact required when there is a 'story-teller'. It is possible that the same effect is seen here, as the registrars are more likely to have background medical knowledge comparable to the consultant and in contrast with the other MDT members.

On occasion the positional inversion of registrar and consultant occurred; a highly experienced registrar on arriving at the bed first, may take up the usual spot of the consultant in front of the charts facing the patient. Unlike the consultant, registrars in this position did not lean over the charts, but stood upright so that they could monitor the reactions of the consultant. The rest of the multi-disciplinary team orient not towards the registrar, but to the consultant, monitoring his reaction rather than focusing on the charts. This confirms that the consultant, as the senior member of the group, sets the focus of the formation. The effect of seniority was also evident in the group's differential reaction to different registrars. When a more experienced registrar spoke, most of the multi-disciplinary team oriented towards him, even adjusting the formation to be able to see him. They did not do this when the more junior registrar spoke.

5.1.4. Other MDT staff

The other MDT members developed a number of communication possibilities suitable to their information needs, their place in the hierarchy, and the ward round situation. As noted above, they requested to speak by leaning inwards and catching the eye of the consultant. An alternative strategy taken by two of the bed nurses was to slide a chart in front of the consultant and allow him to take up the topic in conversation or not. In both cases the consultant oriented towards the nurse and a discussion ensued. More frequently, the staff needed to speak amongst themselves. Frequently, they would take a chart from the table indicating a desire to discuss it, at which point both parties would re-orient towards the chart. Other side conversations did occur but they were short and neither party re-oriented. Even with re-orientation, the MDT staff turned only partially inward, not moving out of the formation. They continued to glance back to the main conversation regularly, indicating that they were monitoring it.

Although the medical staff rarely changed places, some do leave the ward round – the dietician being a prime example. As noted above, her original place in the formation was slightly outside and her focus down rather than on the charts. Her attention often strayed to other happenings in the ward and on several occasions she turned and walked away to attend to something else. Yet, when she wanted to join the interaction, she would lean fully into the circle before starting. Her behaviour in this situation indicates the porosity of the formation. While the focus of those in the formation never left the interior, there were a number of members who would come and go and lean into the formation when they needed, or wanted, to participate. Similar behaviour was seen with bay nurses who often had other duties simultaneous with the ward round.

5.1.5. Staff engagement

Posture and associated gaze are significant in suggesting an openness to engagement. We identified three types of posture. These are demonstrated in Fig. 4: (1) engaged; (2) neutral; and (3) personal. An individual in the engaged posture is leaning forward slightly with gaze clearly focused on the speaker. Neutral can be identified by an upright posture and a gaze that encompasses the entire group. Individuals in this posture often stand with their arms crossed. The personal posture characterizes an individual who is leaning over, writing or reading notes, but still glancing up occasionally. The consultant asked questions or opened a discussion with those in the engaged posture, suggesting that an engaged posture signals readiness to speak.

Fig. 4 – Identified postures: (1) engaged; (2) neutral; (3) personal.

5.1.6.   Disbanding

The session finished with the straightening up of the consultant at which point he asked, 'Anything else?' The consultant always left the conversation first. As he turned, the formation disintegrated and smaller conversation groups formed. For example, a bed nurse might walk over to the registrar and ask for something to be signed. The bay nurse might discuss food with the dietician; the pharmacist might point out an error on the drug chart to the registrar and ask it to be corrected.

5.1.7.   Summary

The analysis of the paper medical record demonstrated, through focusing on the patterning of bodies in space, that there are opportunities to enter or advance the interaction. The consultant has multiple means to lead the group, regulating both the focus as well as the topic of conversation. The other staff also have several ways of joining the conversation and accessing information. We now look at how these same issues play out after the introduction of the electronic medical record.

5.2.   Electronic medical record (4 months)

The EMR, MVICU, provided by (IMDsoft), had been customized by a multi-disciplinary team at the hospital to reflect local practice [27]. The main screen presents trend information based on vital signs as well as the drugs and fluids given. The user can navigate the interface by clicking on tabs at the top of the display with a mouse to obtain all other information as displayed in Fig. 5b. To input data, such as a prescription, the user must log in. There are restrictions on who can enter what data and the user's identity is attached to all work. The computer is mounted on a semi-mobile, adjustable height cart – one per bed. The 19″ computer screen display, depicted in Fig. 5a, is considerably smaller than the nurse's table had been, and has a vertical rather than horizontal display.

The EMR was championed, customized and introduced by the head of the unit. Although the customization aimed to preserve local practice, the system was also expected to improve practice and enforce policy. The system improves data reliability by streaming in vital sign and test results from various monitoring machines, thus avoiding copy and calculation errors on the part of the nurses. It calculates and displays graphical trend data, so doctors can more easily see the effects of a treatment (although some data extends over several screens, rather than being integrated on a single paper chart). The system also enforces attribution of clinical decisions to individuals, via time-stamped actions and user logins.

5.2.1.   Formation (with electronic record)

The consultant arrives at the bed first, stands in front of the computer and logs in. The registrars stand slightly behind each shoulder of the consultant and look on, similar to their position around the paper record. As shown in Fig. 5a, the other nursing and paramedical staff stand in a line off to one side about 1.5 m away or form a second ring behind the doctors. They are unable to see the screen. Some of the staff hold a print-out containing important information about the patients in their charge. It is notable that in the first week of deployment, the ward round team attempted to form a ring including the computer, but this was impractical as nobody could see the screen.
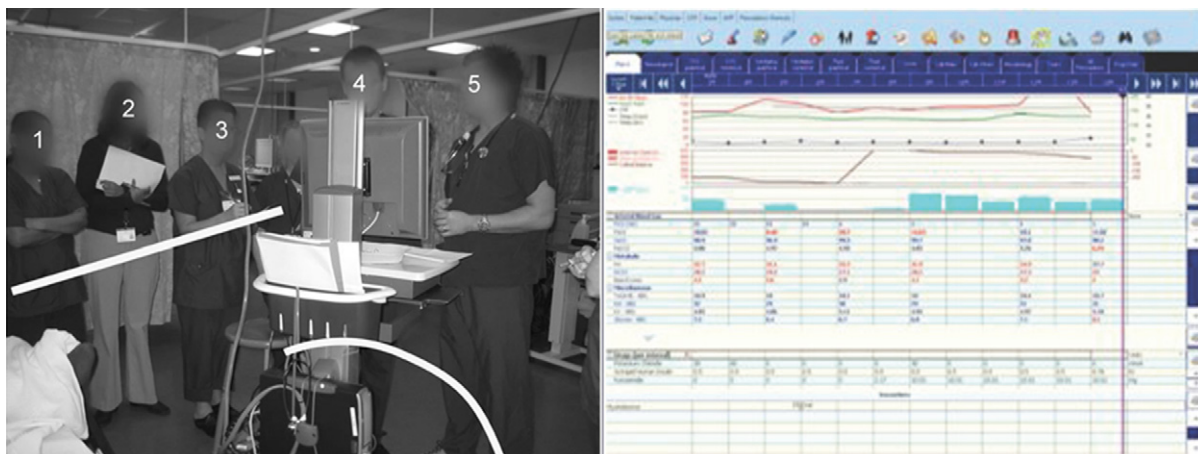

Fig. 5 – (a) The ward round using the electronic patient record: (1) bed nurse; (2) pharmacist; (3) head nurse; (4) consultant; (5) registrar and (b) electronic patient record summary screen screenshot.

5.2.2. The consultant

The consultant's orientation towards the computer and forward leaning posture, along with control of the mouse, enabled him to guide the interaction in a way comparable to that of the paper charts. The mouse provided a means of pointing at the data and directing the conversation. The consultant's posture indicated the focus was on the data, and made it difficult for anyone to catch his eye and request discussion. However, the consultant was only able to direct the focus of those who could see the pointer on the screen – in contrast to his pointing at the paper charts which was visible to the group as a whole. He consequently lost his ability to direct the attention of the whole group.

5.2.3. The registrars

The registrars had similar communication possibilities with the electronic record as with the paper one. The registrars stood slightly behind the shoulders of the consultant. One of them presented the patient and the consultant pointed to the relevant data with the mouse. The second registrar occasionally added a comment or answered a question posed by the consultant. The registrars were free to say what they wanted, and to enter the conversation in the same way as with the paper record, but were guided by the mouse instead of the pointing finger. They have the advantage of sharing the same viewpoint as the consultant, but as with the paper record, they do not have face-to-face contact with the consultant and its usual benefits.

When the registrar and consultant inverted positions – the registrar in front of the screen and the consultant to one side with the mouse – there was no change of leadership. Although the registrar gestured, he did not point at the screen as the consultant continued to keep control of the mouse and use it as a pointer. Further, the registrar oriented himself diagonally towards the consultant so that he could see both the screen and the consultant. In this position the consultant maintained the requisite resources for guiding the conversation and communicating more satisfactorily with the registrars despite not maintaining the expected place.

5.2.4. Other MDT staff

The other staff formed a ring, a line, or occasionally a cluster separate from the doctors. The only consistent feature across these formations seemed to be a disconnection with the group who could see the screen, usually the doctors. If we posed the question: 'What if these staff moved places?' – the answer would be that no relationships would be disturbed. This answer and the frequent movement of people into, within, and out of the cluster, suggests a distinct decrease in focus compared with a single formation.

Side conversations have become a rare occurrence. There is no longer any device to indicate a desire to re-orient towards another person, a role the paper played previously. Moreover, side conversations disturb monitoring of the main conversation, which can no longer be done visually, but only aurally. However, when side conversations do occur there is often significant re-orientation, with the participants turning to face each other, as opposed to just angling towards each other. This seems unproblematic because there is no formation, and thus no set of relationships, which might be upset.

While the above two paragraphs indicate that inclusion is a problem for the other MDT staff, participation is perhaps more so. The only means to gain access to the conversation is either direct verbal interruption, or, towards the end of the conversation, the consultant generally turned around and asked if there was anything else, making it possible to participate at this point. Only in the latter circumstance did we witness the non-medical staff speak. The respective situations created by paper versus the electronic record at the patient's beside do not provide equal opportunity for all members of the group to contribute to the conversation. In the former, the other MDT staff could respond and add to it. In the latter, they can only bring up problems that have not been discussed.

One staff member mentioned that she tried to use the note feature in the software to solve this communication problem in the ward round, but found it problematic because the number of her colleagues using it was not high enough to make it practical.

5.2.5. Summary

Compared to the embodied use of the paper record, we see a number of differences in the patterning of bodies in space after 4 month's use of the EMR. Our analysis indicated that there was a dearth of possibilities to enter or advance the interaction. The consultant has lost his means to guide the interaction of the whole group and the other nursing and paramedical staff could no longer access the information resources, nor participate in the conversation. Communication between the disciplines during the ward round was minimal. While this section looked at the use of the EMR at a very early stage (4 months), it is also interesting to observe how the use of the EMR changed over time. The following section examines usage at the one year point, as the healthcare professionals become more familiar with it and evolve their practices around it.

5.3. Electronic medical record (1 year)

5.3.1. Formation

The consultant arrives first to the bed and the registrars stand behind his two shoulders as in the previous formations. The other nursing and para-medical staff, however, rearranged themselves to form a horseshoe around the patient's bed. The consultant has also adjusted his position, although still in front of, and oriented towards, the screen, he is upright and several steps back. A typical formation is shown in Fig. 6.

5.3.2. The consultant

One significant problem noted in the use of the EMR in the previous section was the inability of the consultant to lead the interaction because the other staff could not see the information he was reviewing or his reactions to it. The consultant's adjusted position, although still in front of, and oriented towards, the screen, is upright and several steps back. From this position, the ward round teams can easily monitor the consultant's gaze and reactions towards the conversation. They frequently followed his gaze to the patient and attached machines used to monitor him or her (e.g. heart rate) or kept their attention on the faces of those speaking. The consultant, able to see everyone, leads the conversation, not by focusing

Fig. 6 – The ward round team using the EPR 1 year after deployment.

the team's attention on the data as with the paper record, but on the conversation itself.

5.3.3. Registrars

The position and role of the registrars in the interaction did not change from the analysis at four months time. The only difference was a more visible use of paper, which will be discussed below.

5.3.4. Other MDT staff

This new formation supports a number of ways for the other MDT staff to enter the interaction, one of the chief concerns in the previous section. As when using the paper record, the staff could catch the eye of the consultant and request the floor by leaning into the formation. The use of non-verbal behaviours more generally is facilitated by this arrangement. Further encouraging the interaction, the consultant logged out of the EMR and stepped back before the interaction ended, focusing attention on the interaction itself rather than the information in the EMR. He also posed general questions to the team to give the nursing and paramedical staff an opportunity to speak up, with staff often leaning into the formation to answer the question or point to something. It is not surprising that interaction between the doctors and the other staff increased once this adjustment was made.

As was the case with EMR usage during the first round of observations, the main conversation remained dominant. Side conversations were rare and limited to a sentence or two, with the parties occasionally shifting closer to one another, but not re-orienting themselves. Following the completion of the ward round, however, there were numerous small conversations. As the intensive care pharmacist commented, before the introduction of the EMR she would have reviewed and made changes to drug charts during the ward round. Now she focuses on the team discussion during the round and makes her interventions afterwards. On the one hand, there is a greater concentration on the main discussion, but on the other, less work can be achieved in parallel.

Another significant change was a much more visible use of personal papers or charts by the ward round team. Practitioners had always been provided with paper print-outs with the names and vital information of their patients. In this observation period, most of the ward round team had the paper records at hand and regularly checked them. This differed from personal paper usage during previous observation periods. When the paper medical record was in use, personal papers were mainly for keeping notes. During the first observation of the EMR, papers were usually tucked away in a pocket and taken out only for the occasional reference, if at all.

Queries to several practitioners revealed two possible reasons for these changes. First, many practitioners now do greater preparation before the ward round, making a note of questions or information that will help them follow the round on their print-outs. Second, although paper use was initially discouraged after the introduction of the EMR, its usage was later accepted as beneficial.

5.3.5. Summary

The analysis of the EMR after 1 year showed significant changes in the interaction. The semi-circular formation around the patient's bed and a less constant orientation towards the data seemed to change the dynamic of the interaction. The consultant focused less on the data stepping back from the EMR. The staff responded to discussions more frequently without necessarily requesting the focus of the group. Paper also became more prevalent. There was an increase in communication between the doctors and the nursing and paramedical practitioners. However, on the negative side, what might have happened concurrently before, such as side conversation or drug review by the pharmacist, has to happen sequentially and therefore at another time. This is a finding consistent with other environments in which there is a switch from paper to electronic documents [27].

6. Discussion

We have been concerned in this paper with making visible the role of the body in interaction during multi-disciplinary ward rounds, looking particularly at how this role changes with the move from paper to electronic medical records. To achieve this we have chosen to focus on visible formation patterns and how different disciplinary contributions were impacted. We drew upon observational and video data, supported by broader ethnographic and interview data, primarily emphasising physical rather than verbal aspects of the interaction. In the following sub-section, we reflect more deeply on these issues, highlighting differences seen between the three points of analysis and considering the process of adaptation as a whole.

6.1. Reflections on the data

6.1.1. Differences

If we compare the use of the paper medical record to that of the electronic medical record 4 months after deployment, we see differences in the way that the interaction was carried out. The semi-circular formation around the paper medical records

supported multi-disciplinary interaction by facilitating a non-verbal interaction system that allowed the negotiation of speaker and topic. The double ring around the EMR after 4 months of use did not support a non-verbal interaction system at all. This comparison demonstrates the primacy of formation around artefacts in supporting people, or hindering them, in drawing naturally on their non-verbal interaction mechanisms to negotiate multi-disciplinary interaction. It also illustrates the role of device in influencing interaction by shaping formation.

The above discussion comes from looking at the differences between the paper medical record and its electronic counterpart. There are also interesting differences between the first and second analyses of EMR use. One change of note is the increase in paper usage. Paper seemed to serve as a memory resource for questions and provided basic data necessary for people to follow the discussion. This in itself is not a surprising finding. Saleem et al. [28] explore the persistence of paper alongside electronic medical records and determine 11 reasons for it, including the two we found, memory and awareness. Sellen and Harper [29] also come to a similar conclusion, noting that the introduction of digital systems increases, rather than decreases, the amount of paper used by an organisation.

What is perhaps unusual about this circumstance is that the paper was not for the most part informal. Although we did see personal notes written on the back of a kidney tray, the usage of paper was usually annotated copies of the customised EMR reports that had been created by the lead staff. Rather than paper persisting independently alongside the EMR, it was part of the EMR. Moving beyond its beneficial tangible properties, paper provided a way of extending the data in the EMR to all practitioners to support the ward round. Considering paper as part of the information system may lend some answers to the design of devices and the adaptation possibilities of particular units.

A second noticeable change between the first and second analyses of the EMR is the refocus from data to interaction during the ward round to relieve the problem of data fixation. The EMR gave clinicians much more data to consider, but not more time. A number of the staff noted the tendency to become absorbed in the vast amount of available data. However, the desire to examine the data in more depth often conflicted with collaboratively determining the patient care plan, the purpose of the ward round. In some cases, having the data available in the record also reduced communication and interaction, e.g., previously the consultant might have initiated interaction with the bed nurse to ask for data but its availability within the system no longer required such a conversation. Other times, it was a matter of prioritising activities in the short time. More data, ironically, seemed to discourage multi-disciplinary communication and interaction.

6.1.2.   Adaptations

It is interesting to probe the process of adaptation that led to the changes noted in the previous sub-section, if impossible to explain fully. After the first analysis of the EMR, we presented our results to the lead consultant and a number of the team responsible for the customisation of the EMR, showing them the pictures in Figs. 3 and 5. The group was quite surprised by what they saw. Although there had been complaints of the ward round being longer and more tedious, these had not been attributed to the way the EMR was being used. Interview data would suggest that the changes to the formation seen between the first and second analysis of the EMR came about mainly from the greater self awareness of the lead consultant in response to this research.

Changes made by the lead consultant to his non-verbal interaction mechanisms were likely reflected throughout the team, who had not been told of our results. If the consultant steps away from the EMR, creating space that he can see, it is not surprising in the light of F-formation system theory that those who want to interact with him, move into that space. His non-verbal interactions are more available and therefore others are likely to adjust the formation to take advantage of them. In this case, that space was around the bed and that is where the formation moved to in the second analysis. Interestingly, changes to formation in ward rounds led by other consultants, who did not adjust their EMR usage, did not occur.

It is perhaps not surprising that our analysis showed that the paper medical record, developed and integrated into the ward round over many years, supported a nuanced non-verbal interaction system which could be used to facilitate multi-disciplinary interaction. One might expect that in ten years time the EMR would do the same. However, there are some differences between paper and digital technology, which, if accounted for, are more likely to make such a scenario true. The next section takes a broader view on the reflections of the data in this study, to consider what differences between paper and digital technology need attention in the design process in order for EMRs to support co-present group collaboration.

6.2.   Reflections on electronic medical records

As Gurses and Xiao [30] point out, EMRs have generally been designed for the single user, and we would add, a user who is seated at a desktop with the EMR as the sole focus of his or her attention. However, the mobile environment of a hospital and the collaborative nature of medicine mean that this is often not the case. In this section, we draw out some of the characteristics that could be designed into an EMR that would help it support group, rather than, individual interaction.

One of the differences often noted between paper and electronic medical records is the tangibility of paper, e.g. [11], which provides a resource for people to conduct interaction as well as construction information, e.g. [12]. This study also demonstrates that the tangibility of the paper record facilitated interaction, allowing people to arrange themselves easily and utilise paper as a resource in the interaction. This led to the noted difference that it is important to choose the correct display device. This could mean reflecting on the size and placement of the device or considering the use of mobile devices.

Paper records offer the further advantage that they can be easily developed. If they do not suit an interaction, any paper form can be customised by a healthcare professional, even if this involves no more than making handwritten annotations. Groups of forms can also be created to extend the information system in order to adapt to situations that arise. Such customisation and extension can be done by any healthcare

professional as it does not require any knowledge outside of the medical domain. This however, is not the case with digital technologies. The difference between the paper and electronic medical record is the divide between the user and the creator that occurs in digital technology but not in paper. Practitioner-customisable EMRs start to bridge this divide, but are relatively rare.

The divide between user and creator of the EMR can also discourage reflection and innovation on the part of the user, or healthcare professional. Their lack of knowledge of how the system functions can be off-putting to healthcare professionals who might image better ways of working with it. The adaption process illustrated in this paper showed that knowledge of the system is not necessary to gain more from it. If the reflective practitioner attends to the interaction around the EMR, she or he can facilitate better multidisciplinary interaction. We would suggest that more attention be paid to the use of technology in group scenarios in training sessions in addition to the standard teaching on using the systems functions, such as inputting and viewing data.

6.3.   *Reflection on methods*

This research drew upon a method of analysing non-verbal interaction systems drawn from interaction analysis, F-formation system theory [24] and extended it to also account for interaction around artefacts, in this case the medical record. It offered an embodied lens through which to view multi-disciplinary interaction during hospital ward rounds, producing insightful observations which led to implications for designers as well as users (articulated below) and revealed subtleties in the process of change from a paper medical record to an electronic medical record. In the next several paragraphs we discuss the possible uses of this method.

This method privileges the non-verbal over other areas of interest, such as log-data, artefact analysis, or conversation analysis. We chose the narrow focus in this study to explore the often neglected realm of embodiment. We would suggest that this study demonstrates the benefit of considering embodiment and that this method can add to the repertoire of established qualitative techniques. For example, those analysing the content of interaction may gain from watching their video data with the sound off as well as on. We would also propose, in line with Pentland's work on accurately predicting interaction using body-sensors [31], that observing non-verbal interaction systems might be, in themselves, a rich medium of study. This is an area that requires future research.

This method also complements other ways of considering embodiment in hospital settings. As put forward in the introduction, some research has already pointed out the importance of certain kinds of non-verbal interactions: orientation [16], gesture [15] and object manipulation [11]. These methods are focused in detail on a specific kind of non-verbal interaction. The method put forward in this paper considers a larger granularity, looking at spatial patterning and body movements as seen through formation and extends it in a new way to also account for interactions around medical artefacts. This provides a structure in which to view whether other types of non-verbal interaction are free to happen or are hindered by formation, which influences the possibilities of body-orientation, posture, gesture, and object manipulation.

In this study we observed ward rounds, but this method could also be applied to other hospital situations in which there are co-present groups, such as *ad hoc* meetings and emergency situations. In an adapted form, it may also suit the analysis of the use of embodied interactions in technology-supported remote team meetings. It stands as an additional way to consider hospital collaboration to the several methods presented in the introduction [3,5,6], contributing further breadth to socio-technical methods to be used in hospital settings, as encourage by Berg et al. [4].

7.   Implications for design

Section 6 has teased out what can be understood from the data presented in this study and its more general ramifications. In this section, we translate those findings into a list of five implications for design to be taken into account by designers of EMRs. We might add that these insights are also relevant to healthcare professionals, both during the procurement process, and for understanding the adaptation process to an electronic medical record and what actions might facilitate it.

7.1.   *Consider the social ergonomics of the device*

Section 6 highlights the importance of paying as much attention to the device on which the EMR is presented as the software itself. As Tang and Carpendale [10] have already noted, poor ergonomic design can lead to difficulty manoeuvring it and therefore decreased usage. We would extend this argument to ergonomics of a display device (or system of devices) that does not support a formation amenable to the use of non-verbal interactions, which will hinder usage, and likely, as in the study presented here, impact multi-disciplinary interaction. Device systems need to be assessed in how they affect access to information (visually and physically) as well as the creation of formation and the use of non-verbal interactions.

It can be challenging to address the choice of device within the many constraints of a hospital environment, ranging from space to budget. Large displays for example, raise issues of ergonomics, as well as, patient privacy [13]. Alternatively, mobile devices allow for more freedom to choose an appropriate formation, but may influence the non-verbal interaction system in other ways, such as posture-related awareness issues [33]. If a system of devices is in used, other groupware issues would need to be researched. Awareness of the information the other group members are seeing is likely to be important [8], as is access rights [34]. We highlight these issues to suggest that research attention into collaboration in healthcare environments should include them.

7.2.   *Design the use of paper into the system*

We illustrated how paper had become an integral part of the EMR, allowing adjustments needed to facilitate the multi-disciplinary interaction in the ward round. We would

encourage more systems to consider this as an option. Tang and Carpendale [35] provide one such example, reporting an evaluation of a prototype that allows nurses to fill in an EMR using an Anoto pen on specially printed forms. This particular technology exploits the tangibility of paper, but there are other possibilities. The technology used in this study, for example, was a practitioner-customisable EMR, which allowed practitioners to create reports of data relevant to them and utilise them in their work. The paper than becomes part of the information system rather than persisting alongside it.

7.3.   Pay attention to issues of data fixation

We described the issue of data fixation above and how it can detract from the multi-disciplinary communication by letting data searching dominate the interaction. Although this is not a concrete technical problem, there is much scope for technical solutions. These may include re-designing the summary page so that it can be easily scanned, as might be supported in practitioner-customisable systems, or advances in visualisation techniques. Cabitza et al. [6] also present an interesting solution, making the EMR more of a flow, with directions to choose, rather than static pages. This would likely encourage communication on what data needs to be looked at.

7.4.   Allow for socio-technical solutions

The preceding three implications for design are oriented towards technical choices and advances. Our data suggests that there is also room for social solutions. If practitioners are more aware of the ramifications of their formation, including both spatial needs and its consequence for non-verbal interaction systems, they can proactively experiment and adjust. One easy indicator that an interaction problem needs addressing is a break in the formation. Any medical practitioner can keep an eye on formation without the training required to carry out a full analysis. A more structured approach is through end-user socio-technical design [32].

Practitioners can also adjust their information environment if the technology is practitioner-customisable. They are then empowered to create reports from the data, change the display and capture of data, which gives opportunities to make social adjustments supported by technical features.

7.5.   Tool to think with

F-formation system theory [24] was used in this study as an analysis method, but it can also be used as a tool for designers to think with. First, it can be used to think about the appropriate formation for the interaction that the designers would like to inspire. For example, Kendon notes that formation helps to distinguish between those in a group and those who are not. This is an important attribute of formations in open wards (common in Europe) in which there is no other boundary between the ward round and the other activities on the ward, such as nurses rushing about or technicians carrying scanners. A closed formation, such as a circle, or semi-circle provides a focusing mechanism for the ward round in a place with many stimuli. More open or linear formations will likely lead to distraction or require other mechanisms of focus.

Second, one should consider the sanctity of the formation. In medical environments, people often leave to attend to other urgent duties and rejoin upon their completion – a bay nurse answering the concerns of a junior nurse for example. We described in detail how the dietician solved this problem by standing slightly outside the formation to make leaving easy and leaning into the formation when wanting to engage with the ward round team. This solution worked well within the open format of the ward and the paper record. We have noted examples in a separate publication [30], in which leaving or interacting with the computer requires crossing the interaction space of the formation, which is disruptive. When considering the device, it is important to think not only of the formation, but also how people may leave and enter it.

8.   Conclusions

In this paper we have considered multi-disciplinary collaboration in hospital ward rounds from an embodied perspective. Using F-formation system theory as an analytical base with a particular focus on formation shape and adjustments, we analysed multi-disciplinary interaction of ward round teams using a paper medical record and an EMR at two points after deployment. Our analysis raised three issues that EMRs could address to improve co-present collaboration: including device choice, the role of paper, and data fixation. We also discuss more generally the ways of adapting to the system and the difficulties that digital technology raises over paper because they cannot be easily created by their users.

We emphasise a continued need to consider embodied practices around medical informatics technology. There have been many documented cases of EMRs failing or being underutilised: some point to issues of design, e.g. [36]; others highlight organisational factors, e.g. [37]. As shown in our study and that of Tang and Carpendale [10], the fit of the device to the usage environment is another possible reason that EMRs may fail. This paper presents one way that embodiment, specifically the shape and formation of non-verbal interactions, might be considered to avoid this fate.

Summary points

What was known before the study:

- Collaboration is an important part of part of hospital medicine.
- Understanding collaboration in hospital environments contributes to the design of electronic medical records.

What this study has added to the knowledge base:

- Embodiment, specifically a focus on the non-verbal, adds insight to the design of electronic medical records.
- A significant difference between paper and electronic medical records is the divorce of the user from the creator in the latter.

Author contributions

CM & AB conceived study and participated in data collection. CM analysed the data. CM & GF discussed the data and conceived and wrote the paper. All authors reviewed and revised the final draft.

Competing interest

The authors declare no conflict of interest.

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