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## **Cover Page Footnote**

This project is funded by CFK - Quality Improvement & Public Health, Central Region Denmark. A warm thanks to staff at the ward included in the study, for letting me in and accepting my presence at the ward and the interviewees for dedicating time in a busy work schedule to talk with me.

# Distributed Plot-Making

## Creating overview via paper-based and electronic patient records

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**Abstract.** This paper investigates how physicians create an overview of patient cases through an analysis of physicians' work practices. Based on observation of and interviews with physicians, we analyse what overview means to physicians and how they establish it by using different socio-technical systems (paper-based and electronic patient records). Drawing on the theory of distributed cognition and narrative theory, primarily inspired by the work done within health care by Cheryl Mattingly, we propose that the creation of overview may be conceptualised as 'distributed plot-making'. Distributed cognition focuses on the role of artefacts, humans and their interaction in information processing, while narrative theory focuses on how humans create narratives through plot construction. Hence, the concept of distributed plot-making highlights the distribution of information processing between different social actors and artefacts, as well as the filtering, sorting and ordering of such information into a narrative that is made coherent by a plot. The analysis shows that the characteristics of paper-based and electronic patient records support or hinder the creation of overview in both similar and different ways. In the light of the current move towards electronic patient records, we explore ways in which the benefits of paper records may be carried over into the electronic patient record as well as the ways in which the possibilities afforded by digital artefacts may be exploited more fully than is currently the case.

*Key words:* .

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# 1 Introduction

Hospitals in the Western world have been substituting paper-based artefacts for different electronic devices and information technology systems over the past decades. The electronic patient record (EPR) is one major such IT infrastructure that has been implemented at hospitals. EPRs are more or less comprehensive and may be more or less integrated with other hospital systems. Their development began in the USA in the late 1960s and 1970s where systems were developed locally in various hospitals. The first EPR systems in Europe were developed in the 1980s, Denmark followed in the 1990s, and many European countries and Canada, Australia and New Zealand joined the trend in the 2000s (Berner et al. 2005; Dorda et al. 2008; Greenhalgh et al. 2013). In 1992, Nygren and Henrikson reported that it had been a main aim for more than 20 years to introduce computerised medical records as a central element in hospital information systems, but that the development and implementation of such systems appeared very difficult to achieve (Nygren et al. 1992, p. 1). In 2009, Greenhalgh et al. concluded that failed EPR programmes were still common. EPR systems are generally envisioned as a means supporting the provision of more efficient healthcare services of a higher quality. Their objective is to make healthcare better, safer, cheaper and more integrated; and it was envisioned that lost records and a variety of errors would be nearly eradicated with the introduction of EPR. Greenhalgh et al. (2009) showed, however, that many of the implemented EPRs have difficulties in meeting these expectations. Simultaneously, EPR systems have been proposed as a solution to the need for timely and location-independent access to comprehensive patient data (Hartswood et al. 2003). All these envisioned improvements aim to support clinical work and enhance clinicians' overview of patient information.

The ability to establish a clinical overview over patient information is crucial to clinical staff. Work at hospitals is often conducted under intense time pressure where access to relevant, reliable information is critical. Furthermore, hospital work often embraces various departments, teams and shifts, and physicians have often not seen their patients before; and when repeat encounters do occur, they are typically separated by considerable time intervals. The ability to quickly comprehend and synthesise many pieces of information into an overview is something physicians are trained at and they continuously improve this skill through clinical practice. In hospitals, the need to establish a clinical overview is aided by various artefacts which have been developed over the past hundred years. To physicians, the patient record is the most prominent artefact supporting these efforts, because it holds nearly all patient information relevant to them. The infrastructure of patient records therefore has a significant impact on physicians' clinical work, and the implementation of an EPR will inevitably transform both the contents and organisation of patient records (Berg 1999).

Despite all the good intentions, Hartswood et al. (2003) states that many EPR systems do relatively little to ease clinicians' day-to-day problems. In particular they identify problems in connection to inter-service work and in the important task of negotiating and re-interpreting information. One of the reasons for this could be that the EPR systems fail "to take account of the lived reality of the work in which the information is used" (Hartswood et al. 2003, p. 242). In order to define and design effective systems, a detailed analysis of the activities performed in the work situations involved is necessary. Such analysis should include systematic, comprehen-

sive and critical assessment of practical EPR use and take into account various user experiences (Ellingsen 2003; Nygren et al. 1992). In line with lack of support for the day-to-day problems of clinicians, findings reported within the computer-supported cooperative work (CSCW) tradition suggest that EPR systems generally support secondary use of clinical data; e.g.; administration and research; better than daily clinical work (Greenhalgh et al. 2009).

Given previous problems with the design and implementation of EPR systems supporting physicians in their daily clinical work and their efforts to establish overview in the clinical setting, it seems crucial to investigate how the shift from paper-based patient records to EPRs affects the creation of overview in the daily clinical work setting.

The main aim of the present paper is accordingly to answer the research question:

*How do paper-based patient records and EPRs, respectively, support the creation of clinical overview among physicians, at hospitals?*

The aim of the present paper is not to assess whether the paper-based patient record is superior to the EPR or vice versa in supporting the creation of a clinical overview. Rather, the objective is to highlight both distinct and similar features of the two technologies and to explore how these features support or hinder the establishment of clinical overview. Rather than a straightforward substitution of one medium for another, we see clinical work as undergoing a reconfiguration that introduces new qualities and new risks. New competences are therefore required and old ones become obsolete (Vikkelsø 2005). When implementing systems like EPRs, “we need to take seriously the transformative and not merely the supportive” aspects of EPRs (Ellingsen et al. 2003, p. 92). Thus, we focus on various aspects of creating clinical overview; some apply to both paper-based patient records and EPRs, whereas others are unique to only one of the two systems. The present paper contributes with the concept of distributed plot-making as a way of understanding the creation of clinical overview. Furthermore, it takes an ecological perspective when studying the transition from paper based patient record to EPR which makes it possible to see changes in all of the socio-technical system at hospitals and not only focusing on the patient record.

Data were collected during two rounds of ethnographic fieldwork conducted at a hospital ward before and after the introduction of an EPR. The shift from paper-based patient records to an EPR made it possible to study work routines and processes that would not have been visible under normal conditions as situations of change or breakdown often highlight background assumptions and mechanisms. In both fieldwork rounds, focus was primarily on physicians who are ultimately responsible for the work conducted in hospitals. However, as should be evident from our understanding of the concept of clinical overview, we are aware that the creation of overview is a collaborative and communicative process involving other hospital professions, nurses in particular, but also, for example, laboratory staff and physiotherapists. Conceptually, we propose that the term ‘distributed plot-making’ may serve to theoretically conceptualise what it means to create an overview.

## 2 Related work

Studies focussing on how physicians establish overview are few according to a survey conducted by the authors of articles related to EPRs published in the *International Journal of Medical Informatics*, the *Journal of the American Informatics Association* and related fields such as the *Computer Supported Cooperative Work*. Existing studies explore cognitive aspects of the transition phase following the shift from paper-based patient records to EPRs, and they identify enhanced information access as the greatest advantage of the shift (Berg 1999; Doyle et al. 2012; Holden 2011; Laitinen et al. 2014; Miller and Sim 2004). One fundamental difference between paper-based records and EPRs is that whereas paper-based patient records can only be present at one physical location at any time and may be accessed only by physicians who are at the same physical location, EPRs enable physicians to access information anywhere at any time and to retrieve information more easily (Berg 1999). Further, the information is often more up to date owing to, for example, real-time entry of results. This and the convenience of not having to search for paper records have been shown to increase time efficiency and also awareness of the patient's situation (Doyle et al. 2012; Holden 2011; Laitinen et al. 2014; Miller and Sim 2004).

However, a shift from paper-based patient records to EPRs also carries certain performance disadvantages. Firstly, information can be difficult to find and access for a number of reasons, including information overload and the need to switch back and forth between different systems and numerous screens (Holden 2011; Miller et al. 2009). Early research into the two media also showed that reading from a screen is substantially slower than reading from paper (Nygren et al. 1992). Also, some physicians experienced fragmentation of data which hampered their ability to see trends in patient information (Bansler et al. 2013; Bossen 2006; Holden 2011). Furthermore, some physicians felt barred from using the records the way they were used to, for example, adding personal markings to the record, placing paper sheets in the order of their personal choice, etc. (Holden 2011). In this connection, some studies stress the cognitive importance of data presentation and typographic options and flexibility (Bansler et al. 2013; Miller et al. 2009).

Previous research has shown that paper has features and affordances that are difficult to translate into digital media (Berg and Toussaint 2002; Luff et al. 1992). One important affordance is paper's flexibility (Militello et al. 2014), while structured documentation in EPRs can be perceived as rigid and inflexible (Laitinen et al. 2014). Regarding standardisation, Hartswood et al. state that the "requirements for speed and flexibility in interaction with the record may be at odds with the wider goals for consistency, standardisation, structure and completeness" (2003, p. 244). In line herewith, Lecluijze et al. (2014) state that for information systems to become a success or to be used, it is important to build flexibility into their structure. Flexibility in the paper-based record is expressed in many different ways. Documents in the paper record have different shapes and can easily be marked with different signs and colours. Nygren et al. found that the paper record "can in this way be seen as multi-dimensional, coded in terms of shapes, colours and pictures and structured but not strictly formalized" (1992, p. 2). The different graphical layouts thus provide visual clues as to where the physician will find specific documents in the record. The thickness of the record or the colour of the paper may guide the physician's choice of strategy for information searching (Nygren et al. 1992). Nygren et al. inter-

viewed physicians claiming that they “recognised the patient and her situation just by seeing the paper folder itself from a distance” (1992, p. 7). An interview with system vendors conducted by Miller and Sim found that “designing easy-to-use software for knowledge workers is a challenge that spans the software industry beyond healthcare, and the vendors doubt that any ‘silver bullet’ technology will change this in the near future” (2004, p. 119).

In the following, we will first outline our conceptual understanding of ‘creating overview’ and propose ‘distributed plot-making’ as a conceptual framing for analysis of the process. Second, we will conduct an analysis of the features of paper-based patient records and EPRs, and investigate how these support the creation of overview. Finally, we discuss the merits and drawbacks of the paper-based patient record and the EPR, respectively.

## 2.1 Distributed plot-making

‘Overview’ is a complex and tricky phenomenon to investigate, and it is conceptually difficult to disentangle and specify. Through previous studies about clinical overview (Bossen & Jensen 2014), we have formulated an understanding of clinical overview that draws on different theoretical approaches outlined below.

Clinicians solving problems and creating overview can be seen as reflexive practitioners as described by Schön (1983). To a considerable extent, this process of reflection builds on scientific knowledge, but its application and use is part of a reflective dialogue with the context, the materials and the special circumstances forming a situation (Schön 1983, p. 133).

In line herewith, Montgomery (2006) labels the process of clinical problem-solving ‘case-based reasoning’ where the physician treats every patient as a unique case in a circular, interpretative and narrative process. Narrative theory within healthcare has been developed mainly by Mattingly (1994). She argues that narratives play a central role in clinical work and that they do not serve only as a retrospective account of past events but also as a form that clinicians and patients impose on clinical time. According to Mattingly, it is not only told stories that have a narrative structure, but also social actions as such. The narrative is created in the clinical setting and it is made on the basis of resources available in that particular setting and tailored to the specific context (Mattingly 1994). In this perspective, medical narratives guide future actions and provide a historical context in which specific actions emerge as the most likely next steps (Mattingly 1994; 1998). Physicians use the narrative to make sense of a patient’s situation, ordering his or her illness history and investigating possible cause-effect relationships within the narrative framework (Bansler et al. 2013). The construction of a narrative is not something added by an outside observer. Rather, it is a significant part of the clinical encounter per se. Physicians have to choose between various fragmented pieces of patient information to create a medical narrative. In the process, they forefront some information and filter out or downplay other information. The physicians try to create a coherent plot that will bring fragments into a meaningful, coherent narrative. As Mattingly puts it: “Most simply, emplotment involves making a configuration in time, creating a whole out of a succession of events” (1994, p 812). She continues by adding that: “This ‘making a whole’ is also making meaning such that we can ask what the point or thought or moral of the story is” (ibid). In the medical narrative, the plot will most often consist of a diagnosis with its causal explanations of relations, possible interventions

and likely outcomes (Mønsted et al. 2011). The medical narrative central to this paper is not a story told by the patient. Instead it is a core narrative of the patient's history authored by the clinicians involved in the patient's treatment as an integrated part of their effort to treat the patient (Bansler et al. 2013). In the words of Bansler et al., the clinician "identifies important 'events', 'signs', and 'symptoms', and arranges them in a certain order to construct a recognizable medical story" (2013, p. 137). Hence, plot-making can be seen as a central element in constructing narratives in clinical work.

The importance of materials and the specifics of the situation were already mentioned in connection with Schön's concept of the reflexive practitioner. This is investigated in more detail by Hollan et al. (2000). Referring to the theory of distributed cognition, they argue that cognition is not only a mental activity, but is distributed across various artefacts and through social organisation. Unlike traditional theories on cognition, distributed cognition sees cognition as a process located beyond the individual. Distributed cognition hence includes interaction between people and interaction with different resources and materials. The central unit of analysis is the functional system or the socio-technical system which is a collection of individuals and artefacts, including all the relations between these individuals and artefacts as they emerge when working out cognitive challenges (Hollan et al. 2000; Rogers et al. 1994). In distributed cognition, focus is on the way in which information is transmitted between team members in the functional system, and how knowledge is produced and transformed through and across these artefacts when information is processed (Rogers et al. 1994). The importance of the socio-material dimension, for example, is made clear by how people may solve problems either solely in the brain through internalised language or rules, or by the use of material space (Kirsch 1995): for example, calculating a proportion like two thirds of three fourths may be done by following mathematical rules or by folding a piece of paper (Lave 1988).

Based on the above theories and empirical data, we see clinicians as reflexive practitioners engaged in case-based reasoning when creating overview. Overview is created by finding plots or diagnoses highlighting some items of information and backgrounding others. Work materials and artefacts are part of this process and together with the clinicians they comprise a socio-technical, distributed cognitive system that performs computations or processes information. A shift in working materials will most likely affect the overall cognitive process, just as a shift in clinicians' reasoning will most likely cause a redesign of the artefacts involved. According to this approach, creating an overview has at least two central features. First, it involves case-based reasoning in which the medical narratives are held together by plots. The creation of overview makes sense by taking the form of a narrative, most often emplotted by a diagnosis, even if tentatively. Second, it involves a sociotechnical or functional system of distributed actors and artefacts transmitting and computing information in the creation of clinical overview. To conceptually pinpoint physicians' creation of overview and incorporate both features, we propose the term 'distributed plot-making'. In this view, the creation of clinical overview is a complex, reflective and narrative process in which organisational structures, work procedures, social relations and different artefacts contribute to the processing or computation and must be aligned in order for the plot-making to proceed smoothly.

This conceptualisation of the creation of clinical overview is to be seen as a general understanding of the process. The concept is independent of the artefacts employed by the physicians,

and it can thus be used in the analysis of clinical overview regardless of which socio-technical system (paper-based or electronic) is part of the process.

### 3 Research setting and methods

The present study adopts a science-technology-society (STS) approach. In an STS analysis, the understanding of technology is based on people's social, everyday and mundane handling of technology, and technology and social life are not seen as separate or independent units (Huniche et al. 2014). The intention is not to study technology and practice, but to study technology in practice. Without a detailed understanding of everyday work practices, it is difficult to design IT systems to support these practices. According to Berg, any concrete work practice is fully unfolded in-the-doing and must therefore be studied as a process (Berg 1999). A methodological implication of this position is that a detailed, empirical investigation of technologies in use in everyday life is important.

#### 3.1 Setting

The study was conducted in a university hospital ward specialised in the treatment of liver and bowel diseases. The ward employs 135 clinical staff, including 24 physicians, and has 22 beds and an outpatient clinic with approximately 14,000 annual appointments. The ward was chosen for this study because of the complexity and long patient histories of the patients affiliated with the ward. Since the aim was to study the creation of overview, a complex environment was preferred to ensure that the physicians were challenged in this process.

Before the implementation of the EPR, the physicians and the other professions in the ward used a combination of paper-based and digital artefacts, since some of the information used by the physicians when trying to create an overview had already been digitised. The most frequently used digital artefacts included a module for laboratory test results and a module for patient medication. Diagnostic imaging was also digitised but images were also printed and placed in the paper-based patient record. The paper-based record consisted of a paper sleeve containing loose sheets of paper organised by a number of tabs dividing the record into various parts containing different types of information. The physicians' progress notes was the section most used by the physicians. The progress notes were further structured in different ways, using typography to mark selected parts on, for example, diagnosis, new medication and discharge.

The EPR comprises modules for booking, ordering laboratory tests and receiving test results, prescribing and administering medication, administrating patients and documenting clinical work. The EPR modules are integrated, use the same database and exchange information seamlessly. The module introduced hence replaced all paper-based records, documenting the work of both physicians, nurses, occupational and physiotherapists, midwives, etc. After implementing the new EPR system, the most used section by the physicians was still the progress notes. These notes were now shown in a window labelled 'Read record'.

## **3.2 Data collection**

To study the complex process involved in creating clinical overview, we were inspired by ethnographic fieldwork. Fieldwork is particularly well suited for the study of everyday activities and interactions in their context. Often it is possible to get people to talk about what they are doing but difficult for them to articulate how they are doing things. To meet this challenge, we conducted a combination of observations and interviews with physicians at a medical ward.

The first round of data collection was performed in the year leading up to the implementation of the EPR. The second round of data collection started 6 months after the implementation of the EPR and ran for 4 months. The majority of data was generated through field observations and interviews.. Field observations are well suited for the study of everyday activities in a given context (Bourgeault et al. 2010; Hammersley and Atkinson 1995; Roth et al. 2004), whereas interviews can provide insight into things that cannot be easily observed. For example, some aspects of decision-making and clinical reasoning may be easier to describe than to observe (Holden 2011).

The first author observed the participants for around 95 hours during 20 days, following the physicians around and observing their work. All observations were conducted in the morning or in the afternoon. Observations focused on the physicians' actions and interactions with other staff and artefacts in order to identify situations where a sense of overview was important and then to determine how overview was created and which factors obstructed or supported this process. The researcher sought to be as nonintrusive as possible so as to reduce the disturbance generated by her presence, but when necessary and appropriate clarifying questions were asked and short informal interviews were conducted. Field notes were taken to capture actions, both vocal and non-vocal. In line with the ethnographic tradition, the researcher kept the scope of the notes wide, and the notion of thick description guided the way data were recorded (Clifford 1990). Following each period of observation, field notes were transcribed and entered into Nvivo, a piece of software for indexing and analysing qualitative data. An interpretive process took place during the observations, where the researcher and the physicians collaborated on the interpretation. Likewise, the field notes were examined throughout the observation period to identify relevant and interesting themes and topics. This approach made it possible to study the identified themes more carefully in subsequent observations.

In addition, 13 interviews with physicians were conducted by the first author to get more in-depth information about the way physicians understand the concept of clinical overview, their thoughts about creating a clinical overview and their understanding of the underlying cognitive processes. To initiate conversation about issues that can be difficult to articulate, the researcher would provide examples from the observation study, thus giving the researcher and the physician some specific situations to discuss and on which to elaborate. Four of the physicians were interviewed twice, once before the implementation of the EPR and once after its implementation. The main inclusion criterion for the selection of interviewees was diversity of medical experience. The interviewees included six males and three females whose experience at the ward ranged from 6 months to 20 years. All interviews lasted approx. 60 minutes and were recorded and subsequently transcribed verbatim and entered into Nvivo.

The researcher's presence at the ward might in some way have affected the physicians and their way of looking upon and talking about their work. The researcher tried not to disturb the

physicians in their work, but as the physicians were aware of the scope of the study they are likely to have paid more attention to work performance and aspects of creating clinical overview than normally.

### 3.3 Analysis

The analysis was inspired by grounded theory which means that codes and themes are developed inductively from the data material *in vivo* (Kvale and Brinkmann 2009). The concept of ‘*in vivo* codes’ is used in grounded theory to refer to the notion that data should be coded as closely as possible to the empirical material, taking words and sentences directly from the material. The codes that emerged in the first process of analysis in the present study were not actually *in vivo* codes, but they were based heavily on the empirical material. The analysis process in many ways followed what Coffey and Atkinson have named ‘the coding and retrieving strategy’ (Coffey and Atkinson 1996).

Even though the aim of this study is not to produce conclusions that are valid for all EPRs, for which reason the findings may not be truly generalisable, they are, nevertheless, probably transferable. The aim of this study is not to identify all consequences relating to the implementation of an EPR in a hospital; instead, we focus on how features of a paper-based patient record and an EPR, respectively, support the creation of clinical overview among physicians. This means that multiple consequences and effects following the implementation of the EPR are left untouched by the present analysis, whereas the topic of overview is studied in detail.

The coding was conducted trying to identify drawbacks and benefits associated with creating clinical overview using an EPR and a paper-based patient record, respectively. A total of 13 themes emerged covering issues that were important for the physicians to create overview. Most themes were constructed by more than one code, and in some instances incorporated both drawbacks and benefits related to the two artefacts. The themes were organised under four headlines reflecting that 1) some aspects of creating clinical overview are more or less the same for both types of records, while 2) other aspects are decisive for both artefacts, but are performed differently in each; and yet 3) other aspects are specific to the paper-based patient record; and, finally, 4) some aspects are specific to the EPR. The following section presents the findings under the four headlines presented above.

## 4 Results

The following sections outline the findings concerning the paper-based patient record and the ability of the EPR to support the creation of clinical overview. As mentioned above, the findings are presented under four headlines which each compile attributes of the two artefacts with a decisive impact on the creation of clinical overview.

## 4.1 Enduring elements of achieving an overview

**Dialogue.** Dialogue and conversations with colleagues and patients are central to the creation of clinical overview when using paper-based records as well as EPRs, and the change in media does not change the contents of the dialogue. The physicians discuss specific patients, diagnoses, the interpretation of test results and treatment plans, and they do quick and sketchy audits of patients. These conversations can take place anywhere inside or outside the ward and are often not planned beforehand. More organised and thorough conversations about patients typically take place at the daily conferences. The physicians often talk about symptoms and illness histories with the patients. Hence, conversations are pivotal in arriving at meaningful narratives and in determining a suitable plot. Physicians and their colleagues are central elements in the distributed socio-technical system that transports, transforms and computes information through conversation.

Both the paper-based patient record and the EPR facilitate dialogue between physicians and their colleagues by providing information. However, the EPR has the advantage of supporting dialogue between colleagues who are not co-located, provided they all have access to the same EPR.

**Notes on paper.** Personal notes on paper also remain central to the creation of a clinical overview. The personal notes are written on a piece of paper or in a notebook and are for personal use only. They are not saved or entered into the official patient record. Nothing in the observations or interviews conducted for this study indicates that the use of personal notes changed following the implementation of the EPR. In the interviews, all the physicians confirmed that they still rely on personal notes to create overview.

The physicians' notes on paper also make information portable and enable the movement of information between more or less fixed objects such as, for example, the computer and the patient. The fact that the notes play a central role in the creation of clinical overview is obvious from the quotation below, expressed by a physician after the implementation of the EPR:

It has many functions [paper notes]. Its primary function is that together with the information already printed on it and the information I have updated from the EPR, then I know what kind of patient he is; what kind of patient I'm about to see. That I have an exact overview of the patient I'm responsible for. What's wrong with him? Which tests have been conducted? Which examinations await an answer? Then I have written down on the paper the answers from x-ray, from blood test, from stool samples, from everything he has attended. There is also a treatment plan, which I have updated myself. When I talk to the patient, I write this information down as well. (Female physician, 4 years of experience in the ward).

It seems as if the first coherent narrative about the patient is produced on these personal notes where the information starts to gather around a potential plot that sometimes has competing plots. The notes, then, serve as an initial version of the narrative which is created before the official version later entered into the patient record.

The paper notes are multifunctional and flexible and, therefore, probably difficult to replace. At any rate, the EPR did not appear to have a function or form that would allow it to replace the

notes. Presently, the physicians need the personal notes on paper to create an overview regardless of which record they use in their daily clinical work.

## 4.2 Specific material characteristics: The paper-based patient record

There are many substantial differences between paper used as a material for information processing and the use of an IT-based system. This section will discuss the special characteristics of the paper-based record in relation to the creation of clinical overview. These characteristics were not transformed or transferred to the EPR.

**Personal markings.** In connection with the creation of clinical overview, several of the physicians mentioned that making personal markings in the record was a valuable resource for them. So far, this option is only available with paper-based records, and some of the physicians missed this option once the EPR had been implemented. When going through a paper-based record in order to create overview of a specific patient case, the physicians could mark specific pages if they wanted to return to them later, or if they wanted to remember sections or highlight them for colleagues. In this way, physicians could go through a large amount of information marking what seemed important and relevant and subsequently extract this information while they were creating a clinical overview. In a sense, they could make their own collections of information. As with the different typographical options, these personal markings in the record function as a support for the identification of critical information.

**Paper's physical presence.** When the staff at the ward used the paper-based record, some test results and diagnostic imaging descriptions were printed when ready and, as described earlier, sent from department to department or from hospital to hospital. When these new paper sheets reached the ward, they were placed on the cover of the record visible to the first physician who would handle the case.

In connection with the creation of clinical overview, the paper sheets on the cover of the paper-based records served as a reminder of test results the physicians were awaiting. When using the EPR, the physicians received no notification when a description of, for example, a CT was available, which meant that they had to actively look for it in the system, and they had to remember that it was necessary to look for it.

## 4.3 Specific material characteristics: the EPR

Like paper, the EPR has special characteristics distinguishing it from the paper-based records. The special characteristics emphasised here are the ones that have significance for the creation of clinical overview.

**Access to data and information.** Following implementation of the EPR, the physicians now had access to patient information and patient records from other departments in the hospital and from other hospitals in the region. Almost all of the physicians in the study emphasised this

as a considerable advantage. The physicians felt that they were up to date and had an overview of the patients' contacts in the healthcare system. One physician described this as being able to 'keep pace' with the patient. During a conversation in one of the observations, a physician brought up one of his patients:

This patient is also treated [for a different disease] at another hospital and the physician says that he thinks that there are a lot of challenges in connection with coordinating these kinds of parallel treatments. He emphasises that it is at huge help now with the EPR, which makes it possible to access new contents in the patient record immediately after the other hospital has entered it. (Male physician, 16 years of experience in the ward)

Almost all information about a patient is present in the EPR, including nurses' documentation and notes. Many of the hospital's vital IT systems are integrated with the EPR, and the physicians appreciated not having to open each system separately. The physicians emphasised that the process of creating overview of a patient case was facilitated by such easy access to large amounts of information. One physician explained:

Well, we have the record or previous progress notes to proceed from. We have test results. We have the nurses' measured values from today. And all of it just enters the record when answers are available. So we have everything together. (Female physician, six months of experience in the ward)

When creating an overview or a case-based narrative, easy access to information will often support the creation of a more coherent narrative. On the other hand, during an interview one of the physicians mentioned the problem of information overload. If a patient had been treated in many different departments, there would be much information in the record which would make it difficult to find the relevant pieces of information.

**Search function.** The search function in the EPR is used by some of the physicians when trying to create overview of patient cases. Most of the physicians found it easy and quick to use, and it would search only through the physicians' progress notes, not the other parts of the record. So, instead of going through many pages in the paper-based record, they could now click their way through different links provided as search results. Most of the time they found that the suggested links were relevant, and it was easy to skip past the links that were not. A couple of the physicians disagreed on this view and instead accentuated the experience of getting many hits, some of which would be irrelevant, when searching through the records, and they stated that going through these links interrupted their reading experience. These physicians were not frequent users of the search function.

One physician explained the usefulness of the search function, when information was not always documented in separate locations:

It is also possible to see if you have ever been exposed to an endoscopy even though it has not been recorded anywhere else than in the progress notes. You simply search for endoscopy [in the progress notes] and the system goes right back to 2011. It truly is a useful search function. (Male physician, 3 years of experience in the ward)

The search function is a special element of the distributed socio-technical system which is very different from the paper-based patient record and in many ways points to a new way of creating overview or establishing a plot. By using the search function, the physicians are targeting specific pieces of information in their creation of overview instead of going through a chronological text about the patient's conditions. They are using the record as a database of information or as a collection of information, instead of understanding it as chronological, progressive narrative about the patient.

**Graphic overview.** The option to visualise various test results through graphic presentations in the EPR was valued by the physicians. For example, this is done for infections counts, vitamin levels and blood tests, which are presented in timeline graphs. In the process of creating overview, the graphic presentations were perceived as very intuitive and were considered a quick way to juxtapose various items of information. Like with the typographical options and the personal markings in the paper-based record, these graphic options help the physicians create overview by highlighting important information.

**Clicks at the computer.** Some, though not all, of the physicians at the ward talked about the issue of 'clicking' in the EPR. They found that they had to click many times to get to the information they were looking for and that they needed to go through many layers before reaching relevant information. In order to compile all the information needed to obtain clinical overview, they felt that they had to open and close many windows on the computer screen which was perceived as delay. Every time the physicians made a click in the EPR, it would take a couple of seconds before the new screenshot was available. This delay gave them a sense of being interrupted in their lines of thought. One physician said:

Well, I press 'Approve'. Then time passes, it's not a long time, perhaps two-five seconds, perhaps five seconds is realistic, you know. And .... well that's not a long time, but it's enough for you to stray from your line of thought. When you are in the middle of something. (Male physician, 20 years of experience in the ward)

Some of the physicians perceived creating overview in the paper-based patient record as a more natural flow where the physical artefact, the record, follows the physician's cognitive process.

#### 4.4 Critical differences in the use of central record properties

As mentioned above, changes in the physicians' conditions for creating a clinical overview occurred after the implementation of the EPR. Some were caused by paper and IT systems having specific, different features, while others occurred because features were changed while changing media. Features or conditions described in the following section are features which are both critical while using the paper-based patient record and the EPR, but the change in media changed the way the features were performed or the way the conditions were handled.

**Multiple views.** Observations made clear that surveying several sources of information simultaneously while trying to establish clinical overview is a common work routine. In order to create a coherent narrative, it is very helpful to be able to juxtapose different information sources in order to analyse information in relevant contexts. This is, for example, done when the physician

accesses the patient's test results and progress notes at the same time. Before implementing the EPR, the ward stored data on patients' test results and medicine electronically which gave the physician an opportunity to view, for example, test results and medicine on the computer screen while consulting the patient's progress notes in the paper record. In addition, having information on paper allowed them to place several sheets next to each other. In this way, they could have more than two screenshots open at the same time. The following is an example of a typical situation from the observations before the implementation of the EPR:

The physician enters the office at the intensive care unit to talk to the intensive care physician about the patient. They find the patient's paper record and open the progress notes. At the same time, they open the patient's test results and medicine chart on the computer screen. The two physicians are sitting next to each other with the progress notes between them and the computer screen in front of them. (Male physician, 8 years of experience in the ward)

An EPR can also show more than one screen display at a time. However, the computers used at this ward only had a small screen, and our analysis showed that this seemed to be an obstacle to fulfilling the true potential of having multiple screens open simultaneously. If a physician opened more than two windows at the same time on one screen, the text became too small to read. Typically, physicians opened a patient's progress notes and then switched between, for example, test results and medicine.

When using the EPR, it is possible to access a considerable amount of information on a single computer screen, but the area of the screen is often limited which reduces the EPR's potential for supporting the creation of clinical overview. When using paper sheets and a desk, for example, it is possible to spread many sheets of paper across the desk without altering their readability. Having more than one screen connected to the computer can support this feature in a similar way, and this was sometimes done by the physicians.

**Access to the record.** One of the most fundamental changes caused by the shift from a paper-based patient record to an EPR is that the physicians' access to the patient record is enhanced. A fundamental property of paper is that it cannot be present in more than one place at any time. The advantage of this physical limitation is access control, whereas the obvious drawback is that access is provided only if the record can be located and is not being used by someone else. Observations before implementing the EPR showed that during their shift, almost all of the physicians spent time looking for a specific record at least once during each shift. This process sometimes obstructed or delayed the creation of clinical overview or forced the physicians to make decisions without taking into consideration the information that was available in the record.

With the EPR, the physicians no longer had to search for the physical patient record because access to any computer allowed them to consult the entire patient record. This often made the process of getting access to the patient record and initiating or continuing the creation of clinical overview less problematic than with a paper-based record. The only thing that can limit access to the EPR is the availability of computers.

A physician expressed it this way:

The main thing is that no one has to look for the records any more. ... You don't have to get the records out anymore. You can sit at home and read it. Two people can sit in different locations and read it at the same time. This is a big difference. It really is. (Male physician, 20 years of experience in the ward)

Access to the record and to information in the record is critical when trying to create overview, a narrative or a meaningful plot on the best possible foundation; and easy access to information is a quality inherent to the EPR, provided it does not suffer from breakdowns or slow response times.

**Order and disorder in the records.** Order within the records is an essential prerequisite when physicians need to find certain information and create overview. One physician stated it as follows:

If everything is in the right place [in the paper-based records], then I will be able to form a rather comprehensive overview over this patient in 5 minutes, without knowing him beforehand. That's not so bad. (Male physician, 16 years of experience in the ward)

The problem is that the sheets of information were not always in the right place in the paper-based records. As opposed to the EPR where information stays in the same place, sheets of paper and hence information can get mixed up in a paper-based record. The physicians described how they sometimes had to go through the entire record to find one piece of paper. There is no search function in the paper-based records helping the physicians drill down to any item of information. One physician described this issue as follows:

They are placed all kinds of mysterious places in the [paper-based] record. Finding an ECG or similar is sometimes difficult. They have fixed locations in the record, but they are often placed somewhere mysterious, so you can't find them. (Female physician, 3 years of experience in the ward)

In EPRs, information stays in place once entered and the EPR's order is fixed. Provided that information has been entered correctly and that physicians know the EPR's order, finding information is easier, hence supporting the creation of overview.

**An updated record.** Another important element in the creation of clinical overview, which is closely related to the topic of order/disorder, is the extent to which information is updated. One physician talked about the importance of making sure the records were updated. He said:

Well, to create an overview of what is going to happen, it's actually absolutely crucial that you have updated material in the record. From my point of view that is what defines whether or not you have an overview. And when I say updated—well, then I mean all of it, all the stuff that belongs to a record. (Male physician, 16 years of experience in the ward)

The observations reveal numerous instances of failure to update the material placed in the paper-based records, from the physicians' progress notes to test results and x-ray descriptions. The physicians were highly aware of this issue; and this was a focus area at the ward in the period when paper-based records were used:

You could say that we have really made an effort to ensure that things are present in the record. And actually, it's at constant struggle. (Male physician, 20 years of experience in the ward)

In contrast, the physicians emphasised their belief that the EPR would almost always be updated. Once information had been registered in the record, the physicians could access this information. Paper sheets did not have to travel between departments or from the secretary to the record. Several of the physicians expressed that descriptions of x-rays and imaging tests, microbiology test results, etc. became accessible much faster with the EPR than with the paper-based records. In this way, an updated patient record may serve to provide overview based on the most recent information.

**Typography.** Some of the physicians indicated that a lack of typographic options in the EPR constituted a considerable obstacle to the creation of clinical overview. The problem mainly concerned the physicians' progress notes. In the paper-based records, the secretaries would highlight text and place the text in a number of standard locations by making insertions, right positioning and bolding text, etc. Typically, information such as the start and the end of admission, operation description, admission history, medication, decision-making, etc. was marked in different ways in the paper-based records. These types of typographic conventions made it easy for the physicians to find specific items of information because they could focus on one typographic characteristic when looking, for example, for a change in the patient's medication. In the EPR, the typographic options were limited. Some of the physicians felt that all of the text in the EPR progress notes was blurry. One physician expressed the loss of typography in this way:

But it will be changed in a future update of the system, so we will be able to use a small amount of the typography we had at our disposal in the paper record. But it is a huge loss when you go through the record. (Male physician, 20 years of experience in the ward)

Some of the physicians did not mention the lack of typography in the EPR as a problem, and they found it rather easy to find information in the EPR. The same physicians would often use the search function in the EPR, which points to a shift in the methods used for seeking and finding information.

In an information-intensive environment like a hospital, it is important to provide support allowing users to easily locate critical information. However small these typographic options may seem, they are a very important part of the distributed socio-technical system that assists the physicians and allows them to make sense of the vast amount of information they use. Presently, it seems as if paper possesses higher flexibility, allowing for more typographic variation and thus supporting the localisation of information in the overview process better than the EPR.

## 4.5 Summary of results

The two different socio-technical systems set the scene differently for the creation of clinical overview. Dialogue with colleagues and patients is central in the creation of clinical overview and so are the personal notes on paper which bring together important information and act as portable artefacts transporting information from one place to another. These two central ele-

ments in the overview process seem more or less untouched by the transition from paper-based patient record to EPR, and the two media support these elements in almost the same way. At present, the EPR has no functionality that can replace the personal paper notes.

The EPR has features which support the creation of clinical overview in other ways than the paper-based patient record. Among the changes that were found to be beneficial were a more promptly updated and well-ordered patient record; information that stayed in place once entered; and greater accessibility to the record and to any information in it. Likewise, the possibility of making graphic data presentations was appreciated by the physicians. Furthermore, the search function in the EPR was emphasised by many physicians as a powerful tool for finding relevant information. These functionalities can all facilitate quick initiation of the overview process and in many instances secure that the overview is based on all available information about the patient.

Likewise, the paper-based patient record has features that support the creation of clinical overview. First of all, the possibility of using a flexible and individual layout with numerous typographical options was appreciated in the overview process. Several of these typographical features which facilitated the physicians' overview of the records were lost in the transition to the EPR. These features had helped the physicians rapidly locate certain items of information. Without these typographical options, navigation and orientation in, for example, the physicians' progress notes became more difficult. Also, the paper-based patient record allowed for personal markings in the text, making filtering and sorting more flexible. All these features supported a flexible and individual way of creating clinical overview. The typographic flexibility also allowed for standard use of typographic characteristics for specific pieces of information on the departmental level, for example, which made it easy to locate this information.

## 5 Discussion

The results from the analysis strengthen several points from previous research (see section 2). With regard to the EPR systems, easy access to the record from multiple locations and an updated record are also in the present analysis pinpointed as big advantages in the creation of clinical overview. On the other hand there is the risk of information overload, fragmentation of information in the record and the cognitive challenge of clicking through the record, which is also identified in the present paper. Some of the previous research also touches on the issue of flexibility in the patient record. The present paper states the issue of flexibility in the patient record as a central element in supporting the creation of clinical overview and in making the use of the patient record smoother. Flexibility is an issue on different levels and in regard to different features in the record.

By studying the socio-technical system as a whole when evaluating the implementation of new technologies in a work practice, the present paper highlights or elaborates some new insights. By studying this socio-technical system, it became clear that some important elements of the creation of clinical overview stayed the same regardless of the media used in the creation process. In this particular case it was the use of dialogue with colleagues and patients and the use of personal notes on paper and the importance of supporting these elements regardless of

which media the physicians use. Likewise, the present analysis shows new features introduced in the creation of overview, like the search function, which in many ways changes the process of creation clinical overview. The analysis also shows the important, and in a way, very physical task of juxtaposing information from different places in the record. As described in the present paper, this task is in the EPR very much dependent on physical conditions like the size and amount of computer screens. This points to a very practical issue in the use of EPRs: the limitation of physical space defined by the computer screen.

Our analysis demonstrates how the two socio-technical systems frame and condition the creation of overview in different ways. Plot-making is accordingly achieved differently in the two systems. In both systems, the sorting, filtering and reordering of information is done via multiple features, artefacts, work routines and organisation of work.

To understand the process of creating clinical overview and why the artefacts involved in this process are so important, we suggested that physicians' process of creating overview may be conceptualised as distributed plot-making. This concept points at both the narrative and the socially and the materially distributed elements involved in the process. This conceptualisation also implies that since the socio-technical system is part of the process of creating overview and computes information, it is important to pay attention to the overall system as well as to its specific elements. Changes in the system or changes of single elements will create minor or major changes in the overall system and the process of creating clinical overview. The narrative element in the concept of distributed plot-making is important to remember, when trying to support the creation of clinical overview among physicians. It is important that information does not lose its context completely and become too fragmented. An EPR system should be able to both support the extraction of information and allow the physicians to read a more chronological narrative about the patient. Many of the physicians from the present study prefer to read, in more or less details, a chronological narrative about the patient. It is therefore important not only to understand an EPR system as a database containing information about the patients, but also to see it as a place where the physicians are able to read stories about their patients.

One important feature supporting the creation of clinical overview is visual points of reference, because they help the physicians identify relevant and important information and hence allow them to identify relevant elements in an emerging plot. As for now, it seems as if the paper-based patient record does a better job of providing these visual reference points than does the EPR. For example, physicians complain that the text in the 'Read Record' (the physicians' progress notes in the EPR) is blurry and lacks typographical mark-up which makes it difficult to identify and remember relevant information. This is in line with research into the difference between reading on paper and on digital media: Paper possesses a different tangibility than text presented on digital media (Mangen 2014; Nygren et al. 1992). A person scrolling through a text on a digital medium runs the risk of imposing spatial instability on the text which has a negative impact on the reader's perception of the text. This impairs the reader's ability to spatially locate information in a text which is significant to understanding and retrieving information from the text. Text on paper is fixed and does not move around, which makes it easier spatially to remember where a piece of information is located (Mangen et al. 2013; Nygren et al. 1992). Hence, a lack of proper support for remembering, navigating and locating between certain items of information makes the process of creating overview more difficult with digital than with paper-based texts (Mangen et al. 2013). Likewise, the typographical flexibility offered by paper

facilitates effective strategies for the creation of overview (Berg 1999) and provide a wide range of visual reference points. Given the need for visual reference points in the creation of clinical overview, it is important to recognise that the need for typographical mark-up and flexibility is probably even more pertinent when presenting information on digital media than on paper because of the special spatial properties of text presented in digital media. It might be beneficial to introduce an equivalent to pages in the EPR or another kind of physical location of information, which makes it easier to locate information, to remember where it is located and to return to the information.

Even though creating clinical overview is understood as distributed plot-making it is a cognitive process that takes place in a distributed socio-technical system in which the patient record holds a central position. It seems as if the EPR sometimes interrupts this process by replacing the possibility to flick through the different pages by lots of clicking around between the different links and screens of the EPR. The latter is found by some physicians to distract their cognitive process. This observation is in line with Miller et al. (2009) who argue that clicking through screens to get to relevant information will overload the user's short-term memory. Hence, some of the advantages of compiling information into a single IT system are lost if the shift entails that the user has to go through too many screens (Miller et al. 2009). Similarly, Mangen et al. (2013) found that the dual task of clicking or shifting between two or more screens on the same computer screen increases the cognitive challenge posed on the reader (Mangen et al. 2013). So when adopting a practical micro-perspective on the availability of information, the EPR may be challenging for users because it interrupts the interpretative and narrative process of creating overview. Several of the physicians wished for a more direct access to often used information and even better if they could select which information to access directly themselves.

In an EPR, information can be stored and retrieved in a way different from what is possible in a paper-based record. One example of this was a group of physicians who had already changed their way of reading the progress notes. They made much use of the search function in 'Read Record' and, hence, based on these searches accessed sections from different parts of the chronological text. If one sees the EPR as a database as opposed to a chronological text about the patient, there are numerous different options for retrieving information about patients. Retrieving information by means of a search function gives the physicians the opportunity to sort information according to specific topics, and thereby to filter the information they need according to relevance. This helps focus the overview process, zooming in on different possible plots and thereby facilitating information retrieval for a specific narrative. On the other hand, not using the search function and instead going through pages of information looking for specific pieces of information could make the physician stumble on other facts that may support or contradict the plot he or she is trying to create for the narrative (Nygren et al. 1992). Once again, it is apparent that changes in the distributed socio-technical system which might seem small when you take a first look at the systems may potentially have considerable impact on the interpretation and computation of information in the unified system.

One of the greatest changes from the paper-based patient record to the EPR is surely access to the record and access to information in the record. This easy access to patient information in many ways supports the process of creating overview in daily clinical practice by making more information available more rapidly. At the same time it also presupposes the ability on the part

of the user to develop new competencies that allow him or her to handle all this information in a meaningful manner.

Dialogue between physicians is a central element in creating overview. Often such dialogue takes place face to face; and since verbal communication is often more contextual and nuanced than written communication (Svenningsen 2004) it helps physicians to arrive at some shared sense of what the meaning of the information actually is (Hartswood et al. 2003), this is an important part of creating overview and establishing a context-sensitive narrative. Hence, it is important to support dialogue between physicians, regardless of the media with which they are working, but also to support dialogue by the way work is organised. While the patient record provides information about patients, it requires dialogue to draw on the experiences of others, compare with other cases, draw attention to the discussion from the morning conference and so on. That said, the EPR does provide for updated and immediately propagated information across locations and, hence, better supports non-colocated dialogue between physicians who may discuss patient cases on the basis of the same material, since information can be shared and a common interpretation be established.

Physicians' personal paper notes remain central to creating overview for two possible reasons. The use of paper and pen provides for flexible and individual annotations and storage of information without the limitations of a fixed template, and it can thus be adapted by each physician in a particular work situation to fit any patient. In line herewith, Perry and Wears (2012) draw attention to the centrality of the physicians' personal paper notes and introduce the term 'shadow charts' or 'ad hoc artefacts'. Such flexibility and individualised use seem difficult to accommodate in EPRs and their screens and keyboards. Similarly, Heath and Luff point to the importance of micro-mobility, which concerns "the way in which an artefact can be mobilised and manipulated for various purposes around a relatively circumscribed, or 'at hand', domain" (1992, p. 306). Such micro-mobility contributes to making information accessible when it is necessary and relevant (Randell et al. 2010). The personal paper notes are important in making essential information more accessible where and when the physicians need it. The flexibility of the personal notes also allows the physicians to compile the first preliminary narrative about the patient and his or hers condition in a personal and flexible format that does not follow any predefined template or structure in the patient record. In this manner, physicians can gather important information and try out different possible narratives constructed around various plots. So it seems as if personal notes which are not going to be part of the patient record are critical in the physicians' work. For these notes to be usable, they should be flexible and easy to use whether they are digital or on paper.

## 6 Conclusion

One overall conclusion of the present study is that taking a more ecological approach to the development, design and implementation of EPRs has considerable potential. Hence, when developing and designing the systems, it is important to pay attention to the overall socio-technical system of which they are going to be part. If too much attention is invested in a particular interface design or in the system as an isolated artefact solving delimited and narrowly defined

tasks, the socio-technical system as a whole and the process-related character of work practices in hospitals are lost; and as a consequence, all relevant practices may not be supported properly. The case in this paper emphasises two important elements of the overview process existing outside the EPR as a system that could advantageously be thought of as belonging to the same socio-technical system, namely dialogue between physicians and the physician's individual notes on paper. The concept of distributed plot-making highlights the socio-material aspects of creating overview. Creating overview is not only a matter of brains computing data, but a question of interpreting, handling and placing pieces of information within and across artefacts. Therefore, the ability to visually provide points of reference and order, as well as support for sharing, moving and combining features are important.

Furthermore, flexibility is a key word when designing EPRs. The need for flexibility is evident at several levels. If the EPR system is to play a central role in multiple processes and in various parts of the socio-technical system, it would probably be beneficial for it to work on different platforms, including PCs, large displays, tablets, smart phones, etc. This would make the use of the EPR system much more flexible. Typographical flexibility in the record similarly seems to be a decisive factor in supporting physicians trying to locate the information they are searching for. The available typographies and flexibility of use may seem as a minor detail when creating EPRs, but visual fix points are important, especially when creating documents with large amounts of text, as for example the physician's progress notes. It could also be beneficial to think of flexibility at an even more individual level. For example, some of the physicians miss an opportunity to insert personal markings in the record; e.g.; to mark-up certain pages, underline parts of a text or highlight important events in the patient's history. It might therefore be interesting to introduce a personal profile in the record, allowing any physician to mark up the record as he or she preferred in such a manner that markings would not be visible for other physicians as they would be stored to the personal profile of a specific physician only.

As shown in the present analysis of the features of a paper-based patient record and an EPR, both systems have merits and drawbacks and for starters we wish to suggest approaching the differences and similarities as a question of reconfiguration. Even though the main advantage of the EPR is updated information that is available at multiple places simultaneously, it is evident that paper has affordances that are difficult to translate into the digital format. We have suggested that the creation of overview may be conceptualised as distributed plot-making; and we aim to further elaborate on this concept and hope that it will prove beneficial to other analyses of the crucial physician task of creating overview, but also to other health care professionals. We hope the present paper will facilitate a discussion of overview that may inform the evaluation and design of future EPRs.

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