Abstract

HCI does not have well developed theoretical underpinnings to capture how different parts of a sociotechnical system impact medical device design and use. We report an issue that was identified during an ethnographic study of infusion pump use on a haematology ward: the frequency of the alarms caused frustration to staff and patients. Staff understood this to be a device design problem outside their control – a manufacturing issue. It is actually configured this way by the hospital – a device management issue. This misattribution impacts corrective action, and the quality and safety of patient care. We highlight three theoretical areas that could provide leverage for understanding issues such as this.

Author Keywords
Medical device, reaching out, meso-ergonomics, distributed cognition.

Introduction

In Nick Park’s 1993 animation, *The Wrong Trousers*, Wallace and Gromit are thrown into chaos as their techno-trousers are configured wrongly and the culprit behind this mess evades detection because he could not be correctly identified (i.e. the penguin was dressed as a chicken). During an ethnographic study of infusion pump design and use we also witnessed users stuck
with the wrong technology (i.e. alarm configuration issues), and the problem evaded corrective action because the root cause had not been properly identified (i.e. it is a management issue rather than a manufacturer issue).

This paper is not only about recognizing issues with devices, but also recognizing which part of the larger sociotechnical system is best placed to take corrective action. We highlight some areas that could provide theoretical underpinnings for such issues.

The Issue: The Nuisance of the Pre-Alarm
We investigated infusion pump design and use issues on a haematology ward. On the ward, each patient had their own room for infection control reasons. Nurses would wash their hands, put on disposable gloves and an apron and even a mask on entering the patient’s room, and wash their hands on leaving it, all depending on the patient’s condition. So there is a relatively high cost in terms of time and effort for accessing patients’ rooms.

Early on in the study, both patients and staff voiced concerns over the frequency of the infusion pumps’ alarms. The pumps had a 10 minute pre-alarm, so 10 minutes before the end of the infusion the alarm would sound. This was intended to give the nurse warning to prepare for the end of the infusion. Generally, the pump would sound next to the patient: it would not be heard by the nurses outside the room so the patient would press their call button, the nurse would stop what they were doing to attend to the patient, the nurse would go through the cleaning procedures to enter the patient’s room, and they would silence the alarm. They could not just wait there for 10 minutes so they would leave and come back when it started alarming again at the end of the infusion.

The patients were frustrated by this seemingly needless alarm, and it disrupted the nurses’ work unnecessarily. On top of this we received reports that some patients would try to silence the alarms themselves which could cause problems if they did not know how to do it correctly; nurses discreetly advised some patients how to silence the alarms (this was against hospital policy and was only done for patients in whom the nurses had confidence); one patient even reported lying next to an alarming pump for the full 10 minutes because they did not want to disrupt the busy nurses.

The nurses reported to us that soon after the infusion pumps were installed they had raised the issue of the pre-alarm with the appropriate person but they were told that this was just how the pumps were designed. The nurses resigned themselves to putting up with the pre-alarm with patients affected and complaining.

Looking outside-in, as a usability researcher, further investigation found that this is a configurable setting on the pumps. Hospitals in the UK have been encouraged to standardize their devices (e.g. see Werth & Furniss, 2011) and in this hospital this included the device configuration. However, whereas a 10 minute pre-alarm might suit other wards, where accessing pumps has low costs in terms of time and effort, it is a nuisance for the staff and patients on the haematology ward. This situation has persisted because after their initial complaint the nurses understood that there was nothing that could be done.

Potential Theoretical Underpinning
This is not the first issue that we have heard of that has been misattributed to the wrong part of the sociotechnical system. For example, we’ve heard from a major infusion pump manufacturer that medical staff
complained that their pumps alarmed too frequently because they were too sensitive to air bubbles in the line. It was not in fact the design of the pumps but how the hospital chose to configure them, i.e. this sensitivity was adjustable and hospital management have control over that feature.

Part of the broader issue here is that until the problem is attributed to the correct part of the sociotechnical system, appropriate corrective action cannot be identified. They are stuck in the wrong trousers and they do not know the right culprit to chase.

We are not aware of well-developed theory in HCI that focus on investigating how the design and use of medical devices are affected multiple sociotechnical levels, and how effects might be misattributed to the wrong part of the sociotechnical system. We review three areas below that could provide a theoretical underpinning for these sorts of issues.

First Area: Distributed Cognition
Distributed Cognition (DCog) looks at how cognition is coordinated in the environment (Hutchins, 1995). It delimits the locus of cognition (i.e. it can happen outside of the head – e.g., a diary is an example of distributed memory), and delimits what can be involved in cognitive processes (i.e. cognition is not restricted to thought processes alone but can include Post-It notes, tools, maps, etc.) (Hollan et al. 2000). Hutchins (1995) uses examples from ship navigation to show how cognition is shaped and influenced by the more immediate use of tools and representations in the environment, but also the development of tools over a longer period of time. This latter feature shows how technological and cultural developments impact the coordination of cognition, e.g. the advent of the computer has dramatically changed how information is processed at work.

We have used DCog as framework to guide our ethnographic data gathering and analysis. More specifically we have used DiCoT (Furniss & Blandford, 2006), which encourages the analyst to develop five models of the system in DCog terms. However, reference to different levels within a system is only implicit in DCog. For example, there are methodological choices about whether to focus the analysis at an individual, desk or room level, but there is no explicit advice on, for example, recognizing if design configuration decisions by hospital management impact performance on the ward. It seems there is potential theoretical underpinning in DCog but it currently lacks the explicit support we are looking for.

Second Area: Reaching Out
Grudin (1990) uses the concept of ‘reaching out’ to describe how problems with computer systems have advanced from hardware issues (1950’s), to software issues (1960-70’s), to perceptual-motor interface issues (1970-90’s), to more advanced interactions with the computer as a dialogue (1980’s +), to group working issues (1990’s +). At each level new problems bring with them new forms of expertise needed to address them, e.g. from electronic engineers, computer scientists, HCI researchers and ethnographers.

Grudin’s term is rooted in the historical development of computer systems and the focus of its research over many years. ‘Reaching out’ has not been operationalized as a concept for analysis, but its focus on technological development and evaluation and its
emphasis on how expanding levels of a system can impact the technology show promise. For example, perhaps a medical device can be considered to ‘reach out’ to different levels of a system, so we can explicitly consider whether we have attended to the correct level in the evaluation of a device’s performance, e.g. to the management’s pre-alarm configuration decision rather than the device manufacturer.

**Third Area: Meso-Ergonomics**

Karsh et al. (2014) define an area of meso-ergonomics, which focuses on the causal relationships between at least two different levels in a sociotechnical system. This contrasts with approaches to ergonomics that look at organizational aspects (macro-) and approaches that focus more on physical and cognitive elements of a system (micro-). They describe a process for defining hypotheses between different levels to investigate causal mechanisms and influences between levels. Meso-ergonomics seems relevant to the problem at hand. However, there is still work to be done in terms of developing models for recognizing and describing these issues in relation to the design and use of medical devices (quite different to hypothesis testing).

**Conclusion**

There is a need for HCI to develop concepts, models and tools that can more readily capture how the interactions at different levels of a sociotechnical system impact on the performance of technology. This is pertinent to the 10 minute infusion pump pre-alarm issue we have raised, and relates to ongoing evaluations we are conducting on an inpatient blood glucose meter. Medical staff and patients may be suffering because they are stuck in the wrong trousers and they do not know the right culprit to chase (e.g. hospital management rather than the device manufacturer). To our knowledge HCI does not have a well-developed theoretical underpinning for dealing with these issues. We highlight three areas that could be developed and appropriated for this purpose.

**Acknowledgements**

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**References**


Theoretical perspectives on the use of social media in the propagation of health messages

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Abstract  
Influence on social media can be conceptualised as both extensive (relating to quantitative spread) and intensive (qualitative impact). Both of these are important considerations in understanding the dissemination of health messages. We outline several theoretical approaches that offer fruitful ideas for future studies including agenda-setting theory, social norms theory, social representations theory, and theories relating to emotion, framing and recontextualisation. Some of these approaches are novel in social media research and are suggestive for future research directions.

Author Keywords  
Social media; twitter; healthcare; theory; psychology

ACM Classification Keywords  
J.3 Computer Applications: Life and Medical Sciences: Health

Introduction  
Social media can be used for the rapid spread of useful information, but can also be used for the proliferation of disinformation and harmful ideas. In a new study, we have begun to explore ways in which social media
can influence the communication of health messages, specifically assessing the proliferation of messages during the last H1N1 pandemic. In this paper, however, we ask what theory can contribute to our understanding of social media influence, arguing that theory can contribute to our understanding of two key constructs: extensive influence (the quantitative spread) and intensive influence (the qualitative force and impact). While our discussion is limited to blogs and tweets (from Twitter), many of the theoretical ideas can be applied to other platforms.

**Theory and extensive influence**

Numerous factors feed into the extent to which a message will be spread. On Twitter these include the use of hashtags retweets, the number of followers a user has and the use of addressing (via the @username syntax) [2, 12]. While debates may be had about the relative importance of this or that feature, when used effectively, a Twitter message can be spread throughout many users. Consequently, three theories are relevant to understanding the effect of this influence: agenda-setting theory, social norms theory and social representations theory.

*Agenda-setting theory*

According to this theory, people acquire cues to the relative importance of various topics based on the emphasis given to them in media [8]. Transferring this to social media, one can conclude that social media *selectively amplifies* traditional media [1] as well as moderating its influence by promoting citizen journalism [9]. In communicating health messages, this can be a mixed blessing. If health authorities wish to highlight an issue, social media has the power to amplify the effects of traditional media thus making the issue salient for many. On the other hand, the effect of extensive blogging and tweeting of conspiracy theories can give undue prominence to harmful ideas. For example, during the 2009 H1N1 pandemic, links to both quality news websites and poor quality blogs were frequently posted on Twitter [15].

*Social norms theory*

While this comprises more than one theory, the idea central to them is that human behaviour is shaped by shared rules for social behaviour. These norms can be either descriptive or injunctive. The latter are moral obligations while the former are indications of the behaviour of others. So, for example, if many people indicate via Twitter that they are going to engage in behaviours such as vaccination or taking medication, this can create or consolidate a social norm. These norms are likely to be generated within specific groups of users who share a social identity and are linked together in an online network [3]. Potentially then, whole groups of people can be identified who react positively or negatively to health interventions.

*Social representations theory (SRT)*

SRT [10] is widely used to explain how stable representations of an issue emerge in society. These representations serve to legitimise particular thoughts and practices regarding issues such as health, disability and criminality. In regard to health, SRT emphasises that beliefs and practices surrounding illness are "intersubjectively negotiated" [4]. Social media would be one area in which these are negotiated yet despite its increasing prevalence, there appears to be little or no research looking at its role in generating social representations. Yet social media may be used for example, to perpetuate representations of health that
focus on weight which may lead to harmful dieting. While other research has fruitfully used SRT to explore how representations of pandemics in online newspapers explain various societal approaches to vaccination and maintaining health [5] research remains to be carried out in social media studies.

**Theory and intensive influence**

Not only may a message be spread extensively, but it can have more or less influence depending on its content. Messages can generate more impact if they express negative emotion [11] or are framed in specific ways [7].

**Emotion**

Numerous theories have cropped up around emotion but considered more broadly, the study of emotions in social media has great potential. In pandemics for example, sentiment analysis can identify clusters of individuals who have negative attitudes towards a vaccine since information seems to be shared among users of similar sentiment [13]. Because there is a positive relationship between the expression of sentiment and the retweeting of information [14] this increases the likelihood that affective information about vaccines or illnesses will be shared.

Appraisal theories of emotion see action-tendencies as essential for emotion [16]. Likewise, discourse analysts see the expression of emotion as functional. In relation to social media then, it is important to ask, “When people express emotion about illness or health, what are they trying to accomplish? What behaviours are they trying to stimulate or repress?” This will help to explain health behaviours that arise through social media.

**Framing**

All messages come framed in terms of a “metamessage” which affects the interpretation of the message. Thus a message may be framed as a “crisis” or “general advice” and this affects how people receive it. Liu & Kim [7] identified four frames used in a recent pandemic on social media: general crisis, disaster, health crisis and general health issues. They suggest that framing has four functions: (1) identify causation, (2) identify source of the problem, (3) make moral judgements about the situation and (4) provide solutions. They note that “general crisis” was often used but that the use of “health issue” framing may have encouraged positive health behaviours by emphasising prevention behaviours and lifestyle factors. Understanding how messages are best framed has the potential for encouraging appropriate messages to be shared on social media by health authorities to encourage healthy behaviours.

**Recontextualisation**

Although a relatively underused approach, this theorises that when a message is reproduced, it inevitably subtly (or significantly) changes the meaning of the original message [6]. On Twitter, this can lead to the production of unfounded rumours [2] or even to the distortion of official health messages. Analysis of how messages are reproduced can uncover this process.

**Conclusion**

Social media has both intensive and extensive influence. This paper has summarised some key approaches that may be taken in understanding how health messages can be influential in social media. In the workshop we will describe how such theoretical frameworks are helping us understand the role of
tweets and blogs made during the last H1N1 pandemic. While we have only explored blogs and tweets, influence is likely to manifest itself in different ways on different social media platforms. For example, emotion will be conveyed in different ways on social media sites such as Instagram or Pinterest which focus on images. Likewise, the framing of messages is likely to be different between Facebook and Twitter where the former allows longer messages whereas the latter does not. Despite this, the theoretical perspectives are helpful even if the way influence is manifested is different.

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The Use of Theoretical Constructs in Studying Health Information Technologies

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Abstract
Theoretical constructs are the foundational building blocks of theories and are utilized as a way of understanding and explaining phenomena. The use of theory and theoretical constructs to study health information technologies have varied based on research communities, research goals, and types of technology. Within the HCI community, there has been a long history of using theoretical constructs to help us understand the use of technology.

In this position paper, drawing on our previous research in healthcare settings, I would like to discuss the role that theoretical constructs can play in helping us better understand the use of health information technologies. In particular, I am interested in exploring not only how these constructs can help us better understand issues but also how we can use these constructs in designing and implementing health information technologies.

Author Keywords
Theoretical Constructs, Health IT, Work, Collaboration, Clinical Settings, Patient Care Teams
Introduction

The use of theory and theoretical constructs in health IT research has varied based on a number of different factors. These factors include:

- The research community (i.e., information systems, HCI, Biomedical Informatics)
- The type of technology (i.e., health and wellness applications, clinical technologies)
- The research goals (i.e., behavioral intervention, workplace studies)

For instance, in the Information Systems community, the use of constructs is central to much of the research on health IT [1]. However, in the Biomedical Informatics community, they are rarely utilized. In HCI, there has long been interest in theories for developing health and wellness technologies for behavioral interventions [2]. Furthermore, there has been growing interest in the use of theories (and constructs) for understanding the use of clinical technologies (i.e., electronic medical records, clinical decision support systems, etc.).

In this position paper, drawing on our previous research, I would like to discuss the role that theoretical constructs can play in helping us better understand the use of health information technologies.

Theoretical Constructs

By theoretical constructs, I am referring to a concept that “defines something in a special way; it is a term used in attempt to solve a problem” [3]. Where a theory tries to provide a general explanation to a question or set of questions, theoretical constructs set the groundwork for the development of a theory.

Theories such as the Technology Acceptance Model (TAM) [4] and GOMS [5], have been used to study the implementation of clinical technologies. These theories and their constructs focus a great deal on the technology itself and issues such as broad adoption (TAM) or task completion (GOMS). While these issues are of interest to the HCI community, HCI health researchers have also been very much interested in understanding the nuances of the activities that surround the use of HIT. Consequently, there has been a focus on constructs such as informal practice [6] articulation work [7], and emotion [8].

The use of these constructs serve two major purposes. First, they help guide the understanding of the observed phenomena in the research setting. For instance, the concept of informal practice helps researchers understand the how and why activities may deviate from those that are organizationally sanctioned. Second, the findings from these studies help further refine/clarify/extend the construct.

Temporality, Collaborative Sensemaking, and Meta-Coordination Activities

In a series of studies that our research group has conducted in various clinical settings, we have used constructs to help us both understand what we were observing as well using the research findings to help extend these constructs. Below, I describe three examples from our research.

We examined health IT use in an intensive care unit (ICU) [9, 10], we used the concept of temporality in
particular temporal rhythms, temporal trajectories, and temporal horizons to help understand how the ICU staff organize their work and how the electronic medical record allows them to organize their work temporally. Through this research, we highlighted both the temporal nature of the work in the unit but also helped, for instance, extend the concept of patient trajectories [11] to highlight the temporal nature of trajectories.

We also examined how staff in the emergency department (ED) worked together to understand the disparate pieces of information that often have to be put together to provide effective and efficient patient care [12]. This collaborative sensemaking builds on the work of Weick [13] and others but has described and extended sensemaking to highly collaborative and information intensive clinical settings such as the ED.

Finally, we examined the process of patient transfers in a hospital [7]. Patient transfers are a perfect example of articulation work – the invisible “work” that is important for the organization to function. Through this research, we developed the construct of Meta-Coordination Activities (MCA) to extend the concept of non-routine articulation work to understand how inter- and intra-departmental goals, resources, and processes are managed to ensure the smooth flow of patient transfers.

The Role of Theoretical Constructs
In our studies, we have utilized theoretical constructs to not only help us understand what we have observed within the framework of a larger body of work (i.e., the research on temporality has existed for more than a 100 years) but also to “name” something in order to help understand an issue (or solve a problem). For instance, the concept of MCA helped us better understand how hospital staff were able to still successfully complete most patient transfers even with all problems and barriers that they faced in the hospital.

Theoretical constructs can play an important and useful role in both analyzing data and “naming” something that has been identified. However, using constructs also raise a set of challenges. First, it is not always clear what is the appropriate construct to use. There are no clear criteria for identifying a useful construct. Second, the issue of how much data is considered sufficient to develop a new construct or extend an existing one is unclear. Finally, there are still a number of issues surrounding how to use these theoretical constructs to design information technologies.

Conclusion
In this workshop, I hope to explore the issue of theoretical constructs and the role that they play in both studying how people use health IT and in the design and implementation of these technologies. Besides the challenges highlighted in the last section, I would also like to discuss:

- How can we translate from theoretical constructs to technology design?

- How should we discuss theoretical constructs (and theory in general) in communities where they are not widely utilized (i.e. Biomedical Informatics)?
Theoretical constructs have been useful in many other HCI domains and can be a powerful tool in HCI health research.

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Activity-Centric Configuration Work in Nomadic Computing

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Abstract
The workflow in hospitals can be described as nomadic, which means that clinicians roam through the hospital while interacting with a large number of people and information related to different patient cases. Over the years, more device types (such as mobile devices, large interactive whiteboard) have been introduced into this workflow to support mobility and coordination. However, most of these devices and systems are intrinsically disconnected from each other, forcing clinicians to manually reconfigure them to match the active work setting according to the situation. In this paper, we describe an activity-centric approach to this multi-device configuration problem that is grounded in activity theory.

Introduction
The workflow of clinicians in a patient ward can be described as nomadic. In addition to sitting in an office or other fixed location for managing, archiving and preparing patient information (as seen in Figure 1), clinicians also roam through the hospital while doing their work [2]. This work typically includes collaborations with a large number of people and usage of physical tools and computing devices that are spread over multiple locations. Clinicians often move from one location to another while interacting with both mobile and stationary tools and devices, such as desktop computers (Figure 2), large interactive
whiteboards (Figure 3) and mobile devices (Figure 4). Our observations in different patient wards show that despite the ubiquity and importance of these tools for the information flow in the hospital, most of these tools are not designed, tailored or suited for this nomadic use, thus resulting in a mismatch between the functionality of the system and the actual work done by the clinicians. Fundamentally, all these different systems and devices are intrinsically disconnected from each other, forcing clinicians to manually reconfigure the active work setting according to the situation. This results in work interruptions, information fragmentation and a disconnected workflow crossing several information resources. Furthermore, there is little support for the ongoing collaborative context, situation or specific role of the device. We describe this problem as the multi-device configuration problem, which refers to the effort required to control, manage, understand and use information, applications and services that are distributed over all used devices.

Despite a growing number of new electronic health systems, most solutions do not transcend the traditional application and file-oriented paradigm, resulting in a preservation of the mismatch between the work done in hospitals and the systems supporting this work. Our prior work [1] has uncovered that work in hospitals can be organized and structured using the activities of clinicians as a central computational construct that encapsulates configuration, communication and coordination processes in day to day hospital work. However, the important role of computing devices as tools in this web of activities is often not very explicit. In this paper, we describe an activity-centric approach to this multi-device configuration problem grounded in activity theory.

Theoretical Background
Activity theory (AT) is a psychological framework that describes human activity as a relation between the subject (S) (human or group that acts in the world), object (O) (which is acted upon and motivates the activity) and the community (C) (or social strata in which the activity is engaged) [3]. The motivation of an activity is projected and reflected into an outcome, which is the contribution of an activity. The S-O-C relation is mediated by tools, rules and division of labour (Figure 6). First, tools provide the subject with a way to act in the world. They externalize the act in the world through enactment and are shaped by affordance and resistance. Second, rules define how the act of the subject is embedded in the social context. It socializes the act in the environment, culture and world. Third, division of labour structures the relation between the social strata and the object of the activity. It links the distribution of work among community to the hierarchical motive towards the object. Activity is not a fixed structure but a dynamic hierarchical interaction between the activity itself driven by motivation, conscious goal-directed actions and unconscious operations that are performed when certain conditions are met. In summary, activities are why we do something; actions are what we do it; and operations are how we do [6]. Engeström [4] categorized four fundamental processes (Figure 7) that are interwoven into this hierarchy. These processes are: (i) production, (ii) consumption, (iii) exchange and (iv) distribution. As activity theory moves into its third generation, it has become clear that the unit of analysis is expanding from an individual analysis to a global analysis that comprises not only the individual, the community, and the artefacts but also the interconnectivity between activity systems. The focus is on networks of interacting activity systems, the dialogues between these systems and the multiple perspectives of these networks of activity [4].
**Activity-Centric Configuration Work**

We define *configuration work* as the amount of work required to locate, prepare, arrange and set-up all necessary resources required to complete the objective of an activity. It is the total effort required to control, manage, understand and use information, applications and services that are distributed over all used devices and users. We extend this to the notion of *activity-centric configuration work* through a conceptualization of configuration work from an activity theoretical point of view. Since activity theory uses activity as first class analytical object, we frame the use of computing devices as *tools* that are part of *activity systems* that are produced, consumed, exchanged and distributed (Figure 7) during nomadic work. Because information on computing devices are often *boundary objects* [7], meaning they can fulfill many different purposes as part of different activities, they can be both in a stable or unstable state. The *stability* of the state refers to the appropriateness of the configuration in terms of goals of the activity system. In case either the configuration of the device does not match the goals of the activity or the device has become part of another activity system, the tool becomes unstable. This requires users to perform configuration work to re-purpose the tool to match the goal of the activity. When, for example, the incorrect patient data is shown on a mobile device, the clinicians’ focus drifts away from the main activity (care for the patient) to configuration work, in order to set-up the device to visualize the information of the correct patient.

One fundamental approach to reducing the mental overload of switching between ongoing work on different devices is to provide meaningful computational representations of real activities. We hypothesize that by allowing users to interact with computation representations of real-world activities, switching between device configurations will be more efficient, more effective and will support users’ mental model in a multi-user and multi-device environment. Activity-centric computing uses the notion of *activity configuration* (Figure 8) as a description of a work context (including files, applications and other meta information, coordination practices and communication tools) that is a reflection of the real ongoing activity.
By explicitly using activities as fundamental first-class computational structures, these activity-related configurations or tools states can be (i) constructed, (ii) shared and (iii) restored across devices thus reducing the amount of configuration work required to change ongoing work. Compared to traditional computing systems, activity-centric computing still requires a configuration step in which users (co-)create or share a new computational activity as part of an emerging real-world activity (Figure 5). However, because of the activity configuration the resumption lag – the time required to switch to another work setting – is reduced as the activity representation can easily be restored as one working context. In a clinical context, for example, all patient-related information can be structured into computational activities that are part of the same distributed activity system. This allows devices to be simply plugged into this system by leveraging the existing patient configurations and work context (e.g. nurse notes) as initializer for the new device.

**SmartWard**

A concrete application of the theoretical concept discussed above is the Smartward (Figure 9) system. SmartWard is an activity-centric distributed context-aware patient management and information system designed to support multi-device location-aware collaborative workflows in patient wards. SmartWard supports patient management across large interactive displays (Figure 9 A), tablets (Figure 9 C) and desktop computers, and uses an ultrasound location tracker for location-aware services (Figure 9 B). The SmartWard system is designed as an activity system [5] in which all information and coordination tools are abstracted into activity configurations that reflect patient cases. These activity configurations can be created, accessed, modified, distributed and shared across different device types showing different levels of information granularity. In contrast to traditional device use (like in Figure 2, 3, and 4), devices can be automatically configured for a specific clinician using existing activity configurations and context (such as the type or location of the device; or the role of clinician in a specific patient case). Devices are thus portals into a shared activity-centric information space in which information is organized in thematically logic abstractions of daily work at a patient ward.

To explore the usefulness and feasibility of the approach in a clinical setting, we conducted a scenario-based field evaluation of the entire SmartWard system. The study indicated that cross-device activity-centric patient information provided clinicians with an automatic redundant and detailed distributed coordination mechanism. They could for example easily double-check information entered by other clinicians or themselves across the different devices to verify correctness. Structuring working data related to a patient case in one activity that could be moved between devices provided clinicians with a quick and ad hoc overview of work in progress. Furthermore, the explicit process of dragging and dropping activities between the large display and personal tablet added an additional verification that the correct patient data was shown. Finally, location-based activity suggestions were considered as very useful as they reduce the configuration overhead and can potentially avoid errors in selecting patient information.

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The Co-production Connection: Community Engagement and Health

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Abstract
Health can be construed in many ways, for example, as the absence of sickness or as a caused outcome of environmental interactions. Here we focus on personal and collaborative agency in a community context, and construe health as an achievement co-produced by a person and other engaged community members.

Author Keywords
Co-production; time banking; peer-to-peer exchange

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction
Co-production of social services is producing social service outcomes through collaborations among recipients, social service professionals, and other stakeholders; in co-production all stakeholders have power and responsibility to identify and achieve successful outcomes. Service recipients or clients work directly with providers to produce the desired service. The concept of co-production originated in the observation that effective delivery of a social service sometimes depends on the active involvement of the service recipient. The signature example is Ostrom’s (1996) analysis of the increase in Chicago street crime.
that coincided with police switching from walking a neighborhood beat to patrolling in cars. Ostrom argued that car patrols reduced contact with residents, diminishing the extent to which neighborhood safety was pursued as a joint project of police (service providers) and residents (service recipients). A police officer in the street is better positioned to co-produce public safety with public involvement: Police and residents get to know one another better, trust each other more, share and display awareness of events, and directly and indirectly collaborate to provide neighborhood safety.

Many person-to-person interactions are co-productions: When Sue gives Joe a guitar lesson; both are active participants in the service exchange. Moreover, the service provided by Sue to Joe creates a capacity for further service exchanges within the community, for instance Joe giving a guitar lesson to Ed. Co-production has been identified as a key to strengthening the core economy of home, family, neighborhood and community (Glynos & Speed, 2012; Stephens et al., 2008).

Cahn (2010) extended the concept of co-production, including partnerships among communities and agencies, as well as among individual community members and service professionals. Drawing on Cahn, Glynos and Speed (2012) distinguished additive and transformative co-production. In the former, service recipients contribute to the creation of a service without changing the way they see themselves, namely, as recipients or clients, and without changing the way the service provider or the larger community see themselves, or participate in the service. In transformative co-production recipient contributions to the service become so integrated as to change the way we construe what the service is, how such service is produced, and the roles and relationships among all stakeholders in the service.

On this definition, Ostrom’s (1996) original example of cooperation among residents and Chicago police is additive co-production: All traditional stakeholder roles are maintained, but the service recipients cooperate with the service provider to (incidentally) contribute to the creation of a service benefitting themselves and their community. Teaching and mentoring interactions can often be transformative co-productions: The service cannot be merely “provided,” but must by co-created. For Cahn, and for Glynos and Speed, the challenge of co-production is reconceptualizing social service provision as relying on recipient initiatives and relationships in the context of a broader transformation of roles and responsibilities, including roles and responsibilities of municipal and other government entities. In Cahn’s notion, social service professionals can become facilitators more than providers, and services themselves can be negotiated and produced by all stakeholders working together toward collective goals.

**Time Banking and Co-production**

*Time banking* is the valuing of service contributions by the time taken to produce them, and mediating exchanges of effort and other contributions among community members by adjusting time credit balances (Cahn & Rowe, 1992). For example, one person might have a car, and can drive neighbors to appointments and grocery shopping; another may be an accomplished gardener. Each can contribute effort to the collective time bank, and draw against their
resulting time balances to make requests, perhaps having someone mow their lawn. Time banking is an alternative economic paradigm to exchanges of money. Because it emphasizes person-to-person interactions, and because everyone’s contributions are valued on the same scale (time), time banking strengthens local social ties and social capital, and it enhances personal dignity in ways that a money-based economy does not (e.g., Seyfang, 2009).

In recent years, several ambitious experiments in health policy and service provision – through the co-production of health and wellbeing – have taken place in the United Kingdom (Glynos & Speed, 2012; Stephens et al., 2008). For example, the Rushley Green time bank is linked to a primary care center in Catford, South London, where doctors and other healthcare professionals refer their patients to the time bank as part of their treatment for depression and feelings of isolation. In the time bank, members receive credit for services such as accompanying elderly members who are shopping, visiting elderly people in their homes, etc. to enable the elderly to live on their own. The time bank is innovatively conflating the traditional roles of recipient and provider of health care services.

The Glynos and Speed (2012) article describes a current policy debate in the United Kingdom regarding broader incorporation of co-production into social service programs (one issue is that the assumption of public service responsibilities through time banking or other civic sector mechanisms could encourage public sector spending cuts; see also Seyfang, 2009). Although government or agency expenditure may be required to launch a time bank, a recent economic analysis of novel approaches to health and social care in the United Kingdom estimated that the return on such expenditures in time bank service delivery was 2.16 – more than double (Knapp et al., in press). And indeed, the authors noted that their analysis was deliberately conservative with respect to estimating quality of life benefits.

Glynos and Speed (2012) observe that co-production is structured by a logic of recognition, rather than by a logic of exchange. Consider a hypothetical case, in the Rushley Green time bank, of a member who has been referred to the time bank for depression, and who goes shopping with an elderly person as part of his or her treatment. Who is the service provider and who is the recipient? This is a case of transformative co-production; each party might very well wish to recognize the contribution of the other. And indeed, doing so would enhance the direct benefits of the interaction, for example, it would create social capital, and provide an affirmative model for other community members.

**My contribution to the workshop**

I believe that time banks and other engaged community interactions can be transformative and effective in co-producing health and wellbeing, specifically with respect to enriching social networks, social relationships, and sense of community (diminishing social isolation), and strengthening self-perceptions of agency, resilience, coherence, and efficacy (diminishing feelings of helplessness and loss of control). These concepts are operationalized in standard survey instruments (e.g., Antonovsky, 1996). At a behavioral level, we hypothesize that co-production will increase time spent and quality of exercise, participation in musical and other
collaborative arts activities, and community volunteering. Prior research shows that such activities enhance health and wellbeing, though co-production as such has not been investigated.

This orientation to theorizing and intervening in health and wellbeing raises many research questions about the specific outcomes of particular co-production relationships (e.g., playing music together), as well as questions about how to facilitate the initiation, development and sustainability of such relationships. It raises questions about how to measure health and wellbeing outcomes broadly (notably, avoiding the simplification that health is just the absence of illness, the salutogenic model; Antonovsky, 1996).

During the last year and a half we have investigated new mobile technology infrastructures for time banking. We are working with largest time banking group in North America (about 12,000 members). We have carried out field studies to understand practices, and how those practices might be facilitated through smartphones and other personal devices, deployed iOS/Android prototypes nationally, and carried out a survey of 430 members (Bellotti et al. 2014). Our initial scenarios for mobile time banking sought to identify how people can do things for others (1) with relatively minimal effort; (2) leveraging the affordances of mobile devices, such as GPS (Global Positioning System) information; and (3) being pre-situated in a flow of embodied activity.

References
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References
On Individuals’ Resilience Strategies: Drawing and Applying Theories

Abstract
Individuals, both in frontline healthcare settings and more generally speaking, frequently deploy a range of resilient strategies and behaviours to maintain performance and mitigate a multitude of potential threats. Our work here describes how theories can be both derived-from and applied-to situated instances of resilience within frontline healthcare settings. We also recognise the value in considering how the concept transcends specific contexts, and the importance and potential significance of establishing such a theory both within, and transferrable across, a range of domains.

Author Keywords
Cognitive, Resilience, Strategies, Theory, Healthcare

ACM Classification Keywords
H1.2. User/Machine Systems: Human Factors. H.5.0. Information interfaces and presentation (e.g., HCI): General

Introduction
The application of existing theory to practice, in healthcare or elsewhere, creates challenges in identifying both the correct theory to apply and the specifics of how to adjust or tailor the theory in response to the immediate context. In contrast, when developing theory, the difficulty for the researcher is in...
identifying the influences of the current context and to find a sufficient abstraction to make a genuine contribution to underlying theory. In this latter case, there are risks such as over-generalising, and including specific features of the current domain that are not true elsewhere, and also in privileging priorities that may mislead or obstruct the application in other contexts.

In our current research, we are seeking to build theories to help researchers understand individual actions taken to maximise the safety or performance of the socio-technical system in which they are working. This both draws from existing theories, and needs to provide interpretative power in the healthcare domain.

It has been demonstrated [1, 2] that workers and clinicians in a medical context take personal steps to optimise the care, safety and outcomes for their patients. We are examining these actions through the theoretical frame of individual cognitive resilience.

One challenge of our research is that it often contests the several established definitions of resilience in the healthcare domain. These are complementary to, yet distinct from, cognitive resilience: often being about systems, rather than individuals, and formal processes, in contrast to individual action.

Another problem is that the term ‘cognitive resilience’ is new. It is therefore somewhat loosely-defined, and its meaning is still being formed. Existing understandings of the term are frequently challenged and questioned by new research. Indeed, the term could itself be seen as misleading or inaccurate: both ‘resilience’ and ‘cognitive’ may be poor labels.

Therefore, the definition with which we are working, and the terminology with which we seek to work, both require substantial interpretation into the healthcare domain. This is a problem that we know is shared by other researchers using the same approach.

In the case of cognitive resilience, there are still shortcomings in the current development of theory. Even commonplace aspects of a theoretical landscape are lacking. For example, there is minimal work on separating and distinguishing different resilient behaviours for ensuring patient safety [3]. This shortcoming is not specific to the domain of health.

**Developing Theory in Cognitive Resilience**

In the context of our wider project, CHI+MED¹, a common goal shared by a number of researchers is to establish a set of strategies, or patterns, that depict the different kinds of actions and responses used in the management of threats, or, alternatively, that enhance an outcome in response to a foreseen possibility of a safe, yet sub-optimal, result. A set of such strategies would enable a closer, more systematic and principled analysis of individual observations of actions taken by medical staff in wards, or other environments.

In addition, a refined set of strategies would allow some degree of predictive power in a theoretical analysis of a specific device, environment or social context. We could, furthermore, better understand the content, form and properties of effective behaviours. It is therefore very desirable to reach the point where there is a well-evidenced set of strategies that has strong analytical, interpretative and predictive power.

¹ www.chi-med.ac.uk
Returning to the point of specific versus general contexts, it is likely that a set of strategies that is abstracted from a wider evidence base than medical contexts alone would be more powerful. Individual coping strategies may be borrowed from life experience or knowledge of another medical context not under current observation. To provide this wider, more reliable foundation, we gather evidence of resilience strategies both within and beyond the clinical domain.

Self-reported instances of individual resilience obtained through a recent diary study we have conducted serve to demonstrate the parallels between resilience on the medical frontline and in a broader range of contexts.

For example, one account detailed how an individual working in a hospital dispensary would, during periods of ‘downtime’, proactively and preemptively check patients’ needs in other areas of the facility. While not a formally recognised or required practice, this served a preparatory role and subsequently led to more efficient management of time and resources.

Immediate parallels can be drawn between the above example and an ‘everyday’ example of resilience recorded by another subject, who described, when preparing to travel to an unfamiliar location, using Google Streetview to perform a virtual tour of the route and destination to familiarise themselves with both.

In each of these cases, a candidate pattern in cognitive resilience, prospective checking, is employed to identify potential challenges and reduce the risks associated with unexpected conditions. In each case, effort is invested in conducting an anticipatory check with the intention of reducing future workload or vulnerability.

The appropriation of smartphone cameras as tools for rapidly capturing information quickly and accurately is another case where resilience strategies are seen within and outside the health domain.

Medical cases include multiple accounts of another hospital dispensary technician using this strategy to record and retrieve information. The data captured included drug and patient details, which needed to be moved from one location to another. The camera serves as a cheap, portable ‘data capture’ device, which preserved the original data in situ, but reduced both the error risk and time cost of transcription.

Likewise, we have several accounts of this same strategy being used outside of the medical context (e.g. individuals recording transport details, work schedules, or personal profiles in the same way). In both cases, again the mechanism (appropriation of a mobile phone) and the motivation (to eliminate the risk of forgetting, or recalling incorrect information) remain consistent across domains. Both are cases of a pattern of managing resource availability.

However, not all cases follow these relatively neat matches between domains. For example, the relatively impersonal and changing physical environment of many open clinical workspaces means that strategies that rely on those features are less common than in personal offices or at home. Our understanding of the few cases in wards, for example, benefits from having a wider view from which these can be more readily identified, and better understood and analysed.

One example of the impact of the environment is the manner in which cues are handled in the dispensary.
The use of physical post-it notes is described in situations where retrieval of particular information is known to be imminent (e.g. needing to call a nurse upon receiving a prescription, or a ‘to-do’ list that was in the process of being undertaken). However different cueing strategies are described in several cases where action was required after an extended period of time, or reoccurring on a long term basis. In these situations, staff instead wrote notes on the backs of their hands or emailed themselves reminders. These adaptations reflect the fact that unlike in a relatively stable home or personal office environment, physical cues such as post-it notes cannot live indefinitely on one’s desk or monitor. Such cues are intrinsically much more frail in an unpredictable, busy and shared environment.

Summary
In this paper we have demonstrated a number of cases where similar behaviours can be observed within and beyond the context of health. This helps reaffirm and validate the theory that we are trying to both derive from and apply to the clinical context. At the same time, challenges to an emerging theory can be provided from both inside and beyond the medical domain. All this contributes to the interpretation of fieldwork within the clinical environment, and we hope would also assist researchers outside our specific context. The challenges to this process, that we have reported here, are shared by other members of the CHI+MED team, and are visible in the output of other researchers [4,5]

Fieldwork benefits from supporting theoretical tools that enable the researcher to interpret their observations both retrospectively and, ideally, prospectively. Our own research has for the recent past travelled across many domains, only a small fraction of which was health-related. However, the ultimate goal of our investigations is to develop theory to explain a key phenomenon in the realisation of the safe treatment of patients: individual ‘positive safety’ or ‘cognitive resilience’. Our ultimate aim is to empower fieldwork in the context of healthcare, but we argue that when developing theory, limiting the range of data from which one constructs an argument is unhelpful. We emphasise how there are strong benefits in contrasting both within and outside the context of medical work.

Acknowledgements
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References
In at the deep end: Contextual Inquiry and DiCoT as “flotation aids” for a novice ethnographer

Abstract
Systematic approaches to observation and analysis have the potential to support a junior analyst in making sense of a complex setting. However, the costs and benefits of learning and applying such approaches have rarely been studied explicitly. In this paper, we present an idiographic study in which a single individual systematically learned and applied Contextual Inquiry and DiCoT (a structured approach to analyzing a system in terms of Distributed Cognition) to understand how anesthetists use infusion devices in their work. We present a reflexive account of his experiences. Contextual Inquiry was found to be a valuable tool for understanding this complex system; DiCoT built on that analysis to deliver rich insights into the design of tools and how information is exchanged around the system.

Author Keywords
Medical device, distributed cognition, contextual inquiry, anesthesiology, anaesthesia, DiCoT, ethnography.

Introduction
Entering an unfamiliar and complex system such as an operating theatre can be daunting for anyone, but particularly for a junior researcher who has limited prior experience of conducting observational studies and no formal training in surgery or anesthesia. However, there is often little choice but to prepare as well as
possible and then “dive in at the deep end”. Ethnography as described by, for example, Randall and Rouncefield [7] offers little inherent support for the novice analyst in terms of what to pay attention to or how to record observations. Contextual Inquiry (CI [1]) provides guidance and a set of representations, particularly tailored towards understanding work with technology with a view to redesigning that technology. However, CI has no explicit theoretical basis. DiCoT [3] builds on CI representations, explicitly considering the sociotechnical system in terms of Distributed Cognition [4]. The question addressed in this study was: what does it take for a novice to learn and apply each of CI and DiCoT in a complex healthcare setting, and what kinds of insights does each approach afford?

**Background**

CI [1] is an approach to requirements gathering based on contextual observations and interviews that take place within the working context. Data is gathered in order to construct five kinds of work model for each interviewee: a flow model showing overall workflow; sequence models describing task structures; artifact models describing the objects that support work; a cultural model showing relationships between and influences on actors; and a physical model highlighting important features of the physical workspace. Following all data gathering, the models for individual participants are aggregated into general models that represent key features of the work, work context and artefacts. Although CI is an established method for requirements gathering, there are few reports on its application in healthcare.

Distributed Cognition (DCog [4]) is an approach to analyzing complex sociotechnical systems in terms of information propagation and transformation within a system, focusing on how the design and use of artefacts mediate work. DCog has been applied, and shown to deliver valuable insights, in a variety of healthcare settings, such as hospital resource management [5] and intensive care [6]. However, the classical accounts of DCog provide little methodological support for the novice analyst. To address this, Furniss and Blandford [3] developed DiCoT as a semi-structured approach to analyzing a system in DCog terms. DiCoT exploits representations from CI by overlaying them with a set of interpretive concepts and principles against which a system is assessed. For example, the concept of an “information hub” (within the information flow model of CI) highlights an actor or artefact within the system that aggregates and transforms information from different sources. An associated principle is that communication channels between a hub and the information resources on which he/she/it relies need to be reliable and effective.

There have been no previous studies of the learnability of DiCoT, or of what added value this theoretical perspective might bring to the analysis of a complex healthcare system.

**Method**

This study was idiographic [8]. It involved one individual (EB) systematically learning and applying first CI and then DiCoT in the observation of the work of anesthesiologists, with a particular focus on their use of technology and how the current technology design supports or impedes their practice. DF took the role of principal tutor, guiding EB on the application of CI and DiCoT as required. AB oversaw the study. All authors had regular scheduled meetings.

Since DiCoT exploits CI representations, CI was learned first. Five weeks were allocated to learning and applying CI, then five further weeks to learning and applying
DiCoT. Six observational sessions were completed during the first phase and five during the second. Each involved detailed observation of one operation, typically taking 3-5 hours. The focus was on information interaction and technology use, particularly on the design and use of infusion devices. EB maintained a detailed diary of activities, difficulties, insights and findings, including detailed notes of discussions. These formed the basis for a thematic analysis of the experience and outcomes of learning and applying CI and DiCoT. While a single case study may not generalize, it permits insights if a kind that are not available from broader nomothetic studies.

Findings: learning
EB spent a week learning CI before feeling ready to start data gathering; he took a further two weeks to achieve a comparable level of confidence in DiCoT. A core text book was used as the principal reference for CI; this included illustrative examples that supported understanding (although they proved to be insufficiently detailed or complex to adequately support the transition into the study setting). In contrast, information about DiCoT was scattered across several papers, and the approach had been adapted to fit each new context in which it had been applied. These earlier studies provided examples that had a similar level of complexity to the study setting; however, DF’s guidance proved essential to enable EB to achieve a coherent understanding of the approach. EB drew on his prior education in psychology for scaffolding his learning of DCog.

Findings: CI and DiCoT as “flotation aids”
EB found it necessary to spend an “orientation week” in the study setting prior to any data gathering because it proved too challenging to both make sense of the work practices and apply any modeling approach initially. Following the orientation week, EB found the flow model of CI invaluable for understanding the workflow of the operating theatre: it enabled EB to structure his observations and identify generalizations across a set of instances. For example, making a distinction between two groups of actors (surgeons and anesthetists) made it easier to subsequently focus attention on the group of interest – namely, the team of anesthetists. CI also encouraged a focus on artefacts and how their design facilitated information flow. Guidance from [1] on achieving an appropriate level of abstraction in the modeling helped EB to focus on elements of the system that were relevant to anesthetists’ work, minimizing distractions from other parts of the complex work system. However, EB did not identify any significant or systematic problems with either overall information flow or the detailed design of infusion devices through the application of CI.

The DiCoT concepts and principles helped to identify a range of issues relating to both information flow and device design. For example, recognizing the roles of anesthetists as information hubs and the importance of maintaining situation awareness highlighted the ways in which they integrate information from surgeons, monitors, each other, and various other sources (external to our analysis) to maintain a coherent picture of the state of the patient as a basis for care management. The analysis also highlighted problems associated with shift changes and reduced communication bandwidth within the team when one of the anesthetists needed to leave the operation theatre.

As well as drawing attention to such issues, the DiCoT analysis helped to identify vulnerabilities in the design of the infusion devices being used. For example,
feedback from the device during the setup procedure was limited, which could make it difficult for an anesthetist to resume programming correctly after an interruption. This possibility had not previously been mentioned by participants.

**Discussion**
This study inevitably has limitations, being based on the activities and reflections of one individual. It was possible to conduct this study because EB joined our lab as an intern with relevant prior knowledge (of HCI and psychology) and with a strong interest in healthcare, but without prior knowledge of either CI or DCog; these are relatively unusual circumstances, making it difficult to replicate the study to assess the generalizability of the findings. Nevertheless, the systematic, in-depth approach taken has yielded valuable insights. Trivially, EB’s experience of learning the two techniques highlights the value of good learning resources for any novel theory or method and the value of a background in psychology for understanding DCog. More significantly, the theoretical concepts and principles of DCog encapsulated within the DiCoT method helped to identify issues that might never have been observed, or might have passed unnoticed, without this theoretical framework. CI models delivered a good basic understanding; the additional theoretically based scaffolding provided by the DiCoT concepts and principles supported EB in identifying a range of issues concerning information flows and technology design in anesthesia. To return to our metaphor: CI served as a basic flotation device to help the novice ethnographer “keep his head above water”; DiCoT propelled him forward to achieve insights that would almost certainly have evaded him in the available time without such support.

**Acknowledgements**
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Using Theoretical Frameworks to Tailor Error Prevention Strategies to the Type of Task Being Performed

Abstract
Numerous studies of errors in health care identify medication-related errors as at or near the top of the list of concerns, both in terms of frequency and severity of impact. Despite the development of automated technologies, such as smart infusion pumps, medication errors are still prevalent and typically occur in more than half of all intravenous (IV) infusions. Incorrect set-up, programming and management of IV systems, particularly complex secondary and multi-line infusions, are often caused by knowledge and performance deficits. These deficits are influenced by several factors, one of which is a lack of clinician training on fundamental infusion principles. Thus, to improve patient safety related to administering IV infusions, there is a great need for (a) infusion system design that optimizes capability and ease of use, and (b) an effective means of educating clinicians on the system fundamentals necessary to support critical thinking and decision making when operating IV medication systems.

We have undertaken a case study in which we have applied various theoretical frameworks/approaches, to determine the underlying cause of IV medication administration-related errors, and to compare types of errors that were best mitigated through improved device design to those that benefited most from improved user training. Theoretical frameworks/approaches used in our case study include an AcciMap analysis taken from Rasmussen’s Risk Management Framework [1], and Rasmussen’s Skill-Rule-Knowledge conceptual framework for human performance [2].

Methods used in our studies included literature reviews, mining of incident databases, ethnographic observations in clinical environments, and laboratory-
based simulations designed to uncover performance
limitations, and to test proposed benefits of improved
technology designs and clinician training.

Results showed that applying theoretically informed
safety-based improvements to known shortcomings in
technology design for IV infusions were beneficial in
reducing, and even eliminating, errors of omission.
Conversely, training-based interventions aimed at
teaching fundamental principles of infusion systems
were beneficial in reducing errors where actions
required higher-level clinical decision-making.

This case study highlights the benefits of applying a
combination of theoretical frameworks/approaches
when identifying and developing error mitigation
strategies that include both technological solutions that
can achieve higher accuracy and reliability than human
processes, as well as user-centric based training
solutions that enhance clinicians’ understanding of the
systems they are controlling and thus their problem
solving skills.

Author Keywords
complex medical devices, AcciMap, Skill-Rule-
Knowledge conceptual framework, technology design,
user training, patient safety.

Introduction
Adverse events and medical errors pose a serious
problem to health care systems [3]. In 1999, the
Institute of Medicine (IOM) report, “To Err is Human:
Building a Safer Healthcare System” [4], concluded that
medication errors account for 7,000 deaths annually,
while total preventable medical errors cause between
44,000 and 98,000 annual deaths in the United States
alone. Even when considering the lower estimate,
Deaths in hospitals due to preventable adverse events
exceed the deaths attributable to motor vehicle
accidents, breast cancer, and AIDS combined [4]. The
IOM estimated that the annual cost associated with
preventable medical errors is as much as $29 billion US
annually. Similarly, research on incidence rates of
adverse events in Canadian hospitals indicated that
approximately 185,000 admissions per year are linked
to an adverse event, and that nearly 70,000 of these
may be avoidable [5]. Medication errors are the most
frequent cause of medical injuries, representing 19.4%
of all adverse events [6]. Furthermore, a subsequent
report by the IOM on medication errors [7] estimates
that a minimum of 1.5 million people are harmed yearly
due to preventable adverse drug events, suggesting
that every hospital patient may be subjected to as
much as one medication error per day. As a result of
these landmark reports, there has been an increased
awareness of patient safety issues over the past
decade, particularly in the context of medication safety.

Clinicians’ user errors and improper use of medical
devices have been linked to multiple patient injuries
[8]. Adverse events involving medical devices have led
to serious problems, including incorrect or delayed
diagnosis and treatment or patient injuries and deaths.
ECRI Institute [9] estimates that approximately 75
percent of the reported problems they receive are
related to user error. Specifically, the majority of
reported problems concern users who do not fully
understand the devices and systems they are being
asked to use. Recent statistics from the FDA show that
that between Jan. 1, 2005 and Dec. 31, 2009, there
were 56,000 adverse events associated with the use of
infusion devices in the United States and these resulted
in 710 deaths [10]. When errors involving medical devices occur, people typically blame the users rather than investigate broader systems factors that are likely contributing, such as a poorly designed interface between the medical device and the user, or inadequate user training. The Medicines and Healthcare product Regulatory Agency (MHRA) has identified inadequate staff training as a primary cause of incidents with medical devices [11]. There is a need to understand how to better ensure that (a) medical devices are designed for optimum capability and ease of use, and (b) clinician training is thorough and effective.

In health care, the objective of human factors is to improve human performance with medical devices and systems, and to reduce the likelihood of error or injury, thereby improving patient and workplace safety [12].

**Objectives**

In the present paper, we present a case study and discuss how we used complementary theoretical frameworks/approaches to determine the underlying cause of intravenous (IV) medication-related errors, and identify the types of errors that were best mitigated through improved device design, and those that benefited most from improved user training.

**Background**

The case study discussed in this paper focused on the safe delivery of IV medication therapies, as these procedures have become more complex over the years due to the introduction of technologies such as smart large volumetric infusion pumps. That is, to address the high incidence of infusion errors, manufacturers have developed pumps that have dose error reduction systems (DERS), which include hospital-defined drug libraries with dosing limits and clinical advisories (i.e., smart pumps). While traditional general-purpose infusion pumps have a wide range of acceptable programming settings/parameters, smart pumps are designed with drug-specific safety software to help nurses avoid programming errors. Smart pumps provide either a “soft” limit warning (allows nurse to override the limit and continue infusing) or “hard” limit warning (requires nurse to reprogram the pump within acceptable parameters). Although the purported benefits of these technologies are that medications can be given accurately and reliably at all times, clinicians often encounter difficulties using the devices, which can increase the risk of patient injury.

Secondary (also referred to as “piggyback”) infusion is a convenient set-up that allows clinicians to administer two medications intermittently to patients through a single channel in the infusion pump. Our own past experimental data demonstrated that the error rates for nurses to complete all secondary infusion task scenarios were as high as 50% [13]. Moreover, we identified that many secondary infusion issues, such as misalignment of infusion bags, errors in tubing setup, and the failure to open the roller clamp on secondary IV tubing, cannot be detected or intercepted by the commercially available smart infusion technologies that are commonly used in the clinical setting.

The lack of effectiveness of smart infusion technologies is attributed to the fact that these solutions don’t fully support clinical reasoning and problem solving [14]. Research has shown that medication infusion errors are not solely attributable to poor system design or lack of system integration [15]. A major factor in the failure to
reduce IV infusion errors is that abstract thinking tasks are essential to the final medication administration process, and current technologies do not support abstract clinical thought [14]. Although automating lower cognitive functions (e.g., perception, categorization) is effective in reducing workload by performing mechanistic tasks that would otherwise be performed by humans, it is not as effective at supporting higher order cognitive functions such as those required during critical thinking tasks [16]. Automated technical systems, such as smart pumps, are limited in that they are designed to deal with the foreseen. That is, technological solutions are based on tasks, actions, or procedures that can be anticipated and therefore built into the design [17]. The reality of health care environments, however, is that they are complex, dynamic, and often unpredictable [18]. Consequently, clinicians must be adaptive problem solvers. Therefore, complementary approaches are needed to benefit from the strengths of technological solutions that can achieve higher accuracy and reliability than human processes, while compensating for their weaknesses through novel solutions that enhance clinicians’ higher cognitive functions (e.g., reasoning, problem solving).

Application of Theoretical Frameworks
In response to the known issues associated with administering IV infusions, we conducted a study using multiple methods to (1) determine the comprehensive set of issues leading to IV infusion administration errors, and (2) identify potential solutions. To support the first objective, we used Rasmussen’s Risk Management Framework [1] to analyze the data collected through a literature review, incident database review, and ethnographic observations in clinical environments. Factors across the entire system were considered and the data were analyzed according to the cause-consequence relationships between factors at each level of the system. To support the second objective, Rasmussen’s Skill-Rule-Knowledge framework for human performance [2] was applied to determine whether each human performance issue represented a failure to apply the appropriate skills, rules or knowledge. Human performance issues associated with the failure to apply appropriate skills and rules were identified as issues where automation or infusion device design changes could potentially be most effective. Human performance issues associated with the failure to apply appropriate knowledge were identified as issues where improving the users’ mental model of the system could potentially be more effective. Laboratory-based simulations were conducted to uncover performance limitations and to test proposed benefits of improved technology designs and clinical training. In the following sections we describe the theoretical frameworks used in this case study.

A. Rasmussen’s (1997) Risk Management Framework
Several theories and analysis techniques exist to understand and model adverse events, such as Leveson’s systems-theoretic accident model and processes (STAMP) model [19], Reason’s model of organizational accidents [20], and Rasmussen’s AcciMap approach within his Risk Management Framework [1]. We opted for Rasmussen’s approach for several reasons. First, it is intended for modeling accident behaviour in complex socio-technical systems (such as healthcare). Second, because it supports looking across all levels of the system and at the
dynamic changes that occur over time that eventually lead to an incident. Third, because it compiles the multiple potential contributing factors to an adverse event in a single causal diagram that illustrates how factors interconnect. Consequently, the AcciMap diagram depicts the context in which an adverse event could occur and the potential contributing factors. The AcciMap enabled us to identify the complex interactions between factors that can contribute to IV infusion errors. These results then led us to the next phase of our study, which was to categorize these factors according to three basic task/error types: skill-based, rule-based and knowledge-based.

The AcciMap generated in this case study is too large to include in this paper. It contains over 100 data elements, spread across six levels of the system. However, Figure 1 illustrates a general approach to an AcciMap.

Figure 1. An approach to structure an “AcciMap” and proposed legend of standardized symbols. Reprinted from Rasmussen & Svedung, 2000 [21]

B. Skill-Rule-Knowledge Framework

Rasmussen’s conceptual framework for human performance structures tasks/errors into three basic types: skill-based (e.g., an execution failure), rule-based (error in applying a rule) and knowledge-based (errors due to a bias or mindset that dictates inappropriate solution for the given situation) [22]. Based on this framework, expectation of errors may relate to the familiarity and complexity of the task. Mechanistic tasks, which compare two tangible sources of information and require minimal stored knowledge, may be prone to skill- and rule-based errors. Abstract tasks requiring integration of knowledge from multiple sources and analytical thought processes for interpretation and evaluation of situations, relate to the knowledge-based level of error.

The skill-based level of human performance involves little thought and is generally related to preprogrammed instructions [22]. In the context of our case study (i.e., IV medication administration), a nurse neglecting to start an IV infusion due to a distraction is an example of an execution failure. Mistakes, either rule-based or knowledge-based, are associated with slightly more complex tasks. Rule-based mistakes relate to problems that occur despite training or experience due to an error in applying a rule. This may involve the misclassification of a situation or incorrect recall of a procedure (e.g., forgetting to lower the primary bag when delivering a piggyback infusion). Knowledge-based mistakes generally occur in novel situations of limited familiarity and rely on conscious, analytical processes and abstract knowledge. Failure to recognize an inappropriately prescribed dosage during
medication administration is an example of a knowledge-based mistake.

At the end of Phase 2, we concluded that current smart infusion pump systems solely address certain mechanistic tasks prone to skill-based and rule-based errors, and identified the need for clinical training that will also address abstract tasks prone to knowledge-based errors. Specifically, we identified that the unique focus of the training should be the elucidation of the mechanisms of higher order cognitive functions, under various conditions (e.g., routine vs. unexpected situations).

We identified existing technological solutions that could address skill and rule based tasks/errors, and developed a novel training tool aimed at addressing knowledge-based problem solving. Our unique focus was to develop error prevention strategies that are tailored to the type of task being performed (e.g., mechanistic vs. abstract) to better manage the various error types (i.e., skill vs. rule vs. knowledge). That is, we identified technology-based interventions that could help prevent skill and rule-based errors (e.g., automatic clamp detector that alarms users when a roller clamp is closed at the start of a secondary infusion) and developed a training-based intervention to reduce knowledge-based errors (e.g., incorrect bag height differential established due to lack of understanding of fluid mechanics).

Our training-based intervention consisted of an online educational module to reduce knowledge-based errors. This educational module incorporated a combination of audio narration, on-screen text, graphics, and animations. We empirically compared the effectiveness of our newly developed training-based intervention to the technology-based interventions on nurses’ ability to safely administer IV infusions. Results showed that safety-based improvements to known shortcomings in technology design for intravenous infusions were beneficial in reducing errors of omission (e.g., user knows that s/he must open the secondary clamp but forgets to perform the action). Conversely, training-based interventions (e.g., education module that addresses information on basic infusion principles and known failure modes) were beneficial in reducing errors where actions required higher-level clinical decision-making (e.g., managing flow of multiple concurrent infusions combined in a single IV line).

In sum, our research findings suggest that IV infusion errors are attributable to both; (1) the way the technology to deliver infusions is designed, and (2) clinicians’ knowledge of key infusion principles.

Conclusion
It has been well established that technological systems can achieve a much higher accuracy and reliability than any human processes [14]. Consequently, considerable attention has been directed towards automating these mechanistic tasks of the IV infusion process through design of smart pumps (e.g., bar code readers). Less attention, however, has been paid to other (non-mechanistic) components of the IV infusion system. Although automated technological innovations are effective at assisting in the performance of mechanistic tasks, they are not as effective at assisting in the performing of tasks requiring critical thought.

Automated technical systems are limited in that they are designed to deal with the foreseen. That is,
technological solutions are based on tasks, actions, or procedures that can be anticipated and therefore built into the design. The reality of health care environments, however, is that they are complex, dynamic, and often unpredictable. Consequently, clinicians must be adaptive problem solvers. Thus, mitigation strategies aimed at reducing medication administration errors must include both technological solutions that can achieve higher accuracy and reliability than human processes as well as user-centric training solutions that enhance clinicians’ problem solving skills. Through our case study, we have shown how Rasmussen’s Accimap enables the identification of causal chains to patient harm, and his SRK framework allows for an understanding of the behavioural or psychological processes involved in the identified errors.

Acknowledgements
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Integrating Cognitive and Socio-Technical Theoretical Perspectives in Health Informatics

Abstract
The purpose of this presentation is to present our approach to integrating cognitive and socio-technical theoretical perspectives for assessing the impact of health information systems. The objective of this work is to lead to the design of health information user interfaces and systems that better meet the information and workflow needs of health professionals. Previously, health informatics research has typically focused either on the cognitive or the socio-technical aspects of health information systems separately. In this workshop we demonstrate how evaluations of health information systems can be designed that take into account theoretical aspects related to cognition as well as socio-technical aspects, including the impact of systems on workflow. Using a case study, we illustrate use of clinical simulations to bring in and integrate both cognitive and socio-technical theoretical perspectives in evaluating health information technology prior to and after system release.

Author Keywords
Cognitive theory; Socio-technical theory; Distributed Cognition; Usability; Health Information Technology;

ACM Classification Keywords
Human Factors; Health Information Systems; HCI

The authors wish to pay for the work to be open access.

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Introduction

Two important theoretical views that have influenced HCI research in health informatics research have been the cognitive perspective and the socio-technical perspective. Each of these theoretical perspectives has had an important impact on the design and evaluation of health information systems and HCI in healthcare.

1. Cognitive Perspectives: Cognitive perspectives for understanding HCI have been dominant for the design of interactions with health information systems, with the application of the human information processor model in many studies. Much of this work has focused on the impact of health information systems on individual cognition. For example, early cognitively focused work in healthcare [1] found that the screen design and layout in an electronic medical record could profoundly affect health professional’s information processing activities (i.e. including decision-making and reasoning processes). This work documented a close relationship between the design of an electronic medical record user interfaces and cognitive processes such as diagnostic reasoning and medical decision making [2]. This work led to a wide range of studies that examined the implications of interface design and HCI on health professional cognition.

Along these lines, Kushniruk, Patel and colleagues [1,2] took a cognitive approach to examine the effects of interface design upon the knowledge, organization and reasoning strategies of physicians when working with health information technologies. In this work it was found that electronic medical records could "shape the way in which health care workers obtain, organize and reason with knowledge" [2]. The layout of information in the electronic medical record was found to affect diagnostic processes. Furthermore, even after physicians returned to using a paper patient record after using an electronic medical record, the residual effects of using the electronic record format were documented. Extensions of this work were conducted in the 1990s where doctor-patient-computer interactions were video recorded and analyzed as the health professional interacted with electronic health records [2]. These studies also showed that physician interaction with the electronic medical record during doctor-patient interviews was greatly influenced by the electronic medical record’s organization of information and the design of the user interface. Such studies have been used both to evaluate systems in use as well as to predict usability problems with systems before release.

2. Sociotechnical Perspectives: In the 1990’s new theoretical perspectives began to emerge and be applied in design of health information systems. For example, distributed cognition, which views information processing in human-machine systems as being distributed across a number of different "agents" (including both human and machine) began to emerge. In addition, socio-technical perspectives in health informatics began to appear as greater consideration of social and organizational context began to appear. This was in part due to the failure of many implementations of health information systems worldwide. Ash, Berg and colleague’s [3] work and the work of other socio-technical researchers such as Aarts [4] have argued that the origins of many of these implementation failures are socio-technical in nature. In particular, poor fit among health professionals, information systems and the organization where the systems are implemented lead to a range of adoption and appropriation failures involving the technology (i.e.
unintended consequences). Changes in organizational structures (e.g. management structures, organizational power structures) were reported as a result of implementation of health information systems, including changes to the organizational environments and alteration in the relationships between patients, health professionals and health professional teams in these healthcare organizations.

In support of the socio-technical view, Wu’s [5] meta-analysis of the effects of health information systems on the quality and safety of healthcare has shown that socio-technical fit may be key to achieving positive health care outcomes after implementing health information technology. Furthermore, many purchasing healthcare organization have ended up adopting the processes and practices of the organization on which the design of the technology was modeled, often leading to poor technology-organization fit [5]. This may have led to implementation failures and end user issues including bypassing system functions, failure to use system functions, boycott of systems and functions being used in unintended ways. This may even have lead to inadvertent changes in the way care is delivered and limited improvements in the quality of patient care after implementing systems [5]. Overall, the socio-technical approach has argued for greater understanding of use of technology within the complex environments it is deployed in. However, such study has typically been conducted after systems have been deployed (i.e. late in the system development life cycle).

Case Study: Integrating Cognitive and Socio-technical Perspectives Through the Use of Clinical Simulations

To bridge the gap between work conducted from a cognitive perspective with the need to consider workflow and organizational issues related to HCI in healthcare, in this workshop we will present a recent case study. The study illustrates the need for identifying where instances of poor cognitive, socio-technical or cognitive-socio-technical fit may not lead to health care improvements. The case study also illustrate how an integrative theoretical perspective that integrates both cognitive perspectives with socio-technical approaches can lead to improvement in the usability and safety of healthcare information systems.

In this work we have employed methods based on a combination of study of user interactions as the cognitive level with clinical simulations that allow researchers to examine both the cognitive and socio-technical impact of the introduction of systems. In this case study a medication administration systems [6] was studied, which included both laboratory-based artificial studies and clinical simulations. This approach initially involved conducting usability tests under artificial laboratory conditions. Although this phase identified cognitive issues related to usability it did not take into account the complex socio-technical aspects of use of the system in carrying out work tasks. To address this, the initial testing was followed by high-fidelity simulations that we conducted in-situ in the organizations where the technology to be studied was to be implemented. By linking results of cognitive studies (involving usability testing) with subsequent studies conducted in real health environments, we have been able to identify and predict a range of serious
issues (e.g. users unable to find medications, locking out of multiple users etc.) with HCI before widespread system implementation. In an extension of this work we conducted both usability testing and clinical simulation studies of users of a new medication administration system [6]. Participants (nurses and physicians) were first presented with realistic cases in a usability testing laboratory in order to identify low level cognitive usability issues and impact of the system on health professional’s decision making, using the “think aloud” method. After a round of improvements and customizations based on this work, participants were observed interacting with the system in the real organizational context (i.e. in-situ in the context of the hospital setting). After video recording of user interactions from multiple perspectives, cued recall and interviews were conducted with all participants post-task to provide insights into participant’s individual perspective.

Video analysis of the participants interacting with the system in isolation as well as analysis of human-computer interaction with the system involving patients were integrated to obtain a more comprehensive picture of the effects of the device and system upon health professional-patient workflows than would be obtained by using either approach in isolation. At the socio-technical level it was found that the system dramatically impacted health professional’s workflow and interaction with other healthcare professionals and patients (in particular causing the workflow to become rigid and highly sequential). Furthermore, under situations involving emergency and stress the new system could lead to predictable error and this information was fed back to the implementation team.

Discussion
The approach described is based on different theoretical perspectives and blurs the distinction between study of cognitive aspects and simulation to explore socio-technical issues. From our experience an integrated approach to understanding HCI in healthcare is needed and can lead to improved system design. The clinical simulation approach also allows for consideration of socio-technical aspects prior to full deployment of systems (when changes are more likely to be made to the system). The researchers suggest the integration of these approaches can allow for a more comprehensive and integrated view of how information systems affect health professional work in organizational contexts. This “cognitive-socio technical” perspective is presented and discussed, along with practical experiences in using a combined methodological approach based on integrating differing theoretical perspectives.

References
A Complexity Theory Perspective for Defining the Digital Persona of HIT Usage

Abstract
It is common for unintended consequences to arise after implementing health information technology (HIT). These consequences occur because HIT creates a digital chasm between the manner in which people conduct business processes pre and post-HIT. Human Computer Interaction (HCI) issues can provide meaningful insight about the digital persona in which people interact with HIT and how we can better design and evaluate HIT to mitigate the digital chasm. In this paper we use complexity theory to analyze HCI issues from the implementation of a perioperative information system. The insight from our analysis provides insight on how we can design HIT to support the digital persona of end users.

Introduction
Our ability to design and evaluate health information technology is often hampered by the complexity of the processes where HIT is used. More specifically, we automate processes without understanding their impacts on other processes. Yet it is often the situational contexts that define how a HIT works in specific settings [1]. Contexts shape the interactions of people, processes and technology, and often not in predictable ways [2]. A better understanding of

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Complexity theory; Digital Persona; Health Information Technology;

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contextual fit would help us improve the design and evaluation of HIT [3].

A consequence of not having contextual fit between HIT and the situation where it is implemented are issues such as technology induced errors, communication issues and workarounds [4,5]. Complexity theory can help us understand contextual fit, specifically the interrelationships and degree of interrelatedness between processes [6]. Complexity theory has been used to study processes like discharge or handover that are complex and have a high degree of interrelatedness [6,7]. A key tenet of complexity theory is the non-linearity of processes and how behaviors and tasks emerge as a result of the non-linearity [8].

Figure 1 shows our perspective on the digital persona, which defines the activities and manner in which people engage with technology. Overall the persona is poorly understood and there is often a significant gap between the ostensive (i.e. ideal representation depicted through flowcharts and models) and the performance (i.e. what actually takes place in real settings) dimensions of a task [9]. We refer to that gap as the digital chasm.

Complexity theory has not been used to empirically study HCI issues. However we believe it can provide valuable insight on the complex and non-linear processes that spawn HCI issues. In this paper we use fig.1 as a framework to study HCI issues using complexity theory. Our objective is to better understand the digital persona and more importantly, to provide insight on how to design and evaluate HIT to overcome the digital chasm.

**Case Study**

We conducted a study of a perioperative system called the Surgical Information Management System (SIMS). SIMS was implemented in April 2009 in a multi-campus hospital in an urban Canadian City across all perioperative areas (pre-admit unit (PAU), same day admit (SDA), surgical day care (SDC), operating room (OR) and post-anesthesia care unit (PACU)). The goal of SIMS was to bring common data and connectivity across the perioperative spectrum. From April 2012 to June 2013 we conducted over 130 hours of non-participant observations across all the perioperative areas and campuses. We also conducted 8 interviews and 3 focus groups with different categories of users including anaesthetists, nurses and managers. The observational notes were transcribed into written notes that documented users, activities and processes. The interviews and focus groups were transcribed verbatim. We analyzed the case study using four tenets of complexity theory: non-linearity, emergent behavior, connectivity and process variation, in order to identify HCI issues.
Results
We briefly discuss the analysis from each complexity tenet and how it helps us understand the digital chasm.

Non-Linear Processes
Changes in one area affect tasks in another area, often in non-linear ways. PAU is the patients first touch point and it is where the digital persona starts. In the pre-SIMS system anesthetists would highlight or bold patient issues that would be important in subsequent areas. This feature was not was not available in SIMS and it resulted in issues down the perioperative spectrum on the day of surgery and beyond. For example, patients with latex allergies are supposed to be the first surgery of the day to prevent exposure to latex. However because a latex allergy was not highlighted in PAU it resulted in a patient’s surgery being scheduled later in the day.

Emergent Behavior
HCI issues can result in emergent behavior caused by HIT. One emergent behavior was the ‘over automation’ paradox. It was identified that people were more than they needed to because of the ease of clicking on a field to enter data. Some fields only needed to be charted once per hour but nurses were charting them every time they assessed the patient. One nurse described this problem: “I think some people are documenting a lot more than they needed to document. I often found myself saying, "Did you do that on paper?" And they would say, "No." And I’m saying, "Well then, why are you doing it now?". Excess data presented a problem in that it swelled the perioperative reports making them excessively long but more importantly make it harder to find relevant data about a case as it was buried within unnecessary data.

Connectivity
Connectivity caused by HIT can lead to unintended issues. An example of a connectivity issue took place in the OR. During observations there were several instances where the anaesthesitist would put a memo in SIMS to help patient care when the patient gets to PACU. An example could be a memo saying the patient’s blood pressure is prone to spikes. However, because there was no common protocol on where memos should be put, nurses in PACU may not see the memo. Another connectivity issue was assuming that module interoperability exists. Each perioperative area has a unique SIMS module. However there are variations in interoperability between different modules. In the OR Manager module nurses were charting in a particular field about an antibiotic given in the OR. However, that field did not transfer to the PACU module, so the nurses there could not see that the medication was given. A nurse in PACU commented ‘until last week, we did not know the OR nurses were giving anything [in the OR]...”. HIT mediated connectivity can be problematic. At best connectivity is unhelpful if not seen, and at worse, it could lead to medical errors or adverse outcomes.

Process variation
The manner in which different clinicians interacted with SIMS varied greatly across the perioperative areas. Data entry is an example of such a process. In PAU the objective is passive data entry about patient history. In the OR data entry is active real time entry about the patient’s surgery. Anesthetists described how a benefit of the paper based system is that writing down complex drug data helped them think about the data. In SIMS the data entry is a drop down menu which did
not provide the same cognitive stimulation. Another process variation was the need for mobile data entry. In the pre-SIMS paper system an anesthetist could chart on the edge of the bed. In the OR the cart with the PC is about 15 feet away from the patient. As a result anesthetists may have to remember drug doses or other data to chart it later. As a work around one anesthetist wrote drug doses on his scrubs at the side of the bed and later entered the data into SIMS.

**Discussion**

This paper used the tenets of complexity theory to identify HCI issues from the implementation of SIMS. While existing research has acknowledged the complex nature of HIT we extended that work and identified specific HCI issues caused by complexity. These issues enable us to better understand the digital persona and how to close the digital chasm that exists between current and automated business processes.

It is essential that we focus on HCI issues at key interaction points. HCI issues at PAU led to a ripple effect down the perioperative spectrum that was not linear but exponential. We also need to pay attention to process variation as a driver of HCI issues. For example, the loss of charting mobility in the OR caused huge HCI issues for anesthetists and could pose safety risks by forcing anesthetists to remember essential data. Finally there were several emergent HCI behaviors that were spawned by HIT.

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**References**


Using A Third-Wave HCI Approach for Researching Mobile Medical Devices

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Abstract
Theoretical frameworks are often applied and created in the HCI healthcare fieldwork domain, but for less contained non-clinical settings such as mobile devices used on the go, there has been little exploration of theories involving user experience. In this paper, I will introduce a project that is focusing on the situated use of mobile medical technologies by people with Type 1 diabetes and the user experience theories that are framing this work. Using user experience frameworks that have developed from the third-wave HCI shift from focusing on technologies used in the workplace to technologies used in everyday life, I present how they might be connected to the evaluation of medical technologies used by laypeople for the self-management of their own health and safety.

Author Keywords
Healthcare; user experience; diabetes; mobile; theory.

Introduction
There is a worldwide trend to move patients out of clinical settings in order for them to self-manage health conditions at home with medical technology [6]. This move is meant to reduce the cost of hospitalizations as well as improve quality of life by allowing patients to live more independently, but issues arise with taking medical devices outside professional institutions. Some devices must be used on a more regular basis and have to be used by laypeople such as caregivers and patients. These medical devices can be used in people’s homes, but some devices must be with the patient throughout the day, which means that the devices have to be mobile and they will not be used in static contexts.

My research is on one such group of mobile medical technologies: those used for the self-management of Type 1 diabetes. Type 1 diabetes is a chronic condition that requires a lifetime of everyday self-management [7], and the technologies to aid these practices can be used anywhere, anytime, and with anyone. As such, the user experience of the device is an important consideration, and has shown to influence adoption and use of these medical devices in my preliminary results [8]. User experience theories have been used to plan the studies, choose the data collection methods, and conduct the studies with users.
of Type 1 diabetes technologies, and they will also be used to frame the analysis.

**Everyday Type 1 Diabetes Technologies**

In order to manage blood sugar levels, people with Type 1 diabetes use a variety of tools and technologies and because of the complex nature of the condition, people’s adoption and use of diabetes technologies differ significantly. The technologies focused on in this research include glucose meters, continuous glucose meters, insulin pumps, and mobile phone applications.

Glucose meters are used to measure blood glucose levels. These measurements are used for everyday calculations of medication doses as well as identifying hypos and hypers [10]. The meter is used in conjunction with a finger-pricking device or lancet that is usually used on the tip of a finger. The small droplet of blood is put on a testing strip that is used by the meter to test blood glucose levels.

Although people with Type 1 diabetes use glucose meters manually several times per day, there are technologies that allow more consistent monitoring but they are not that commonly used. Continuous glucose meters are used to give blood glucose readings every few minutes [4]. A sensor is attached to a person’s torso with a small needle inserted to test the level, which is communicated through a small wearable transmitter to a receiving device.

Insulin pumps can come in a few different form factors, including attached to the back of a user’s arm or in a pager-sized device that is attached to a tube on the abdomen of a user. They require power from batteries, liquid medication from vials added to the device by the user, and also for the user to use it like a remote to control the injection of medication through the tube. When the are used properly, they can help control blood glucose levels better [11].

In order to maintain their condition, people with diabetes can turn to personal informatics sources, including tracking their own health data and getting suggestions for insulin doses using applications (apps) that they have downloaded on their mobile phones. There are many apps currently on the market: a quick query of smartphone application stores for diabetes related applications results in a large search result (over 1500 in the Android Play store at the time of writing).

Although people with Type 1 diabetes can choose to use a variety of these mobile technologies, the majority have used at the least one for many years: a glucose meter. As such, they are an ideal set of users to explore the influence of user experience on the use of mobile medical technologies through third-wave HCI approaches.

**Third-Wave HCI Approach**

There has been a shift in HCI to address the move from technologies used in the workplace to ones that pervade everyday life. Third-wave HCI seeks to address issues of emotion, needs, values, etc, in the design of interactive technologies [2]. The problem is, modern medical devices that resemble third-wave technologies challenge traditional definitions of usability, and distort the boundary between medical devices and consumer technologies. Some of these technologies are mobile, and as such, are used in many different environments in ways that are hard to predict.
Suchman first presented the idea that plans do not always represent the actual performance of tasks in the situation [9]. Through looking at the use of a photocopier machine, she was able to observe that the task breakdowns in plans did not represent the actions those using the technology actually did in the situation. Plans are inherently connected to the situations in which they are used, and therefore are context-dependent. This flew in the face of traditional HCI researchers who did not take sufficient account of the 'situatedness' of actions, relying on traditional accounts of cognition as internal and independent of context in interaction design. Her work has been highly influential in HCI, and particularly for those looking at the influence affect can have in interaction design.

Affective experience is hard to define and attempts may seem reductionist, with Boehner, Sengers and Warner claiming that for the related concept of an aesthetic experience, "most maintain that it cannot be fully understood through rational explanation but must be lived" [3]. These researchers fall into the interactional approach to affect [3]. They suggest the traditions of HCI are rationalistic, and many might approach defining aesthetic experience by formal and HCI legitimate methods. Although HCI values formal models, taxonomies, and context-independent methodologies, limitations to these methods are quite significant as they are all reductionist in nature. Opposed to delimiting emotions, they claim that emotions are culturally informed and experienced dynamically, influenced by action and interaction.

Like the interaction as affect perspective, McCarthy and Wright’s Technology as Experience approach does not attempt to reduce emotion to definable components and focuses on the entirety of the experience with technology [5]. It goes beyond the interactional approach in that it does not treat emotion separately, but rather as a part of a holistic ‘experience’. The authors suggest a move from a deterministic view of design to acknowledging users’ agency: not designing an experience but designing for experience. The authors argue against taking the richness of experience and trying to reduce it to “design implications, methods, or features” [5], although this leaves designers with a fuzzy concept to work with. McCarthy and Wright take examples from art and literature as inspiration about the way we should deal with interactive systems: it is not just the design of the system, but rather the entire experience of interacting with the technology in context which is of importance.

**Third-Wave Mobile Medical Device Research**

The third-wave approach shifts HCI from a focus on strict usability towards looking at user experience. HCI has progressed from seeing a user as a cog in the system to a source of error to a social actor, and now users are seen as consumers. As such, user experience is an important concern for the adoption and use of third-wave technologies, even those used in safety critical domains such as healthcare.

Affective experience should be a consideration for something that might elicit strong and complex emotions, such as using a mobile medical device on your personal being when your health or welfare is at stake. By making assumptions for a certain population, emotion, context, etc., the device might be designed inappropriately. As such, my work on mobile medical technology has used these third-wave influences to frame my research approach.
Although the medical usability standards [1] do note the importance of context, the methods recommended by the standards do not fully accommodate the range of emotions and experiences that could accompany the personal use of mobile medical devices in context by patients. As such, I am exploring the use of methods used in the user experience domain, such as autoethnography, contextual interviews, diary study, and contextual focus groups.

Additionally, how the studies were conducted was influenced by the focus on affective experience. I started this body of work with a self-study in order to gain empathy for some of the experiences that mobile medical device users go through [8]. This also influenced how the diary study was planned as it allowed me to experience what it is like to have to add another step when using a medical device in order to collect data. The interviews were conducted with a focus on the user experience and context of use of the device, with questions that explored people’s past experiences with the devices. The interviews were conducted in a semi-structured manner in order to allow more open comfortable conversations about past affective experiences.

I intend to use the Technology as Experience approach to not delimit emotions and experience when examining the use of these devices. By first focusing on the adoption/non-adoption and use/misuse and then looking at the greater context in which these actions happened, I hope to explore the influence that affective experience has on this user behaviour.

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References
ViA - Values in Action within Healthcare

Abstract
The shift in HCI towards emotions, values, needs etc., (third-wave HCI) reflects a new understanding of interactions between users and technology. We identified a lack of suitable theory, frameworks and concepts, which provide an integrated view on values as well as on usability, user experience and user acceptance [6]. Therefore, we applied the Values in Action (ViA) approach, which aims to support healthcare related Ambient Assisted Living (AAL) projects, in order to develop valuable ICT solutions for older adults, their relatives and formal care giver. It helps to understand what is valued by different users.

Author Keywords
User-Centered Design, Value-Centered Design.

Introduction
As older adults are increasingly ageing in place as a preferable alternative to institutional care, a lot of new ICT solutions are developed for them within healthcare. The acceptance of these technologies and services depends on obvious advantages and benefits, like functionality, utility, usability, price/financial resources, (data) security and adequate (i.e. barrier free and not stigmatizing) design but also on the technological experiences of older adults.

We are interested in those aspects of the technology, which account for the users’ values, in order to develop valuable prototypes within two healthcare related projects.
Ambient Assisted Living (AAL) projects (CVN\(^1\) and GeTVivid\(^2\)). These aspects can be related to how usable the technology is, but also to how the users experience the interactions with and via the technology, as well as the acceptance of the technology. Therefore, we applied an approach that combines value- and user-centered design with factors related to usability (U), user experience (UX) and user acceptance (UA).

**The ViA Approach**

During a literature review on values, U, UX and UA, we came across value-centered design [5] and value sensitive design [7]. However, both were not sufficiently suitable for our purposes, as they are rather abstract and the integration of U, UX and UA factors was not practicable for us. Additionally, we encountered the theory of consumption values (TCV) [11], which was used by Hedman and Gimpel [9] to explain the adoption of a hyped technology, i.e. the iPhone. The most salient finding was that it encompassed aspects of U, UX and UA aspects per se. The TCV focuses not only on functional values, but also on hedonic qualities (e.g., emotional or epistemic values).

We called our approach *Values in Action (ViA)* as it is based on the consideration that values can include the user’s perspective (e.g., emotions, experiences) as well as technological aspects, which are important for our projects. Figure 1 illustrates the six values (that we already proposed earlier [6]) and the assigned potentially relevant U, UX and UA factors for AAL projects. In other AAL projects, we have used ViA for evaluating ICT solutions and wanted now to apply it in the whole development process.

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1. [http://www.connectedvitality.eu/](http://www.connectedvitality.eu/)

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**Figure 1: ViA U, UX and UA [6]**

The functional value, which is defined as the perceived utility for achieving a specific task or a practical goal, refers directly to the UX factor perceived sociability (e.g., [10]), to the UA factor perceived ease of use and perceived usefulness (e.g., [4]), as well as indirectly to many usability factors like efficiency and effectiveness (e.g., [2]). The epistemic value, which is related to experiencing new products, captures the UX (and also UA) factors curiosity and learning (e.g., [12]). The conditional value referring to products being tied to specific contexts is similar to the situational context, like Grill and Tscheligi [8] understand it. The social value, as the symbolic importance of the artifact for conveying social image, can be linked to the UX factors social image (e.g., [3]) or self-expression (e.g., [12]). Finally, the emotional value is the potential of the product to arouse emotions, which are believed to
accompany the use of a product. Taking UX factors like fun/perceived enjoyment (e.g., [14]) or computer anxiety (e.g., [14]) into account.

In this way we assigned many U, UX and UA factors, which we identified in literature, to the values as long as they were relevant in our project context. However, in the end some factors were remaining, as they did not fit to a value so far, like the UX factors social presence (e.g., [1]) and social connectedness (e.g., [13]). Therefore, we added the ‘interpersonal’ value, which refers to the experiences while an interaction between humans via a technology, but not for the purpose of self-presentation. The difference to the social value, which might at the first glance have also been appropriate for the above-mentioned factors, is its goal referring to the social image, i.e. representing oneself in a certain group of people.

**Application of the ViA Approach**

In both projects we started with the user requirements analysis and identified needs in workshops, interview and a survey. On basis of the ViA, we identify relevant values at the end of the analysis phase, which are connected to aspects of the technology and are important for the end users in order to actually use the system. For identifying the values and factors we analyzed the results report again with the help of an affinity diagram. These values are an integral input for the concept, design, and development phase, and also serve as a basis for the evaluation phase. Although the functional value consists of many different factors, other values might be equally or even more important.

Our approach not only presents a pool of potential user values, but also offered the possibility to weight them according to the users’ requirements, their needs and wants. The most important values and factors guided then the design/development phase, e.g., helped to prioritize functionalities together with user needs or develop an ICT solution with an added value.

The aim of the evaluation phase is to figure out whether the ICT solution satisfies the users’ needs, wants, and whether it delivers the intended values. For conceptualizing the evaluation phase our approach takes into account the manifoldness of the users’ requirements regarding U, UX and UA. In our lab studies the functional value is of particular importance as typically only limited prototypes are tested. In our field studies the weighted values and related factors helped us to prioritize them, as not everything could be evaluated in detail (otherwise the user studies would have become too extensive for our older adults).

**Discussion**

We emphasize that ViA is an open approach and believe that for other projects and user groups different factors or values might be appropriate. Additionally, one ViA per project might not be enough and different ViAs (containing different factors with different weights) are needed for the different user groups (i.e., older adults, relatives and care givers). This can help to prioritize the development of functionalities addressing values being most important for the user groups. This ensures that the developed system is valued by user groups.

**Conclusion**

We extended the theory of consumption values [11] with U, UX and UA factors and combined it with user-centered design to provide a valuable framework for developing appropriate ICT solutions within healthcare.
for older adults. With our approach we try to combine theory with applied user research in order to inform the design and development of ICT solutions from different perspectives. Even if the current collection of values and related U, UX and UX factors is not complete, we think that they may help to get a balanced view on the healthcare solution. In order to not only address potential deficits to be compensated by the technology, it offers a perspective also on potentials and benefits that may arise.

Acknowledgements
This research was enabled by the CVN and GeTVivid project (funded by AAL JP). Special thanks go to the end user organizations which support us in conducting the studies for our research and the technical partners for providing access to the developed technologies.

References
Collaborative Reflection: Long-Term Sensemaking in Health Services

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Abstract  
Fieldwork in health service settings has mainly explored collaborative sensemaking as a short-term activity. However, not all providers perform sensemaking in order to make time-critical decisions that could be the difference between life and death. In this paper we present fieldwork that reveals long-term sensemaking. We use the term collaborative reflection to distinguish this type of sensemaking. We discuss how (1) the features of an organization, and (2) the long-term nature of services, affect sensemaking activities and make collaborative reflection a new and unique concept. The goal of this theoretical framework is to inform the design of different classes of systems for different types of sensemaking activities.

Introduction  
Sensemaking is the process of constructing an understanding by piecing together information, and “making sense” of the aggregated information. The outcome of sensemaking is generally decision-making based on the understanding gained, and action based on that decision. Sensemaking has been discussed in the literature of various disciplines, especially since Weick’s seminal work *Sensemaking in Organizations* [18]. In this paper, we take a similar organizational perspective (rather than cognitive or individual) and thus refer to collaborative sensemaking.
In health services, collaborative sensemaking has typically been viewed as a short-term process. Health service organizations are often required to make time-critical decisions (e.g., scheduling and coordination of resources [1], handoffs [3]), and some can have life-threatening consequences (e.g., surgery [2], trauma resuscitation [5]). Much of the literature has focused on the need to provide sensemaking support for this type of short-term sensemaking, when quick decisions can mean the difference between life and death.

Our fieldwork in behavioral and mental health organizations revealed a need to support a different type of collaborative sensemaking, which is long-term.

**Fieldwork**

The first kind of organization we studied was a psychiatric clinic. Our focus was on the long-term relationship between a psychiatrist and a patient receiving outpatient treatment for bipolar disorder. We studied three psychiatrists and seven of their patients. Bipolar disorder requires lifelong monitoring and treatment in order to manage and prevent critical episodes of depression and mania. Treatment is also highly individualized. An effective and satisfactory combination and dosages of psychiatric medications for each individual can take years to get right. In addition, psychotherapy and coaching over time can help an individual learn personal warning signs and reduce or avoid critical incidents and hospitalizations.

We also studied seven organizations providing behavioral and mental health services for children with special needs in a special education setting. Children received support—in the form of added structure and integrated behavioral therapy—for developmental, emotional, or behavioral issues including autism spectrum disorders, attention deficit hyperactivity disorder, oppositional defiant disorder, and anxiety. Their treatment can be considered long-term because it will take a minimum of several years for progress to be made with treatment. Treatment teams were individualized to the needs of each child, and consisted of a subset of the following: psychiatrists, clinical supervisors, speech therapists, occupational therapists, and behavioral specialists.

Due to the long-term nature of treatment at the organizations we studied, sensemaking was ongoing and informed frequent decisions about the course of treatment. In the following section, we describe the qualities of the organizations, and how the long-term sensemaking we observed differed from short-term sensemaking in the literature.

**Loosely vs. Tightly Coupled**

The organizations we studied were loosely coupled in order to provide individualized and long-term services. A loosely coupled organization lacks rigidly defined roles and formal ties, so collaboration occurs informally as needed to serve the needs of its clients (see Table 1). As a result of these qualities, technology tends to be unavailable or problematic for supporting services. Indeed, we observed a lack of technology adoption due to a need for flexibility and adaptability which only paper has been able to provide.
In contrast, a tightly coupled organization involves formal ties that prescribe coordination and collaboration. Due to the qualities outlined in Table 1, technology can be well defined for this kind of organization, including decision support systems for deductive logic, and electronic medical records for standardization.

<table>
<thead>
<tr>
<th></th>
<th>Loosely coupled</th>
<th>Tightly coupled</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Adaptability</strong></td>
<td>Adaptive to individual and environmental needs</td>
<td>Less adaptive</td>
</tr>
<tr>
<td><strong>Logic of service delivery</strong></td>
<td>Inductive; services are customized for individual needs and malleable over time</td>
<td>Deductive; deduces individual needs based on an assessment and delivers services according to protocol</td>
</tr>
<tr>
<td><strong>Innovation</strong></td>
<td>Promoted because small and relatively powerless units of the system must respond in new and better ways to environmental pressures</td>
<td>Rigidly defined roles can stifle innovation; high potential for developing and diffusing innovation once it is standardized</td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td>Problems are difficult to define and standardization is avoided, so technology is unavailable or problematic</td>
<td>Problems and technologies are well defined</td>
</tr>
</tbody>
</table>

Table 1. Comparison of relevant qualities of loosely and tightly coupled organizations, adapted from O'Looney [1].

**Effects on Sensemaking**

We found that the long-term nature of treatment in loosely coupled organizations had significant effects on sensemaking. We use the term collaborative reflection to distinguish the sensemaking we observed, which was characterized by the factors described below.

**Inclusion of many perspectives**
The complexity of individualized long-term treatment requires many perspectives from providers with different expertise and knowledge. In addition, with more time available there is increased opportunity to include more perspectives as needed.

**Potential to identify broader trends**
Long-term sensemaking also enables providers to explore large amounts of data and identify trends. For example, psychiatrists were working with patients with bipolar disorder to identify personal warning signs that can help them predict, and therefore prevent, the recurrence of critical episodes of depression or mania.

In schools, psychiatrists and clinicians wanted to compare behaviors of students in the same classroom, behaviors of siblings in different classrooms, and behaviors based on period in order to identify behavioral patterns that could inform intervention.
Unfortunately, none of these providers had the tools to support such sensemaking. The only tools available to them were paper data sheets and software that lacked scalability for their client caseloads. They expressed many ideas for how they might look for informative patterns in the data, and noted the limitations of their existing tools, but they knew of no other options.

Challenges of introducing standardization
Standardization in tightly coupled organizations supports sensemaking activities. In loosely coupled organizations, introducing standardization is challenging and can be frustrating for providers, since their focus is long-term. We observed that a long-term focus on services meant that providers were concerned with larger goals, and frustrated with minor tasks that were not, to them, directly connected to those goals. Without defined work roles and protocols, it appeared supervisors and agencies determining new requirements were not realistically taking into account the workload of providers meeting the individual needs of clients based on long-term goals.

Conclusion
This paper defined the concept of collaborative reflection, a type of collaborative sensemaking that is a long-term activity. Table 2 situates the collaborative reflection we observed in behavioral and mental health services among other types of collaborative sensemaking. Collaborative reflection is found in loosely coupled organizations that perform long-term sensemaking. A lack of defined roles within an organization provides opportunities for collaborative sensemaking, as well as unique challenges. In addition, the ability to focus on long-term treatment goals gives providers flexibility to explore data in sensemaking and identify broader trends. Future goals of this work are to develop a deeper understanding of how sensemaking activities are affected by organizational features and a focus on long-term treatment goals.

<table>
<thead>
<tr>
<th></th>
<th>Loosely coupled organization</th>
<th>Tightly coupled organization</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time-critical sensemaking</strong></td>
<td>Social services (child protective services)</td>
<td>Emergency medicine (emergency department)</td>
</tr>
<tr>
<td><strong>Long-term sensemaking</strong></td>
<td>Behavioral &amp; mental health (special education)</td>
<td>Medicine (general practice clinic)</td>
</tr>
</tbody>
</table>

Table 2. Examples of services and organizations based on coupling of organization and temporality of sensemaking.

References
Exploring Patient Experience PX

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Abstract
This paper contributes to the discussion and definition of patient experience (PX). The aim is to promote discussions around the concept and its conceptualization. Our experience is, that in order to support patient-centredness in healthcare and user-centred development of related services and technologies, we need to understand following: What patient experience is about? How can it be defined, researched and measured?

Introduction
Healthcare is moving towards employing a more patient and consumer centric practices and approaches. Such a shift is reflective of the need to provide high quality services that lead to a pleasant if not even enjoyable patient experience. Patients – or more broadly users of healthcare services – are becoming more and more demanding of healthcare providers and organizations where health services are concerned.

Patient experience (PX) has started to emerge in the design and professional discussion [1]. PX has been identified to be one of the top three priorities of for hospital leaders in the next three years [12]. The concept has also been included in the development goals for public healthcare in UK. Our own experience is similar: Our recent activities in ongoing activities in the capital area of Finland (the new children’s hospital [3] and the Apotti programme [4]) indicate an urgent need to define and operationalize PX. Emerging consumer health information technologies such as personal health records and consumer health applications bring such healthcare information, technologies, and services to citizens’ use that were previously targeted for healthcare professionals only.
Despite these needs, there is little research literature that fully describes and defines PX. Such a definition would support patient-centred design and the evaluation of healthcare services from the end-user perspective. In addition to the high-quality medical treatment, properly defined patient experience facilitates the design of technologies and activities for comprehensive and balanced high-quality care.

Gerteis et al. [5] point out: "What patients experience, and what they think of that experience, should also matter to healthcare planners, policy makers, and managers, because the experience as much as the technical quality of care, will determine how people use the healthcare system and how they benefit from it." This statement underlines the need for creating a better and shared understanding of what PX is, how it can be studied, measured, and designed.

**Citizens, Customers, Patients, Users**

Patient is an established concept for describing citizens or customers of healthcare services. However, one can argue that not all end-users in healthcare are patients. Patient, citizen, and customer emphasize different viewpoints, but none of them is fully appropriate to describe a user of healthcare – an individual person in the context of receiving healthcare.

A potential user in healthcare is not always in the role of a patient. Sometimes we may talk about customer experience in healthcare [8]. A customer may refer to the selection between different providers (professionals, organizations) based on the available services and intent to pay. On the other hand we may talk about users and user experience in the context of healthcare. This emphasizes the minimum and expected baseline quality requirements where healthcare services are concerned. Both concepts have been elaborated in academic forums. These concepts provide grounding for further elaboration and definition of the "patient experience".

**Experience**

The expression experience is currently used in conjunction with a multitude of contexts. It can be glued to almost everything such as an "amusement park experience", "holiday experience", or even "yoghurt experience" [8]. However, on most occasions a clear definition and breakdown of the concept is not elaborated on further. This leaves room for different and inconsistent interpretations and expands ambiguity on the concept. Not only this ambiguity makes goal-minded, focused and measurable development work difficult but it makes research and development of methods for experience design and engineering problematic.

Oxford Dictionaries [15] provide following definition for experience: an event or occurrence which leaves an impression on someone and feel (an emotion or sensation). This definition emphasizes the impact of an event or occurrence to a person. The activities that surround and involve the person provoke thoughts and feelings that eventually constitute towards a whole experience. In order to enable and support systematic design and engineering of products, activities, situations, and contexts that are capable of producing positive experiences, we need to understand the conceptual building blocks of this experience.

**User Experience (UX)**

During the last decade, user experience (UX) has been under active discussion. The UX White Paper [9] outlines characteristics of UX from different
perspectives. Key characteristics of UX are outlined as follows: UX is ... a subset of experience, related to the experiences of using a system, about encounters with systems, unique to an individual, influenced by prior experiences and expectations, rooted in a social and cultural context. The allaboutux.org website (maintained by the "White Paper" workgroup) lists 27 different definitions about UX covering broad definitions such as Alben’s (1996) All the aspects of how people use an interactive product and Nielsen-Norman Group’s All aspects of the end-user’s interaction with the company, its services, and its products. Some constrained ones are A person’s perceptions and responses that result from the use or anticipated use of a product, system or service (ISO 9241-210) and Users’ judgement of product quality arising from their experience of interaction, and the product qualities which engender effective use and pleasure (Sutcliffe 2010) [10]. In these definitions UX is about subjective relations and responses towards the system. Some definitions include technologies as part of UX but others leave these out focusing on user’s impressions and feelings based on the perception of the systems. 

Patient Experience (PX)
Some emerging descriptions of the concept PX can be found from the healthcare literature and web sources [13]. The Beryl institute defines PX as “The sum of all interactions shaped by an organization that influence patient perceptions across a continuum of care” [13]. The consulting company Beyond Philosophy explores PX in the following way: “[PX] is a result of the interaction between an organization and a patient as perceived through the patients' conscious and subconscious mind. It is a blend of an organization’s rational performance, the senses stimulated and emotions evoked and


These emerging definitions have not yet been widely adopted and operationalized for empirical context. Additionally, they indicate that PX has a flavour of being a loosely defined service development approach for consulting companies and individual institutes indicating an approach on philosophy of care [11]. In literature PX appears as a not-explicitly defined concept [7], [8].

Patient-centred care provides a viewpoint to PX. It has been described as an approach that consciously adopts the patient’s perspective [5]. During the last decade, patient-centredness has been illustrated in following concepts: consumer health informatics, electronic and mobile health services, pervasive healthcare, patient-centred care, and even citizen empowerment. Further, patient-centred healthcare is comprised of coordination of care, cooperative care and collaboration between patients, clinicians, and other involved parties [2].

Gerteis & al. [5] approach PX as a component of healthcare quality which consists of 1) technical excellence (e.g. the skills and competence of professionals) and 2) subjective experience by patients. Patient’s “perceptions of illness or well-being -- their encounters with healthcare professionals and institutes” addresses PX. Their continuing list of dimensions of patient-centred care illustrate this further: 1) Respect for patients' values, preferences, and expressed needs, 2) Coordination and integration of care, 3) information,
communication and education, 4) physical comfort, 5) emotional support and alleviation of fear and anxiety, 6) involvement of family and friends, and 7) transition and continuity [5].

Conclusion and Discussion
There is a practical need to define PX for the systematic creation of high-quality healthcare services. In addition to currently being a general philosophy-of-care and a development approach, an operationalized definition of PX would help in identifying proper methods, practices, and tools for the development and evaluation of healthcare services. The resulting impression from the interaction with healthcare provider affects the patient’s relation to the services. The impression formulates in patient’s mind in relation to dimensions of patient-centred care such as respect, needs, expectations, preferences, comfort, and emotional support. Unveiling, understanding, and even measuring these responses contribute to the definition of PX and systematic PX design.

References
Abstract
A field investigation may often serve multiple purposes, placing a significant burden on social theory to aid understanding of critical issues, their appropriate resolutions, and to contribute to design decisions. As a theoretical lens for sociotechnical work, activity theory provides an ecologically-validated social theory frame for studying technology mediation and information use for care practices in complex workflow contexts. An activity view studies work behaviors that can inform design decisions for healthcare informatics; to do this we must understand sources of information uses that justify design claims, which involves workflow critique. This paper presents a research program that adopted activity theory in nursing and clinical work studies and critiques the contradiction between workflow and patient-centred care evident in the ethnographic study.

Introduction
This brief paper presents a theoretical frame adapted for ethnographic research in clinical informatics design, based on activity theory analyses [1] of information practices. The ultimate purpose of the ethnographies was to inform the design of evidence-based information resources for point of care decision making. Activity system analysis enables a researcher to traverse levels of data and task, while maintaining a common focus on a focal activity, in this case, nursing care workflow.

This paper attests to the value of activity theory in both research and design contexts. While some of the author’s research [3,4] is published, design outcomes remain proprietary. The workshop affords exchange of research learning from these applications of activity theory in information service design contexts. While other theoretical frames offer similar social interpretive keys for understanding sociotechnical systems, activity theory better fits workflow studies in particular as:

- Activity theory (AT) was developed specifically for work studies in context, and evaluates actions as cognitive tasks, based on knowledge and context.
• AT integrates a model of adaptive learning in the work activity context.
• Activity theory enables the researcher to model complex work arrangements as cognitive practices.
• AT enables design, by locating points to intervene for change or to reinforce desired social behavior.

**Nursing Workflow as an Activity System**

Activity theory supports research into enterprise level system design, as the scope and boundaries are enlarged beyond the user to collect data and evaluate at multiple units of analysis. In nursing, the socially-reproduced routines surrounding informatics are critical factors in informatics adoption, where user experience, usability and content utility can be merely instrumental factors. A highly usable product remains unused if its fit to actual empirical workflow is poor, a well-known problem in electronic medical records studies [2].

The unit of analysis of a sociotechnical system is defined as activity, represented by actions of both individuals (nurses) and work teams. An activity is identified by a common outcome of intentional actions. Collective activity of nursing teams (or interprofessional teams) is a well-structured, goal-oriented practice that affords a close study of “workflow” in situ. In our studies the actions associated with nursing information practices were analyzed, using workflow as an (etic) categorical reference model. Several of our research goals were suited for activity system analysis:

• Understanding the information needs and critical information tasks of healthcare professionals
• Evaluating and designing information artefacts for clinical practice

• Designing point of care resources for medical students or residents (all separate studies) and content formats and interactions for practice
• Understanding the actual uses and workarounds for ICT systems
• Understanding the functions of workflow in technologically-mediated professional work

**Theorizing Activity**

An activity system represents a complete unit of analysis of an individual role within a collective performing a continuous activity toward an objective. Activity is defined by its objective; with a patient care workflow study we might associate a routine such as “admission” as a specific activity. Admitting a patient is composed of multiple tasks (actions), composed of further operations, performed sub-attentively. The activity system is hierarchical, not structurally but rather cognitively. Differing roles learn and conduct actions (and operations) differently, according to learning and development.

The Engeström [1] activity system model is a common reference for visually describing the relationships of individual and team work practices, and their use of information technologies and artifacts. The classical model is modified in Figure 1 to illustrate the double-mediating functions of Instruments (the tools of work-information, computer systems, documents) and Team (the organization of locally-responsive work units). This inclusion clarifies the mode of directed work in professional teams, as is the case in nursing. Subject and Team share a direct patient outcome; Community (e.g. "of practice") does not share the same object or outcome, even if relevant information is shared. (Abstract length prevents full description of the model).
Activity theory (AT) provides explanatory structure for information-mediated cognitive work, and guidance for developmental issues of technology and innovation, showing technology transformation of activity in use over time. As presented in earlier studies [3,4] AT can be formulated to include cognitive work / work domain analyses by extending the hierarchy of the action-activity unit as a sub-activity within in a larger organizational containing system. In the present case this would be a nursing department or a service.

**Nursing Workflow As Activity**
From a workflow design perspective, activity theory aligns unit of analysis and unit of work. In a nursing information ethnography, 17 workflow functions were established a priori. An activity analysis reduced these to 8 canonical activities, selected based on their *continuous* performance in a clinical setting (Table 1).

<table>
<thead>
<tr>
<th>Activity</th>
<th>Information task / need</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Admission</strong></td>
<td>Impact of admission diagnosis on treatment &amp; care planning.</td>
</tr>
<tr>
<td><strong>2. Documentation</strong></td>
<td>Prompts inquiries &amp; plans based on entries in patient records &amp; other documents.</td>
</tr>
<tr>
<td><strong>3. Transfers &amp; Discharge</strong></td>
<td>Negotiate discharge or transfer (where data shared by nurses at two locations.)</td>
</tr>
<tr>
<td><strong>4. Complex care</strong></td>
<td>Care as object, context for expert action. anticipating surgery, medications, etc. Procedures as skilled action, informed by practice.</td>
</tr>
<tr>
<td><strong>5. Medication admin</strong></td>
<td>Management of schedules and drug types. Must search side effects &amp; interactions.</td>
</tr>
<tr>
<td><strong>6. Committee service</strong></td>
<td>Representing nursing in inter-professional projects. Organizational objectives, triggering needs for research, evaluation, evidence collection.</td>
</tr>
<tr>
<td><strong>7. Shift change</strong></td>
<td>Informing nurse of patient status &amp; needs in assumption of shift. Partial knowledge prompts need.</td>
</tr>
<tr>
<td><strong>8. Clinical Education</strong></td>
<td>Teaching nurses about diseases, procedures, risks, patient care. discharge. Nurses also teach patients about their conditions.</td>
</tr>
</tbody>
</table>

Table 1: Activities in Nursing Workflow
Each activity registers a specific outcome, mediated by distinct information tasks. The workflow model shows well-defined clinical work and associated information needs, mediated by different systems or forms in each activity. These forms help to distinguish regular workflow modes from exception practices.

The majority of a nurse’s actions are directly disposed to patient care, and are mediated by cognitive and material instruments toward care demands, not workflow. An AT orientation searches for mediations toward outcomes (the object of care, or e.g. discharge in a workflow scenario), indicated by arrows (Fig. 1).

**Whither the Patient, a Workflow Object?**

Nursing activity analysis shows structured “workflow” is found in actual observations as scheduling, or patient flow. In staff nursing, work tasks and information needs are triggered by patient status, not “steps” in workflow: Admission, care planning, preparing and administering medication, documenting, procedures, discharging - all center around a patient’s individual needs. While these patient needs are coordinated in aggregate in the clinic, they are represented administratively as accountable statuses in systems that record data for workflow management (EMR systems, CPOE, bed scheduling).

A central concern is recognized that in both workflow and activity analysis, the “patient” has become an object of process. The patient as unique person in care is at risk of information loss in workflow systems and in the abstractions of activity theory. When “patient discharge” becomes a shared object of workflow and analysis, the individual attentions of patient-centred care risk being overlooked.

Clinical practice is complex, dynamic and unscripted in its everyday practice. Yet technology discourses (and system development and implementation projects) require standard models from which to assign data to patients, patients to “clinical pathways,” and staff to units of performance. Workflow is about managing what is measured. But innovations have little chance of disrupting practice and workflows if they cannot resolve the contradictions between these concerns. Patient-centred care (PCC) re-introduces some historical notions of care that have been in decline since automated healthcare management. PCC intervenes in workflow to an unknowable extent - what does it mean to the patient to “involve the patient in care to the extent he or she desires?” PCC values, if acted upon, insert a normative demand which may disrupt the automation of workflow-based accounting. This alternative mode of care argues against the technological efficiency of “care delivery,” and redefine our understanding of a patient’s experience in ways we do not yet measure or perhaps even question.

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Abstract  
Drawing on the concepts of temporality and pace to analyze the experience of a new technology for transfusion practice, our analysis articulates the relationship between adoption experiences, task dimensions, and the coping strategies that emerge. We discuss the implications for design of interactive systems in healthcare as well as the theoretical implications for understanding unfolding healthcare practices.

Author Keywords  
Collaborative computing; health; human performance.

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Introduction  
Medical settings present a challenging research domain for human computer interaction (HCI). The complexity of work, variability of work, richness of, and reliance on information, and continuous collaborative activity [1,4,5] provide opportunities to explore new forms of interaction and to advance theory.
In this paper, we review HCI approaches to understanding work practices in medical settings focusing on notions of space, time, and temporality [6]. In addition, we extend current approaches by investigating a mismatch between a new technology solution for transfusion procedures (Electronic Remote Blood Issue (ERBI)) and the dimensions of the work practices of the OR suite through the lens of pace [2].

**RELATED WORK**

Several researchers have explored the concept of temporality and applied it to medical work. For instance, Dourish, Reddy, and Bardram [1, 26] have discussed sequencing and simultaneity of work, complexities around how work practices unfold over time with respect to attributes such as information and information transfer between members of healthcare teams, and the way in which work is reorganized in a mobile context. More recently, Reddy, Dourish and Pratt [6] described features, such as temporal trajectories, temporal rhythms, and temporal horizons. Temporal trajectories describe how a situation changes over time whilst temporal rhythms describe recurring patterns. Flexibility and urgency determine the temporal horizon chosen. For instance, if there is greater flexibility and little urgency for a task a distant time horizon could be chosen by an individual. Pace as a concept is part of this idea, but has been discussed briefly in relation to near or distant temporal horizons necessitating a change in pace of a person’s activity in order to achieve an overall work commitment and schedule. Alan Dix introduced the concept of pace to interaction research in 1998 [2] in a different manner. Drawing on concepts from information theory, Dix identified several coping strategies, which emerge as a result of a mismatch in pace between task and interactive system. He characterized these strategies as delegation, laziness/eagerness, or multiplexing. Our aim in this abstract is to explore new work practices as they unfold in response to a technology implementation through the lens of both pace and temporality concepts. We use a conceptual diagram (figure 1.) to illustrate this interplay.

![Conceptual Diagram Linking Temporality and Pace](image)

**STUDY DESIGN**

The fieldwork for this study was carried out in the operating suites and blood banks of three large urban hospitals. The study was conducted over three years between 2008-2011, and included collection of qualitative and quantitative user survey data, formal and informal interviews with managers and staff, 6 weeks of observation at each site with 24 hr video capture and in person observation, and analysis of software log data. Two researchers carried out qualitative inductive content analysis, using survey and interview data, following suggested practices for ensuring quality of qualitative research of this type [3].
FINDINGS
We used Dix’s predictions about coping strategies and applied them to an understanding of ERBI system use.

Mismatch and Breakdown
As users became familiar with the system and started to try to interact with the system at the pace that the blood request demanded a breakdown in the interaction was observed. As Dix predicted “cooperation can only succeed if the pace of interaction is sufficient for the task” [2]. Users started to skip confirmatory steps in the interaction missing key information and consequently triggering error messages and then a delay in the task completion (delivery of blood to the patient). OR nurses, in particular, felt the spatial and temporal configuration of the new blood issue system to be mismatched to the task.

Delegating
Nurses were considered the primary users of the ERBI system. Training efforts concentrated on this group from the outset. However, the mismatch between the pace of interaction with the system and the pace of time horizon in the OR rooms meant that nurses were seeking workarounds to using the system. One way to achieve a better match between the interaction channel of the ERBI system and the pace of the task was to delegate to those staff not facing the same constraints.

Eagerness
The software logs for 120 days for the first study site were examined and in some cases the final safety step in blood unit issue with ERBI (scanning the unit) was missed (a ‘no scan’ event). The final scan of a blood unit completed the safety procedure for checking that the blood supplied for transfusion is compatible with the patient’s blood. An error at this stage could cause a serious adverse event. The number of ‘no scans’ did not decrease over time as staff got used to the new system. The instances of multiple ‘no scans’ coincide with trauma patients who required an unusually high number of blood units in a short space of time.

Applying a near time horizon to the task of blood supply for a large bleed, the teams had adapted by quickening the interaction pace (eagerness). Alternatively, in order to avoid issues of pace mismatch, fresh frozen plasma could be ordered and delivered in a cooler, the OR team could secure a place to store red blood cells in the operating room, then a porter or support staff could retrieve blood from the ERBI system whether blood was needed or not.

Multiplexing
Multiplexing involved simultaneously interacting with the ERBI system to retrieve blood whilst calling the blood bank to order a cooler containing blood units. Thus the required ‘bandwidth’ of the task was achieved using two channels of interaction. This workaround caused confusion between the two channels with redundant blood orders and a confused blood bank staff. With one communication channel to the blood bank for large blood orders (usually by phone) the urgency and volume of blood require is directly communicated to the blood bank staff, and they can then respond accordingly. If the communication and interaction is split into two channels (blood bank via phone plus ERBI) some of the information involved in the interaction (volume and pace of red blood cell need) is lost in turn affecting the response of the blood bank. Disruption to the flow of information has the potential to create a critical situation for the patient.
DISCUSSION
Several researchers have explored concepts related to temporality in HCI research but few have applied the concept of pace specifically, as an extension of temporality to medical work practice. Drawing on theoretical concepts, we presented the findings from a study of work practice adaptation with the introduction of a new technology for blood unit issue for operating room use (ERBI).

In this research case study, using the concept of the temporal horizon helps us to understand the dynamic nature of the task itself, and the circumstances of the individual healthcare worker. The idea of pace is key here. The pace of activity necessarily quickens when a close temporal horizon is called for, whereas, a distant temporal horizon may accommodate a slower pace or result in postponement of activity. The temporal horizon for the OR nurse retrieving a unit of red blood cells for a patient would be different from a porter’s temporal horizon for the same activity.

Using the concepts of pace and temporality together aids us in the analysis of work practices and the interactive systems that support them such that these dimensions become more apparent. This also helps us make the bridge to potential solutions whether it be variable pace of interaction, or communication of knowledge about pace for the reassessment and planning of temporal horizons.

CONCLUSION
Studying the process of adoption and adaptation to a new interactive system reveals some of the characteristics of the tasks and context that shape work practices. While these characteristics might seem particular to the task of blood issue only, when the lens of temporality and pace are applied we see a more general pattern emerge that may be applicable to other settings. The concepts of temporality and pace offer a theoretical lens with which to understand how medical professionals adapt to new healthcare information systems.

REFERENCES