Designing Better Prescription Charts: Why we can't just ask the nurses

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Abstract
Prescription charts are not designed with the task of programing medical devices in mind [cf. 1]. This is surprising because we know that charts need to be consulted for programing values. This paper summarizes what we know about chart design, and then reflects on what we do not know. In order to design charts that facilitate programing, we need a better understanding of how they are used in hospitals. We cannot only ask nurses about how they use them since they may omit information about context and clinical practice. We discuss approaches that we plan to use to obtain the required understanding.

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

Introduction
Many errors resulting in patient harm involve medical devices, with one cause of these errors being incorrect end-user programming [5]. Some progress has been made towards reducing errors by improving the safety features of devices. However, the design of prescription charts has received little attention.

Figure 1. Pump simulator.

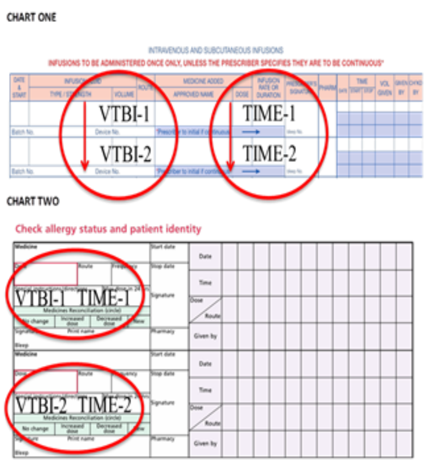

Figure 2. Prescription charts.

Traditionally, the focus of chart improvements has been on transcription legibility and ensuring all relevant information is recorded [1]. Charts are often highly structured documents with restrictions on the nature and format of what can be recorded. This can make it impossible to appropriate them in a way that supports an individual's device programing activities. We are concerned with how chart design influences the end-user programming procedure, and how this impacts on the likelihood of errors being made. Our focus is on how safety manifests itself in everyday practice using prescription charts, and how those practices are developed through training and experience.

Firstly, we report on laboratory experiments that have demonstrated the impact that changes in chart design can have on error rates. We then reflect on the need for situated studies that explore how people use prescription charts in practice. Finally we consider current standards and recommendations for prescription chart design, and argue that design should be mindful of programing tasks.

Laboratory-based Studies

To date our laboratory-based studies have focused on programing where people know how to use a simulated device, but do not know the required values, and are therefore required to rote copy them from a chart into an interface. Participants were recruited from the UCL Psychology subject pool and were trained to use a computer-based simulation of two infusion pumps (see Figure 1). These pumps are widely used within hospitals, and allow for an amount of drug treatment to be given to a patient over a period of time.

In our experimental scenario, both pumps were required to be programmed. Participants were free to choose the order that these pumps could be programmed in. Our first experiment found that the time cost of retrieving values from a prescription chart influenced how the pumps were programed [2]. Errors were made when participants decided to interleave the entry of values into both pumps, rather than program each pump in turn. Participants were more likely to make errors when consulting the chart for every value needed, rather than remembering all the values associated with programing one pump.

Further experimentation has explored whether the design of a chart can encourage people to program pumps in turn [3]. Two NHS chart designs were compared (see Figure 2). These were selected because they closely adhere to best practice guidelines in the UK [1]. We found that whilst it might seem sensible to organize different types of values in separate columns, this can inadvertently result in unsafe programing. This is especially the case when programing values are presented in separate columns that are not alongside each other. Designs that do not group values needed to program one pump increase the likelihood of error.

Before recommending design guidelines based on these findings, the assumptions that were made about how charts are used need to be examined. In our experiments, we assumed that people did not know the values they are entering, had little expertise in this area, and had no history with the numbers. In practice these assumptions are likely to vary depending on the context in which the programing takes place. We need a combination of approaches to understand chart use in practice across contexts.

Understanding Context

In our laboratory-based experiments we used an eye tracker to capture which values were being retrieved from a prescription chart. This is because individuals are poor at reflecting on and articulating low-level, often automated, cognitive processes. This is one reason why we cannot just ask healthcare practitioners about how they use charts. Another is that practice varies across different areas in hospitals. In order to obtain an understanding of how nurses use charts to program devices, we propose three complementary approaches, described below. Although the range of practitioners that administer medications and may use charts is varied, here our focus is on nurses.

1. Observational Studies

Assumptions used to conduct our laboratory-based studies are in contrast to observations we have already made on an Oncology ward. In this particular context nurses were familiar with regular drugs and their dosages, had a great deal of knowledge and expertise that they had built up over years of work, and had a history with the numbers. This history might be because they have just prepared the medication prior to using the pump, or because they have been looking after the same patient for three consecutive shifts.

In practice this history, experience and expertise may have an impact on programming devices. Furthermore, the assumption that nurses copy numbers by rote from prescription chart to infusion device is challenged. Sometimes nurses will have the numbers memorized. Sometimes nurses refer to other artifacts, like the labels on medication bags; other forms e.g., chemotherapy drugs have their own separate instruction sheet; or even a scrap of paper, e.g., we have observed a student nurse note down values to refer to when she was programming the pump.

We have observed nurses programming by rote when the numbers are particularly complicated, e.g., one drug has its own instruction sheet that specifies incremental infusions and careful monitoring because of the likelihood of a reaction. We also find that any combination of the above artifacts might be used in different contexts, i.e., it is hard to generalize and say that nurses will always behave in a certain way.

2. Eliciting Mental Models

In addition, it is important to understand how expertise and training impact on programming behavior. Our previous interviews with device managers and trainers have indicated that infusion devices are used not only in a variety of clinical contexts, where different forms of functionality may be required, but by users with differing levels of expertise. Understanding how nurses conceptualize the activity of programming an infusion can lead to improved design through a consideration of the interactions between user, device, prescription chart and any other supporting artifacts.

User models can be elicited through techniques such as teach-back [7], where participants are able to reveal cognitive processes to a co-learner without having to reflect on them explicitly. Eliciting these models will help reveal key concepts that relate to nurse understanding, which is influenced by training received, clinical area and level of expertise. Thus it is necessary to include nurses from a range of clinical areas in order to develop a richer picture of the types of activities prescription charts need to support.

Figure 3. Bespoke chart.

3. Understanding Ad-hoc Artifacts

People make ad hoc artifacts to help them with everyday activities; it is reasonable to assume that clinicians make them too. These artifacts can be bespoke charts (see Figure 3), scraps of paper, or notebooks, and are kept solely by individual clinicians. Hospitals do not officially recognize these artifacts, and their use is often discouraged. However, they can be critical for maintaining an individual's awareness of what needs to be done when programing devices. Our aim is to better understand how ad-hoc artifacts are used alongside officially recognized documents such as prescription charts through interviews. Redacted ad-hoc artifacts will be used as boundary objects to encourage nurses to reflect on their own practice.

Discussion

In order to design prescription charts that facilitate programing, we have argued that a better understanding of how they are used in hospitals is needed. Our proposed approaches allow for consideration of how practices relate to the interaction between user, device and supporting artifacts. These approaches may also be able to help explain why some errors are "unremarkable" [4] i.e. routinely recovered from and others are "catastrophic" i.e. ones that are not recovered from and impact patient safety.

Conclusion

When moving between hospitals in the UK, there is no guarantee that healthcare professionals will use a similar style of prescription chart to the one that they were trained on. Although there is a standard for general prescriptions (the FP10), it has not been applied in hospitals, due to the complexity of the prescribing process and variability in context [6]. Hospitals have been free to develop their own solutions, resulting in multiple different prescription chart types. Recently, a study resulted in a recommendation for a standardized design, to help reduce the potential for error [1]. In principle, standardization offers benefits associated with consistency and familiarity. However, forcing a generic solution may risk unanticipated, negative, knock on effects. In some cases a generic solution will apply, in others it won't, but it is clear that a range of evidence types is needed to understand the importance of designing charts with programming tasks in mind.

Acknowledgement

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