# UNINTENDED CONSEQUENCES OF THE USE OF COMPUTERIZED PROVIDER ORDER ENTRY IN THE UNIVERSITY OF PENNSYLVANIA HEALTH SYSTEM

This thesis was submitted in fulfillment of the requirements for the degree of Master of Science in Health Economics, Policy, and Law at the Institute for Health Policy and Management, Erasmus University Rotterdam

**by**

**Kevin Veninga**

Supervisor
Dr. J. Aarts
Institute for Health Policy and Management
Erasmus University Rotterdam

Co-evaluators

Prof. R. Koppel
Department of Sociology
University of Pennsylvania

Dr. M. de Mul
Institute for Health Policy and Management
Erasmus University Rotterdam

March 2013

## Abstract

Health Information Technology (HIT) is believed to have the potential to tackle the ever rising costs of healthcare. The use of HIT should lower error rates and increase efficiency. However, research indicates HIT does not succeed in this task. Unintended consequences of HIT use may cause HIT to lead to opposite effects: higher error rates and a decreasing efficiency. In this thesis I discuss the use of a Computerized Provider Order Entry (CPOE) system in the University of Pennsylvania Healthcare System (UPHS) in Philadelphia. Our research focused on unintended consequences of the use of Sunrise Clinical Manager as a CPOE system. The main research question was '*What unintended consequences of the use of Sunrise CPOE system pose a threat to the quality of care in the University of Pennsylvania Health System in the Summer of 2012?*' Data are compared with three earlier studies performed at UPHS over the last decade. The ISTA model, developed by Harrison, Koppel and Bar-Lev in 2007, was utilized as a framework to study the development of issues over time and compare our findings.

To gather data, we interviewed house staff, with a focus on residents, and HIT authorities within UPHS. 86 residents responded to an online survey. Results were used to develop a questionnaire, which was utilized in face-to-face interviews with 45 residents and 21 other house staff. 4 meetings were held with HIT authorities for a different perspective on issues, and to discuss findings. We studied 38 unintended consequences of CPOE use, 8 of which were newly identified. Several other issues were identified which require further studying to determine their origin, significance, and possible link to other issues. No evidence was found of previously identified issues that were fixed since the preceding study in 2011.

Following the ISTA model, I found the main contributor to the emergence of unintended consequences to be the complex interactions between new HIT and the social system, and to a lesser degree the interactions between new HIT and the technical infrastructure. These interactions cause a mismatch between the way HIT is designed to be used, and the way it is used in practice. I expect that more focus on these interactions and their effect on the way HIT is used in practice will help achieve a better match between the design and the actual use. With this thesis, I aim to contribute to achieving this goal of the use of HIT: lower costs for healthcare by a decrease in error rates and more efficient use of our limited resources.

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# 1. Introduction

## 1.1 Errors in Healthcare Delivery

Errors in the delivery of healthcare impose a big burden on healthcare systems worldwide, and thereby they burden our societies. They add to the suffering of patients and people close to them, they decrease job satisfaction for healthcare professionals, and they increase the cost of healthcare to society. Research shows that adverse events in the delivery of care in hospitals in the United States, which cause both deaths and injuries among the patient population, are most frequently caused by prescribing errors (Kaushal, Shojania, and Bates 2003, 1409-1416; Kanjanarat et al. 2003, 1750-1759). Goodman, Villareal, and Jones estimate these adverse events increase the total social costs of healthcare in the United States by 18 to 45 percent of the total health care budget, which amounts to a number between $348 billion and $912 billion, annually (Goodman, Villarreal, and Jones 2011, 590-595). The situation in European countries is said to be similar (Cordis 2011). In 1999, the landmark report 'To Err is Human' was published by the Institute of Medicine to inspire efforts to improve this situation. Unfortunately, little progress has been observed in reducing the number of errors since then (Landrigan et al. 2010, 2124-2134).

The way in which large amounts of information are handled is a factor engendering errors in healthcare (Institute of Medicine (U.S.). Committee on Improving the Patient Record, Dick, and Steen 1991). There is an enormous amount of information available on each patient, on each piece of equipment, and even on each tablet that is administered. It is difficult to properly make use of all this information in order to make healthcare better and safer. According to Ash, Berg, and Coiera, Health Information Technology (HIT) may be vital in handling these information flows efficiently (Ash, Berg, and Coiera 2004, 104-112). The US Department of Health and Human Services (DHHS) is a strong advocate of the use of HIT (HRSA 2012; AHRQ 2012; FDA 2012). To support the adoption of HIT in practice, the DHHS was ordered to appoint a National Coordinator for Health Information Technology in 2004 (Office of the National Coordinator, ONC), which was tasked to 'provide leadership for the development and nationwide implementation of an interoperable health information technology infrastructure to improve the quality and efficiency of health care' (Bush 2004). Scholars confirm that HIT systems have the potential to improve quality by reducing errors, to support evidence-based medicine through their built-in guidelines and protocols (de Mul, Berg, and Hazelzet 2004, 208-214), and to improve the efficiency of healthcare systems (Bobb A, Gleason K, Husch M, Feinglass J, Yarnold PR,Noskin GA 2004, 785-792).

But, even though HIT may assist healthcare providers in their jobs, and is thereby expected to help reduce the number of errors, it may come with new errors of its own. Research shows that new technologies often do (Battles and Keyes 2002, 84-88). Computerized Provider Order Entry (CPOE) systems were introduced to decrease the risk of errors in medication prescribing, and improve the efficiency of this process. However, research in a VA hospital in the USA in 2005 showed 52 adverse drug events (ADEs) for every 100 hospitalizations, even though the hospital was highly computerized. 9% of these ADEs resulted in serious harm to the patient, and 66% necessitated additional interventions and/or monitoring of the patient (Nebeker et al. 2005, 1111-1116). Unfortunately we can't compare these percentages to the situation in a hospital that is not computerized, ceteris paribus. But with the DHHS, I believe that if HIT is used properly it should lead to significantly lower amounts of ADEs. When healthcare safety watchdog Leapfrog evaluated the quality of CPOE systems in hospitals in the USA on their reliability in avoiding errors, they found CPOE systems on average missed 'half of the routine medication orders and a third of the potentially fatal orders' (Leapfrog Group 2010). Koppel et al (Koppel R, Metlay JP, Cohen A,et al 2005, 1197-1203) identified 22 potential errors in prescribing, facilitated by the CPOE system. In these publications it is argued that there may be several factors causing these errors, such as bad design, faults in the implementation process, or other issues. Unintended consequences of the use of HIT are identified as one of the main causers of errors in our healthcare systems.

## 1.2 Background Of This Study

The research we did is part of a longitudinal series of studies on unintended consequences related to the use of CPOE in the University of Pennsylvania Health System (UPHS) conducted in the past decade. Since 2002, the CPOE system in use in the hospitals of UPHS has been studied by Koppel and his team. This resulted in an AMIA publication in 2005 disclosing 22 different types of potential medication error risks, in which TDS 7000 (later the Eclipsys 7000) CPOE system was the subject of study (Koppel R, Metlay JP, Cohen A,et al 2005, 1197-1203). This system was in use from 1997 until 2004, after which it was replaced by Eclipsys Sunrise Clinical Manager (SCM). The switch to a new system was also studied by Koppel and his team, until 18 months after the introduction of SCM. However, the results of this study were never published (Koppel et al. 2008). In 2011 a follow-up study was done by Kraaijenbrink. She did research on the extent to which SCM contributed to the sources of potential risks of medication errors (Kraaijenbrink 2011). This led to a three-stage comparison of the old system (TDS 7000), the new system shortly after introduction (SCM around 2004) and the results of Kraaijenbrinks study in 2011. This thesis

will use the results of these studies and add to that new data which was gathered since the Kraaijenbrink study, up until the summer of 2012. This new data consists of an online house staff survey, face to face interviews with house staff, and interviews with UPHS executives.

### 1.3 Objectives

This study focuses on errors related to the use of HIT, be they caused by the design or by the manner in which this design is used in practice. To prevent these errors from sustaining, HIT systems and the way they are used evolve over time. This study aims to contribute to current insight in this evolution of CPOE systems, therefor focusing on the extent to which these systems contribute to the sources of potential risks of medication errors, and to see if the systems decrease these risks while evolving over time. To reach this goal, this study will focus on the research question

> *What unintended consequences of the use of Sunrise CPOE system pose a threat to the quality of care in the University of Pennsylvania Health System in the Summer of 2012?*

To answer this question, I will first focus on finding an answer to the following sub-questions:

1. What taxonomy is suitable as a framework to understand and explain the phenomena that are examined?
2. What unintended consequences of the use of Sunrise CPOE system are currently found in UPHS?
3. How do the currently identified unintended consequences compare to unintended consequences identified at UPHS in the past, employing existing taxonomy as an interpretive scheme?

In chapter 2 the phenomenon of the unintended consequence is introduced, including a discussion of existing taxonomy. This makes for a start in addressing the first sub-question. Chapter 3 will discuss the methods that were used to gather data, and the setting of the study. The data will be presented in chapter 4, where the findings will be put into perspective to findings from earlier studies on the subject, and a start is made in answering the second and third sub-question. In chapter 5, I discuss what insight was derived from the data, and an answer to the sub-questions is formulated. Chapter 5 also holds a critical reflection on the limitations of the study, and I will give my recommendations for further research. This leads to a conclusion in chapter 6 in which I formulate an answer to the research question, based on both theory and our findings.

# 2. Theoretical Framework

In this chapter I discuss the theory that forms the foundation of the study. To that end, I first explore the concept of unintended consequences, which is an important concept in this study. After that I discuss existing theory on unintended consequences and search for a taxonomy for them. In the third paragraph I focus on a particular taxonomy, the ISTA (Interactive Sociotechnical Analysis) model, which may be a useful model to understand and explain the evolution of CPOE systems over time and the nature of unintended consequences.

## 2.1 Unintended Consequences

CPOE systems, like many forms of HIT, have the potential to enhance the safety and the quality of healthcare, and to help providers focus on the patient, while containing costs and increasing efficiency (Bates 2005, 259-261; Chaudhry et al. 2006, 742-752; Garg et al. 2005, 1223-1238; Halamka 2006, 775-776; Kensaku Kawamoto et al. 2005, 765). However, in reality we see HIT failing to achieve these goals all too often. Diverse errors and problems caused by CPOE systems have been reported by different scholars (Aarts, Ash, and Berg 2007, S4-S13; Wachter RM 2006, 2780-2783; Tsai, Fridsma, and Gatti 2003, 478-483; Sittig et al. 2007, 671-675; Sinsky 2008, 6-8; Shulman et al. 2005, 516-R521; Khajouei and Jaspers 2010, 3-19; Coiera 2000, 277-286). Ash et al (Ash et al. 2009, S69-76) studied and identified 380 unintended and undesired consequences, and Koppel et al (Koppel R, Metlay JP, Cohen A,et al 2005, 1197-1203) found 22 types of medication error risks, facilitated by a widely used CPOE system.

According to Laudon and Laudon, there is a gap in communication between users and designers of technology, which is an important cause of unintended consequences in the design of HIT systems (Laudon and Laudon 2010). When a designed HIT system is being put to use in practice, it has to be implemented into the sociotechnical system of a healthcare organization. Complicated interactions between the HIT and the existing sociotechnical system may cause unintended and unanticipated consequences to occur, causing the system not to work as intended (Harrison, Koppel, and Bar-Lev 2007, 542-549). These are ‘unintended consequences (UCs) of Computerized Provider Order Entry’, and studies confirm they are an important enabler of errors that are facilitated by CPOE systems. (Ash, Berg, and Coiera 2004, 104-112; Ash et al. 2006, 11-15; Ash et al. 2007a, 26-30; Ash et al. 2007b, 198-202; Ash et al. 2009, S69-76; Ash et al. 2007c, S21-7; Ash et al. 2007d, 415-423; Campbell et al. 2006, 547-556; Harrison, Koppel, and Bar-Lev 2007, 542-549)

In 1936, Merton was one of the first to study unintended consequences in general. He focused both on consequences that are a direct and an indirect result of the actions of men. Even though this concept was written almost 80 years ago, it has proven to be of interest in our time as well. Merton declared that the reasons why these unintended consequences occur can be very diverse, but that they are unpreventable. He distinguishes five factors that limit an actor's ability to anticipate these consequences:

1. Lack of foreknowledge
2. Errors because of false assumptions or habits: the believe that "actions, which have in the past led to the desired outcome, will continue to do so"
3. Blindness to the possibility of unintended consequences because of an adamant focus on the desired beneficial consequences
4. No consideration of further consequences because of the felt necessity of certain action enjoined by certain values
5. A feedback loop, which may ignite either a self-fulfilling prophecy or a self-defeating prophecy. (Merton 1936, pp. 894-904)

The concept of unintended consequences as proposed in the Merton article has recently been used by social scientists and political economy scholars. (Sveiby et al. 2009)

Consequences can be categorized into several groups. They can be anticipated or unanticipated, and desirable or undesirable (Khan and Healy 2012, 155-172) . Consequences that are both undesirable and unanticipated are the category called unintended consequences (Campbell et al. 2006, 547-556). Also, the term 'unanticipated' means that the event lacks purposeful action or causation, and thereby it could not have been predicted, nor should it have been expected (Ash et al. 2007d, 415-423).

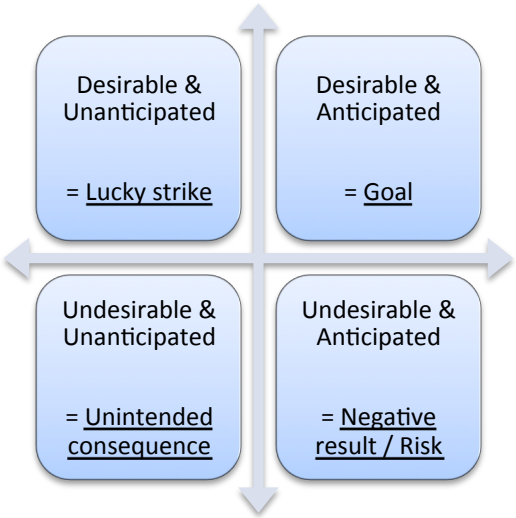


*Figure 1: Consequences Of Purposive Action*

In literature, unintended consequences for CPOE systems are encountered in two different contexts: (1) UCs as a result of system design and (2) UCs as a result of the integration of the CPOE system into workflow processes (Moniz 2009). Moniz wrote that 'many UCs can be managed if rigorous system development priorities are set during initial design/implementation stages'. But still, men's limited ability to anticipate unintended consequences has a big influence on the result of the implementation of HIT, may it be a succes or a failure. Using this insight may prove to be helpful in the phase following implementation. In paragraph 2.2 I discuss UCs that are commonly found in HIT.

## 2.2 Types of Unintended Consequences in HIT

Ash et al worked on the taxonomy of UCs (which she called 'silent errors'). This led to an initial grouping into two categories: The first category involves errors originating from the process of entering and retrieving information held in the system, the second involves errors in communication and coordination in the patient care process. This categorization is essential to understand both the positive and the negative effects of HIT (Kies 2009). Both categories were split up into subcategories. The first is divided in (1) errors caused by the fact that the human-computer interface didn't fit the highly interruptive context in which it is used, and (2) errors caused by a cognitive overload by overemphasizing structured and complete information entry or retrieval. Structuring means the physician is forced to enter comments in a certain way and in a certain field. This leads to frustrated clinicians, because it forces them to diagnose and do their work different than before. The data is presented differently, leading to different interpretations of this information. The second category is divided into two overarching problems: (3) HIT may be misrepresenting collective, interactive work as a linear, clear-cut, and predictable workflow. Also, (4) entering an order in an HIT system only allows for information transfer, while actual communication is often needed because it allows to give additional information. HIT may be misrepresenting communication as information transfer (Ash, Berg, and Coiera 2004, 104-112). Eventually, after more analysis and data gathering, these categories were further split out into 9 categories of UCs, as is shown in table 1 with examples for each category. (Campbell et al. 2006, 547-556)

*Table 1: Nine Categories For Unintended Consequences With Examples*

| **Type of Unintended Consequence** | **Example** |
|---|---|
| 1. More/New Work Issues | Multiple Passwords<br>Responding to alerts<br>Entering required information or more detailed information<br>Extra time |
| 2. Workflow Issues | System "re-orders" the workflow<br>HCI problems<br>Inconsistencies between system and policy/procedures |
| 3. Never Ending Demands | More space required for computers<br>Persistent upgrades<br>Screen space not large enough<br>Perpetual training<br>Maintenance |
| 4. Paper Persistence | Paper process does not end |
| 5. Communication Issues | Communication patterns change as a result of system<br>Physicians and nurses spend more time entering information than at bedside |
| 6. Emotions | Frustration and anger on the part of professionals in attempting to use systems and alter workflow |
| 7. New Kinds of Errors | Juxtaposition errors<br>Automated entry |
| 8. Changes in Power Structure | IS/IT become authorities<br>Those who know how to use system leverage that knowledge<br>Administrators can track compliance more easily |
| 9. Overdependence on Technology | System failures leave hospitals merciless |

The strength of this typology is that it captures all identified UCs and offers a framework for systematic approaches to address these issues. The development of a typology for UCs did not stop here though. Harrison et al (Harrison, Koppel, and Bar-Lev 2007, 542-549)

proposed a more abstract model, which they call the Interactive Sociotechnical Analysis (ISTA) model. In the next paragraph follows and in depth discussion of this model.

### 2.3 The ISTA model

Harrison et al (Harrison, Koppel, and Bar-Lev 2007, 542-549) developed a model to determine how UCs are facilitated: the Interactive Sociotechnical Analysis (ISTA) model, which is depicted in figure 2 and 3. It models the reciprocal influence of HIT on both the social structure and the infrastructure in a healthcare system. It shows how all subcomponents of the sociotechnical system are influenced by each other, either direct or indirect, forming a very dynamic system. The model makes a distinction between 'new HIT' and 'HIT-in-use', and between the 'social system' and the 'technical and physical infrastructure' in a healthcare organization.

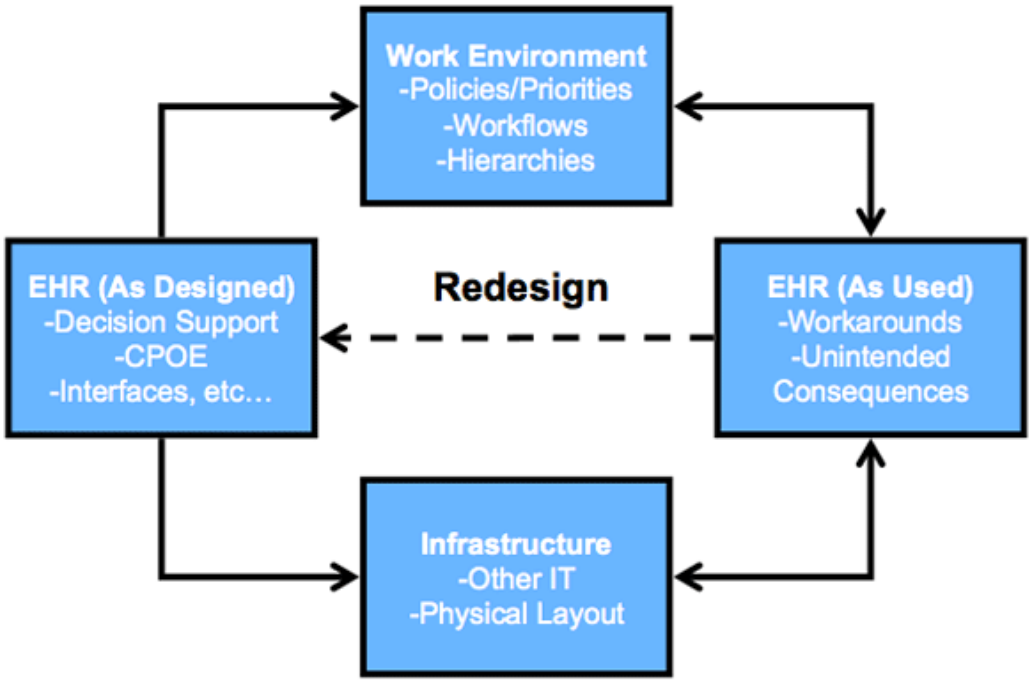


*Figure 2: The 4 subcomponents Of The ISTA Model (HealthIT.gov 2012)*

More in depth, these subcomponents entail the following:

- New HIT (as designed)

  This is how the developers envisioned that the HIT would be used
- Social System or Work Environment

  This comprehends the policies and priorities, the relationships and hierarchies within the organization, and the way people are used to doing their work.
- Technical and Physical Infrastructure

This may consist of other IT systems, the workstations at hand, medical devices, or the design and layout of the building.

- HIT (as used)

  This is how the HIT is eventually used in practice. It is the product of the interactions between the new HIT, the social system or work environment and the infrastructure. It may include workarounds and unintended consequences of the interactions, which were not foreseen in the design-phase.

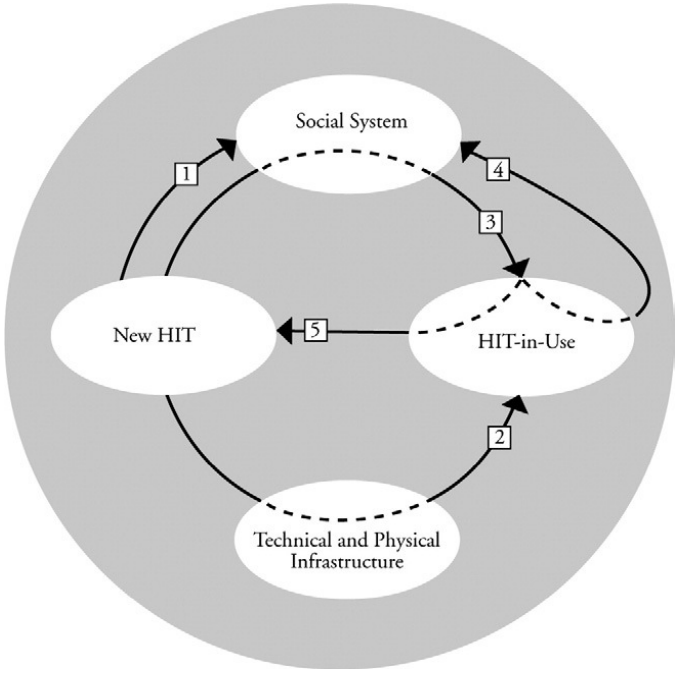


*Figure 3: The ISTA Model (Harrison, Koppel and Bar-Lev, 2007)*

The 5 most important ways these subcomponents influence each other are depicted in figure 3. The designations for the subcomponents in figure 3 are different from those presented in figure 2. The designations as discussed directly below figure 2 are used.
The 5 interaction effects are the following:

(1) New HIT changes existing social system

This type of interaction alters prior patterns of work, communication, relationships among clinicians, or policies and priorities in the work environment by the introduction of new HIT. This is often a desired outcome of HIT design and implementation, but some changes are undesirable and unintended. HIT design and implementation often influences all facets of the work environment. The challenge is to improve problematic and unwanted flows of communication, work practices, and relationships between clinicians, while leaving the positive and desired parts of the work environment as is.

(2) Technical & physical infrastructures mediate HIT use—Interaction of new HIT with existing technical and physical conditions affect HIT-in-use

This type of interaction alters the way HIT is used from the way it is designed to be used, through a poor fit between the designed HIT and the infrastructure. Infrastructure here may be other (IT-)systems that were used for the task prior to implementation, systems that are used in combination with the new system, or the physical setting (i.e. the building, furniture, and spaces) in and with which the system is used.

(3) Social system mediates HIT use—Interaction of new HIT with the social system affects HIT-in-use

The way HIT is designed to be used is often reinterpreted by the users, causing the system to be used differently in practice. Workarounds are a good example of a result of this type of interaction, as are other unintended consequences. This type of issues often eventually leads to redesign of the HIT system.

(4) HIT-in-use changes social system—Interaction of new HIT with the social system affects HIT-in-use, which then further changes the social system

Implementation of new HIT may have recursive consequences. Parts of the work environment may alter the way HIT is used, which can be a workaround. To counter this workaround, changes in the work environment like the social system may occur. This is the case when some house staff takes measures to counteract workarounds by other house staff. This is often reflected in tension or conflicts between groups of professionals.

(5) HIT-social system interactions engender HIT redesign—Interaction of new HIT with the social system affects HIT-in-use, which then leads to changes in HIT properties

This type first alters the way HIT is used via an interaction between the new HIT and the work environment. Workarounds and unintended consequences may be the result. Because this goes against the original intentions of the designers, this engenders redesign of HIT. Many unintended interactions between the 4 factors ultimately result in redesign of the HIT, to counteract and prevent the undesirable effect of the original HIT.

The depiction of a very complex reality that is offered by the model suggests that the design and implementation of HIT systems is not a matter of a simple equation that needs to be solved. Efforts to design a system that fits the complex world in which healthcare professionals operate are constantly challenged by an abundance of interaction effects.

ISTA was designed to capture common types of interaction between the mentioned subcomponents of a sociotechnical system, with special emphasis on recursive processes. It was intended to help advance research on emergent and recursive processes – which play a big role in the evolution of HIT as it is being used – and their unintended consequences. It draws from older taxonomies and categorizations, and incorporates elements from various relevant research areas. (Harrison, Koppel, and Bar-Lev 2007, 542-549)

Therefore, in a provisional reply to the first sub-question, the ISTA model seems to be a suitable framework for the study of the evolution of HIT and its unintended consequences. The results in chapter 4 will be categorized using this model. In the discussion, this categorisation will be evaluated, and thereby a definitive answer to the first sub-question will be formulated.

# 3. Methods

In this chapter I discuss the methods used in this research. The first paragraph describes the design of the study and the setting in which I conducted the research. In paragraph 3.2 until 3.4, I present the data collection methods. In paragraph 3.5, I discuss the statistical methods used to analyze the quantitative part of the data.

## 3.1 Design And Setting

I conducted a quantitative and qualitative study into CPOE use by MDs, building on older studies from 2005 (Koppel R, Metlay JP, Cohen A,et al 2005, 1197-1203), 2008 (Koppel et al. 2008), and 2011 (Kraaijenbrink 2011). The study was performed in 3 independently managed hospitals in Philadelphia, Pennsylvania, all part of the University of Pennsylvania Health System (UPHS): the Hospital of the University of Pennsylvania (HUP), a 695-bed academic hospital in which about 600 residents use SCM; Presbyterian Hospital, a 275-bed community hospital which employs about 110 residents; and in Pennsylvania Hospital, a 385-bed community hospital which employs about 150 residents. Until January 2004, TDS-7000 was the CPOE system in use in these hospitals. The current CPOE system, Sunrise Clinical Manager (SCM), has been in use in these hospitals since then.

The target population is comprised of both residents and other clinicians (Nurse Practitioners, Physician Assistants and some attending physicians) in UPHS who use SCM to enter medication orders, and who have had time to become accustomed with the system. Since residents enter most medication orders, they comprise the largest part of the group of respondents: for the Redcap survey 100% of the respondents were residents, for the face-to-face interviews 74,2%. Also, the older studies mostly focused on residents, so to keep comparability they were the preferred population.

Data were gathered in an online survey, which took place from June up until October 2011, and in face-to-face interviews, which were conducted from May up until July 2012. UPHS HIT authorities were interviewed for additional information on the development of the system and background for certain issues. In the following paragraphs I discuss these data gathering methods in detail.

The study was approved by the Institutional Review Board of the University of Pennsylvania (protocol # 809039).

## 3.2 Redcap Survey (n=86)

Initially, 420 residents were asked to participate in this online survey. 76 of them replied and took part. In July 2011, a new cohort of house staff began residencies. After about 3 months to let them become accustomed to SCM, 160 interns were approached to participate in the survey, of which 10 replied. Study data were collected and managed using REDCap

electronic data capture tools hosted at University of Pennsylvania (Harris et al. 2009, 377-381). The names of the respondents were not recorded, to ensure confidentiality and to provide subsequent anonymity. There were no open-ended questions asked. The survey questions were developed based on the work of Kraaijenbrink (2011).

The strength of the REDCap survey is the large amount of information that was gathered on previously identified issues with the CPOE. The survey enabled us to gain a good overview of the state of the system and its known issues, and we gained insight in the way users experience these issues.

The weakness of this study is the fact that the sample is not randomly selected, so it is not possible to calculate statistical estimates that are representative of the population. Nor is it possible to determine if changes are actual improvements or deteriorations in the issues, compared to the older studies. However, I do not expect the characteristics of the sample to deviate substantially from those of the population. Therefore, data gathered from the sample are expected to reflect the situation for the total population.

### 3.3 Face-To-Face (F2F) Interviews (n=66)

The respondents, who were residents (45), nurse practitioners (7), physician assistants (6), medical students (4) and physicians (4), were asked to participate while doing their work in the hospitals. They were recruited on the floors and in residents lounges. A form of snowball sampling was used to build the sample. Since the interviewer was unfamiliar with the population, this technique was very helpful in building a broad sample comprised of people from as many sub-groups of the population as possible. We aimed for a sample with characteristics that are comparable to the characteristics of the population as a whole.

Each of the respondents was experienced in using SCM to order medications. As with the REDCap survey, the names of the respondents were not recorded to provide confidentiality and subsequent anonymity. Respondents signed an informed consent form that specified anonymity and protection from legal repercussions to responses. The consent form was approved by the IRB.

The questionnaire was developed based on both the results of the earlier studies and results of the REDCap survey. It was developed further incorporating insights from the initial interviews. This caused a slightly smaller amount of respondents for the new questions. Follow-up questions were used at the judgment of the interviewer, where clarification was needed or additional information was deemed useful. The shortest interview took about 10 minutes and the longest about half an hour.

The open-ended questions next to the listed closed-ended questions are one of the strong aspects of this study. The interviewer could ask additional questions so that all facets of the CPOE system were covered, and a complete view of the state of the system was gathered.

Snowball sampling has some drawbacks. First of all, respondents are subject to several biases. For example, house staff with many social contacts are more likely to get into the sample. Also, the sample is not randomly selected, which makes it impossible to calculate confidence intervals for the entire population. In paragraph 3.5 I discuss what this means for our statistical options.

### 3.4 Consulting With HIT Authorities At UPHS (n=4)

To review the results of the questionnaires and gain further insight in identified issues, we had meetings with (1) the clinical director and the nursing clinical director of Pennsylvania Hospital, (2) the associate chief medical information officer of UPHS, (3) a clinical consultant to UPHS on Information Services and the director of Sunrise Inpatient EMR in UPHS, (4) and a supervisor at the Central Drug Distribution of HUP. Ambiguous results were discussed, we gained insight in the pharmacists' demands to the system, and discussed the development of the system over the years. All interviews were face-to-face, 2 involved follow-up contact via e-mail for extra information or clarification.

### 3.5 Statistical Methods

Responses from the F2F interviews were categorized as 'residents and medical students' versus 'other', to retain comparability between the residents sample and older studies, including the REDCap survey. Results of the two categories were compared, and striking differences are emphasized in chapter 4. After analysis I found that results of the two groups did not differ a lot. Differences I did find can be explained by the fact that residents have less experience with the system. Also, they are often younger, so they grew up using computers, where this may not be the case for many of the NPs, PAs and physicians.

The 5-point scale of observed errors (never; less than once per week; a few times per week; about daily; a few times per day) was collapsed to a 4-point scale, with a highest category called 'at least about daily'. This addressed sparse data in the 2 highest categories, and was done in the earlier studies as well. In the appendix these categories are presented both separately and combined.

Neither the REDCap survey, nor the face-to-face interviews use probabilistic sampling methods. Therefore it is not possible to do significance tests or calculate confidence intervals for the entire population. We can't determine if issues have improved, since there are no estimates on the population to compare with data from older studies. However, because the characteristics of the samples do not deviate substantially from those of the population, it is reasonable to expect the situation for the total population is similar to the situation observed in the samples. Therefore the gathered data is very useful to explore the current state of the system. The data is used, with the realisation in mind that it is important to remain cautious when inferring from the sample to the total population.

# 4. Analysis Of Results

In this chapter I present the results of our research, categorized within the ISTA framework. A comparison is made with results from the previous studies. The data are presented by topic. The evolution of the issues is discussed, where T=1 refers to (Koppel R, Metlay JP, Cohen A,et al 2005, 1197-1203), T=2 to the unpublished (Koppel et al. 2008) study, and T=3 refers to the (Kraaijenbrink 2011) thesis. The situation after T=3 up till July 2012 is presented in a separate column. Compared to the issues in the previous studies, some changes were made. Some issues did not appear to be salient, even though they may have seemed to be during the previous studies. I saved and combined topics when this was possible and made sense to do. For each topic, the code used in the Kraaijenbrink thesis is displayed to facilitate easy comparison. N1-N5 refers here to the 5 new issues identified by Kraaijenbrink, O1-O4 refers to issues from the Koppel 2005 study which were previously reported to have been fixed, and were not included in the Kraaijenbrink thesis.

The current situation is described using data from the online Redcap survey from 2011, data from the face-to-face survey (F2F) from 2012, and data from the consulting interviews with UPHS HIT authorities. From the F2F survey, just the results from residents (n=49) will be used to guarantee comparability with the Redcap survey and the older data. Results from the other respondents will be added where they provide interesting insights. Insights derived from the data are summarized in paragraph 4.1 through 4.6. Known issues are distributed according to the five ISTA categories in 4.1 through 4.5, and newly identified issues are listed in paragraph 4.6.

The data gathered in the 2011 and 2012 surveys are displayed in tables in Appendix A. When these data are used, I indicated where in the appendix the full information can be found in a more elaborate form. Here, 'R#' refers to question number # in the 2011 online Redcap survey, and 'Q#' to question number # in the 2012 F2F survey.

## 4.1 New HIT Changes Existing Social System

There were 8 issues studied where the new HIT changes the existing social system, without actually engendering any further changes.

| Previously Identified Error Risk | Evolution of Error Risk | Current situation in CPOE system |
|---|---|---|
| **1.1 Inflexibility Leads to Incorrect Medications (B2)** – Nonformulary | T=1 (issue identified): Nonformulary medication orders are not noticed by nurses, not sent to the pharmacy or even lost. | Issue remained problematic. Both in 2011 (47%) (R17) and in 2012 (63%) (Q3) many respondents experienced issues with ordering medications due to inflexibility at least several |

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| medications must be ordered on separate screen sections. | T=2: After an initial period of increased errors, improvement was measured.<br>T=3: Further improvement. However, close cooperation with the pharmacy was needed, since the CPOE wasn't suited for clear off-formulary order entry. | times each week.<br>One respondent said: 'ordering off-formulary is definitely very annoying'. Another noted that medications for the patient to take home can only be oral.<br>It was noted that formulary medications can also be hard to order, because the name of the medication has to be typed exactly right, which is hard for meds that are hardly prescribed. |
| **1.2 Inflexibility Leads to Incorrect Tests (B2)** – The process of ordering tests is un-intuitive on several points, making it hard to order the needed test. | T=1 (issue identified): It is often not possible to enter nonstandard test specification, such as modifications or specific scan angles.<br>T=2: Issue seemed to have improved<br>T=3: Issue seemed to have improved even further | The issue with nonstandard test-specifications did not seem to have improved, since it was still reported in the face-to-face interviews.<br>A new issue with ordering tests was identified: it is hard to order the right test if you don't know under what name it can be found in the system. 71% of respondents (n=21) reported they spend extra time finding the right test at least a few times each week because of this (Q28). |
| **1.3 Sending Medications to Wrong Rooms When the Computer System has Shut Down (C1)** – If the system is down when a patient is moved, the pharmacy is not alerted and sends medications to the old room. | T=1 (issue identified): Meds were reported to be sent to the old room, causing a loss of medication or a delay in administration. It was also reported that the wrong medication may be administered to a patient.<br>T=2: No change reported<br>T=3: Problem solved. System is reported to have only been down for 3 short periods in 1 year. Causal relationship between these facts is not confirmed. | It is unknown why the issue was reported to be solved in T=3. Little downtime may have caused the issue to disappear temporarily. In 2011, 86% of respondents reported to have had delays in ordering because of system downtime less than once a week or never (R15), which suggests very little downtime. Actual amount of downtime in 2011 is unknown. The issue may only present itself in case of downtime. |
| **1.4 Late-in-day Order Lost for 24 Hours (E1)** – When medications or lab orders are admitted | T=1 (issue identified): Some patients did not receive medication or a test for an extra day. | *No new data* |

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| late in the day, and are requested for 'tomorrow', it might already be 'tomorrow' (i.e. after midnight). The order may be actually administered 24 hours later than intended. | T=2: no change<br>T=3: no change | |
| **1.5 Discontinuation Errors Linked to Canceled Procedures (E2)** – When procedures or certain tests are cancelled, linked medications may not be automatically stopped. | T=1 (issue identified): Unneeded medications may be administered if a test or procedure is cancelled, because linked medications or dyes are not automatically cancelled in the process.<br>T=2: no change<br>T=3: no change | In 2011, 43% never observed this issue and 42% observed it less than once a week (R20). In 2012 this was 61% and 29% respectively (Q7). Respondents from the f2f confirm the issue has improved. What action was taken to achieve this change was not determined. |
| **1.6 Total Dose vs. Tablet Format (L2)** – In order formats, doses are presented in tablets/dispensed-units, rather than in total doses. | T=2 (issue identified): Issue leads to unclarities in the dose a patient should receive, increasing error risks.<br>T=3: no change | In 2012, 45% of respondents confirmed they find problems with order formats of doses at least a few times each week (Q17). One respondent said that for a certain 15mg order, you have to put in a 5mg – and a 10mg order, which will generate a redundant duplicate alert. Another said sometimes it's unclear if a dose should be entered in mg or in number of tablets. They need to contact the pharmacy each time for clarification. One respondent said for potassium, the amount is only displayed in number of tablets, mgs are not mentioned.<br>Several other respondents mention this issue is mainly problematic in discharge summaries. |
| **1.7 Orders temporarily disappear prior to verification (N3)** – Medication orders were listed after approval by the pharmacists, causing | T=3 (issue identified): The risk of duplicate orders increased in the time between entering and verification of an order. | 48% and 39% of respondents in respectively 2011 (R36) and 2012 (Q10) observed other clinicians could not see medications they ordered prior to approval/validation by pharmacists at least a few times each week. In 2012, 18% reported this to cause duplicate |

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| the order to disappear from the system for some time. | | orders at least a few times each week. Duplicates are reported to be caught by a duplicate alert though. |
| **1.8 Workload (N5)** – The system does not sufficiently help residents handle the high pressure of the work environment they have to cope with every day. | T=3 (issue identified): The system did not facilitate the handling of high workloads sufficiently, but instead was error-prone when MDs were distracted, tired, and under a heavy workload. | Based on the data gathered among residents in 2011, stress is considered to increase the risk of medication errors. Residents do not seem to experience a big difference between different stress factors. Slightly bigger seem to be: the number and timing of admissions, and the lack of good sleep. The biggest influence on the risk of medication errors: these issues and the number of patients, albeit by a small margin. Extensive results from the research can be found in appendix A. |

### 4.2 Technical And Physical Infrastructures Mediate HIT Use

*Interaction of new HIT with existing technical and physical conditions affect HIT-in-use*

There was 1 issue studied that changes the way HIT is used by an interaction between new HIT and the infrastructure.

| Previously Identified Error Risk | Evolution of Error Risk | Current situation in CPOE system |
|---|---|---|
| **2.1 Delayed Ordering Because of Terminal Unavailability (D2)** – A lack of terminals leads to delays in medication ordering. | T=1 (issue identified): Delayed ordering by clinicians increases the risk of errors. T=2: No improvement. T=3: Delayed ordering due to lack of terminals differed per location. In general not reported to be a big issue anymore. | In 2011, 58% of residents were forced to delay ordering because of a lack of terminals several times each week (R16). In 2012 no specific questions were asked about this issue. The issue was not mentioned by respondents either, suggesting only a limited inconvenience was experienced. |

### 4.3 Social System Mediates HIT Use

*Interaction of new HIT with the social system affects HIT-in-use*

There are 4 issues studied where the way HIT is used differs from the way designers intended it to be used, caused by an interaction between the new HIT and the social system.

| Previously Identified Error Risk | Evolution of Error Risk | Current situation in CPOE system |
|---|---|---|
| **3.1 Unclear Log On/Log Off (C4)** – MDs can order medications at a terminal after a previous MD forgot to log off. | T=1 (issue identified):<br>This issue led to medication subscription to the wrong patient.<br>T=2: no change<br>T=3: issue fixed | *No new data* |
| **3.2 Automatic Canceling of Repeated Labs (J1)** – SCM automatically cancelled some lab orders. | T=2 (issue identified):<br>Issue engendered missing tests/medications.<br>T=3: Problem solved | In 2011, 36% of respondents observed this to happen at least a few times each week (R31), opposing the claim in T=3 that the problem was solved.<br>In the f2f this was confirmed by residents: Certain blood level-measurement tests (e.g. magnesium) are not allowed if the values were within normal range in the previous 3 days. A workaround was developed, in which a more elaborate test was ordered, which tests for 7 values instead of just the one that is needed. Also, residents mentioned lab-workers frequently cancelled lab-orders, without communicating why. Contacting lab-workers to find out why labs were cancelled takes a lot of time. |
| **3.3 Estimation Pt's weight to order medications (L1)** – When ordering meds, 'patients weight-field' must be filled, while measurement may not be possible instantly, resulting in a guessed entry. | T=2 (issue identified): MDs entered an estimated weight, but were not able to indicate it's informal basis.<br>T=3: Nurses made sure an accurate measurement is available in the system most of the time, but residents still frequently reported having to estimate a patients weight. | In 2011, 49% of respondents had to estimate a patient's weight to order a medication at least a few times each week (R32). In 2012 this was 35% (Q18). The pharmacy at HUP noted an MD's estimation after seeing a patient is sufficient for a prescription in many cases. However, if these estimations get into the system, other MDs may use them out of context. Several workarounds were observed to find an estimation if the weight is not logged in the patient's file: (1) Ask the patient. (2) Go to a heparin-order, and the weight will be displayed |

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| | | even though it isn't accessible anywhere else. It is unknown where this reading origins from. (3) Find a medication order from the patient's past, divide the number of mg's administered by the normal amount of mg/kg, this should give the patient's weight. |
| **3.4 Listed 'reasons' for ordering tests do not reflect needed options (L3)** – MDs selected reasons that may or may not be close to the actual reason, when an accurate description is not available or easily found, which leads to inaccurate information in the charts. | T=2 (issue identified): The listed reasons do not map the needed options. House staff reported to 'make up reasons that are close' T=3: No change | In 2011, 51% of respondents found the list of possible reasons when ordering a test did not reflect the actual reasons at least daily (R35). In 2012 this was 49% (Q19).<br>In 2012, the question asked was slightly adjusted from 2011, including a question about if respondents had ever picked the first option, rather than just asking if they picked a reason close to the actual reason. Respondents noted it can be very time-consuming to select the best matching reason in a long list of options. If frustration level is high or when they're busy, residents do not select an applying reason, thereby entering inappropriate information in the patient's file. One example that was encountered: when ordering an echo, 'arrhythmia' is not listed as a possible reason, but 'ventricular premature beats not approved by Medicare NJ' is. Another respondent indicated she always called the lab to explain the order she just entered, because the system keeps her from communicating this well.<br>Results of this issue are that respondents often have to call the pharmacy to give an oral explanation with their order, which takes time, and wrong information gets into the patient's file, which may be dangerous.<br>Some respondents noted the diagnosis is unknown before the test is done, so it's not possible to give a sensible answer in this field. |

### 4.4 HIT-In-Use Changes Social System

*Interaction of new HIT with the social system affects HIT-in-use, which then further changes the social system*

There are 3 ways studied where the system is not used as it was designed to be because of an interaction between the new system and the work environment, resulting in a recursive change in the work environment or social system.

| Previously Identified Error Risk | Evolution of Error Risk | Current situation in CPOE system |
|---|---|---|
| **4.1 Redundant drug-allergy alerts (G1, N1, N4)** – Drug allergy alerts are displayed if a patient's file indicates an allergy to a component which is prescribed. | T=1 (issue identified): Allergy alerts were reported to be displayed after the medication order was submitted, causing MDs to rely on pharmacists to check for drug-allergies. Also, allergy alerts were provided in an unclear format, and sometimes filled with false information. Responsibility for drug-allergy checks shifted to pharmacists.<br>T=2: Warning fatigue was reported to be universal, causing massive ignoring of frequent and sometimes dubious warnings.<br>T=3: Alert fatigue is still the major issue. MDs assumed the pharmacy would correct all errors, which caused a dependency to pharmacists. They also called on the pharmacy for help, where the helpdesk would be appropriate, causing friction between pharmacists and MDs. | In 2011, 52% of respondents reported to have ignored between 50% and 100% of alerts. Another 36% ignored 25% to 50% (R9).<br>In 2012, respondents ignored or overrode 46% of drug-allergy alerts (Q14).<br>One respondent noted it is not possible to indicate subtleties. One patient had a nauseous reaction to a medication, but when this was entered in the patient's file, this information caused a full-on allergy alert for every related medication.<br>The pharmacy IT administrator indicated they started to turn off certain alerts to counteract alert fatigue. |
| **4.2 Redundant drug-drug interaction alerts (N1, N4, O2)** – Drug- | T=1 (issue identified): Some drug-drug interaction alerts were not displayed in the CPOE, while they | In 2011, 79% of respondents indicated they ignored/overrode between 50% and 100% of drug-drug interaction alerts. Another 17% |

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| drug interaction alerts are displayed if a patient is receiving drugs with a contra-indication. | were displayed in the pharmacist's systems. Pharmacists spent time contacting MDs to clarify questionable orders, increasing error potential. This generates tension between pharmacists and MDs.<br>T=2: *No new data*<br>T=3: MDs assumed the pharmacy would correct all errors, which caused a dependency to pharmacists. They also called on the pharmacy for help, where the helpdesk would be appropriate instead, causing friction between pharmacists and MDs. | ignored 25% to 50% of alerts (R8).<br>In 2012, respondents ignored or overrode 81% of drug-drug interaction alerts (Q13).<br>A respondent indicated that if an interaction effect is known for a certain antibiotic, the alert is also displayed for distantly related antibiotics, even when this is not relevant. Another respondent indicated he and his colleagues were aware that some alerts were important, but because the majority is not, they found it to be hard paying attention to them all.<br>The pharmacy indicated they started to turn off certain alerts to counteract alert fatigue. |
| **4.3 Redundant dosage alerts (G1)** – Dosage alerts are displayed when a chemo dose that is prescribed seems to be incorrect or dangerous. | T=3 (issue identified): Not all residents reported having received dosage alerts. If they were received, most were overridden. It is unclear if this is because of redundant alerts, or because of alert fatigue. | In 2011, 21% of respondents indicated they received a dosage alert (R10); that is, only 21% said they ever received such an alert. 35% of them indicated they ignored/overrode between 50% and 100% of alerts (R11).<br>In 2012, 23% of respondents reported they ever received a dosage alert. On average they ignored or overrode 25% of these alerts (Q15). |

### 4.5 HIT-Social System Interactions Engender HIT Redesign

*Interaction of new HIT with the social system affects HIT-in-use, which then leads to changes in HIT properties*

14 issues were studied where the system is not used as it was designed to be, because of an interaction between the new system and the work environment, resulting in a partial redesign of the HIT system.

| **Previously Identified Error Risk** | **Evolution of Error Risk** | **Current situation in CPOE system** |
|---|---|---|
| **5.1 Charting Difficulties leading to Inaccurate** | T=1 (issue identified): House staff consulted RNs to determine time | 64% and 39% of residents reported to have been uncertain about exact administration time |

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| **and Delayed Medication Administration (A1)** – RNs often postponed the time-consuming charting of drug-administration time.<br>MDs couldn't trust the charted times as a result, which is an error-risk, and spent time seeking RNs to determine actual times, which is an error-risk. | of administration. Some medications, especially insulin, were recorded on parallel systems (i.e. paper charts, separate paper sheets, directly in CPOE, etc.). Causing confusion and loss of information.<br>T=2: Improved charting & screen-navigation, however issue not solved. Post-hoc and 'anticipatory' charting remained prevalent.<br>T=3: No change, frequent consulting of RNs remained. | for time sensitive drugs in 2011 (R37) respectively 2012 (Q4).<br>The big difference may be explained by a different interpretation of the question in 2012, which was stated more concise. When asked about their answer, some respondents explained they were uncertain at what time time-specific medications were supposed to be administered. One respondent noted about insulin administration, that 'sometimes the registered dose is different from the actual dose, because actual dosage may be constantly adjusted based on the patient's needs.' Parallel systems were not reported. |
| **5.2 Using Ambiguous Dose Information (B1)** – To determine what dosage to give for unfamiliar medications, MDs unknowingly used ambiguous information from the CPOE, leading to erroneous dosing. | T=1 (issue identified): Dosages listed in the CPOE, based on the pharmacy's warehousing and purchasing decisions, or based on dosages for other patients, were used, either to determine minimum doses or normal ranges of doses.<br>T=2: SCM did not display misleading dosages as TDS did, but house staff still subtracted doses from the CPOE, which were not likely to be suitable for their particular case.<br>T=3: There was strong improvement, with most residents using the appropriate databases to follow clinical guidelines. | In 2011, 19% of responding residents used string searches or pop ups within SCM (R7). In 2012 this was only 2% (Q12). In 2012, an additional 4% reported to use Google, and 2% called the pharmacy. The rest reported to use appropriate databases. The used databases and way of approach are displayed in figures 4 and 5.<br>Only 1 respondent reported to know about a convenient button that was hidden in the ribbon (!) with a link to Lexicomp. Everyone else either entered the URL manually or used a hidden link on intranet.<br>Of the 17 non-residents that were interviewed (i.e. NPs, PAs and physicians), none reported to use anything other than the appropriate databases. |
| **5.3 Gaps in Antibiotic Therapy (B3)** – Antibiotic therapy needs to be re-approved every | T=1 (issue identified): Frequent re-approval was introduced to maximize appropriate prescribing. A paper system was used for | In the consulting interviews it was noted antibiotics need re-approval every 7 days now. In the last 24 hours, anyone entering an order for this patient will receive a reminder that re- |

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| 3 days. If this is overlooked, therapy will be stopped unintentionally. | reminders, but was out of sync with the electronic system, creating unclarities and errors.<br>T=2: Significant improvement, because of electronic reminders in the CPOE, but gaps in therapy were still observed.<br>T=3: Further improvement, most residents did not observe any gaps in treatment. | approval is needed.<br>Caused by an unintended pause in re-approval, 9% and 20% of the residents observed a gap at least a few times each week in 2011 (R13) and 2012 respectively (Q2). For antibiotics being removed from the list, these percentages are comparable: 20% (R14) and 18% (Q2). |
| **5.4 Loss of Data, Time, and Focus When CPOE is Nonfunctional (B4)** – Orders being entered when the system crashes are lost. The need to wait for system revival to re-enter orders increases error risks. | T=1 (issue identified): Crashes and shut-downs for periodic maintenance are common<br>T=2: System downtime declined<br>T=3: Downtime declined further, but sluggishness delayed ordering and information retrieval, especially around midnight. IT department was aware. | *No new data* |
| **5.5 Limited one-screen overview possibilities (B5, D1, N2)** – The system did not provide in a possibility to see listings in a one-screen overview. This goes for both medication lists as for notes, leaving important information unnoticed. | T=1 (issue identified): A patient's medication is seldom synthesized on 1 screen. Older medication orders were unnoticed and remained active while a new order was placed, causing double doses or conflicting medication.<br>T=2: Screens improved. Concise medication lists were introduced, but problems were still reported.<br>T=3: Both medications and notes still fell off the list sometimes. Filters were introduced to hide information temporarily. | In 2011, 38% of residents reported they are uncertain about the complete listings and dosages of a patient's medication, because it was difficult to see them all at one time, at least a few times each week (R33). 17% reported this led to a failure in discontinuing medications at least a few times each week (R34).<br>In 2012, 53% of residents reported they had been uncertain about the complete listings at least a few times each week, because of difficulty viewing all meds on 1 screen. This difficulty caused 33% of residents to have been uncertain about dosages at least a few times each week. 39% reported these issues caused a delay at least a few times each week, either in their work routine or in administration of medications. (Q1) |

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| **5.6 Failure to Chart or Discontinue NOW & PRN meds (C2)** – NOW (immediate) and PRN (give as needed) are not listed with standing orders but on fragmented screens, and ordering them is cumbersome. | T=1 (issue identified): The divergent processes for NOW & PRN orders resulted in unintended medications due to problems discontinuing an order, and may lead to duplicate orders as well. These orders are often not discussed at hand-offs, increasing error risks.<br>T=2: No change<br>T=3: Issue solved | NOW & PRN are no longer in separate processes from other orders. Issues were reported in 2011 and 2012:<br>In 2011, 30% experienced NOW-order routines to be clumsy or unusual at least a few times each week (R24). For 10% of respondents this led to unintended or missed medications at least a few times each week (R25). In 2012, 25% of respondents reported to have problems with NOW-orders a few times a week (Q8a).<br>15% of respondents found PRN order routines to be clumsy or unusual at least a few times each week in 2011 (R26). For 6% of respondents, this led to unintended or missed medications at least a few times each week (R27). In 2012 20% of respondents have problems with PRN-orders a few times a week (Q8b).<br>One respondent reported he entered a PRN order to be administered in case of high blood pressure. The patient's blood pressure was too high for 1,5 hours, and still nothing was administered. An adjustment in PRN-order possibilities is desired here. Another resident noted they were taught to always call a nurse when a NOW order was entered, to make sure it was administered on time. |
| **5.7 Easy Selection of Wrong Patient (C3)** – It is easy to select the wrong patient's file due to confusing screens: names and drugs are close together, a small font, patient's names are not displayed on all | T=1 (issue identified): 55% of MDs reported having difficulty identifying for which patient they were ordering.<br>T=2: displays improved, but results have not changed<br>T=3: Displays are further improved, no problems were reported anymore. | In 2011, 15% of respondents reported they had "never" ordered for the wrong patient and 72% reported "less than once a week" (R29). In 2012, these figures were 16% and 47% respectively (Q9).<br>It is unclear what caused the big difference in percentage between 2011 and 2012. For non-resident respondents in 2012, the percentages were 6% and 76%, which seems more in line |

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| screens, and inconsistent use of colors. | | with the 2011 result. This suggests the difference is attributable to the resident-respondents in 2012, however further research is needed to find out why, and clarify this. |
| **5.8 Essential patient information stored in other systems (F1)** – MDs required to log out of CPOE and in to other systems to find labs, vitals, notes, etc. | T=1 (issue identified): Essential data (vitals, lab results, etc.) were found in other systems. MDs had to log out of the CPOE and into other systems to view them.<br>T=2: Access to lab reports improved. Other information still in other systems, requiring frequent switches between systems.<br>T=3: Info was still reported to be found in systems other than the CPOE. | In 2011, 56% of respondents had to leave SCM at least daily to find information such as *notes and I-O sheets* in other systems (R38). 47% had to leave SCM at least daily to find essential data such as *lab reports (R39)*.<br>In 2012, 65% had to leave SCM for *notes* at least daily. Notes are often reported to be on paper, which is covered further in the issue 'parallel systems' in paragraph 4.7.<br>64% reported they never had to leave SCM for *I-O sheets*.<br>45% had to leave SCM for *lab reports* at least a few times each week.<br>51% had to leave SCM for *other* at least a few times each week, other mostly being reported to be radiology reports and information in outpatient systems.<br>There seemed to be differences between hospitals in 2012, which may be caused by differences between the IT systems in these hospitals (see figures 6-9). Further research is needed to determine statistical significance of these differences. (Q11) |
| **5.9 Dosages Listed Alphabetically Rather Than Numerically (J2)** – At the introduction of SCM, dosages were not listed numerically, but the way they were spelled out instead (five, four, one, seven, two). | T=2 (issue identified):<br>The illogical order suggested certain dosages may be the default option, since listed first, thereby increasing the error-risks.<br>T=3: Problem fixed, numerical order was used. | In 2011, 37% of respondents indicated they found the dose listings to be presented in a confusing or illogical order at least a few times each week (R40). In 2012 this was 37% as well (Q16).<br>Part of the issue had been resolved in T=3, but apparently there still are issues here. This may partially be explained by a misinterpretation of the question. Many respondents in the f2f in |

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| | | 2012 indicated that when answering this question, they were actually referring to the issue about ordering for a total dose vs. ordering in tablets/dispensed units. |
| **5.10 Loss of 'Tapers' (K1)** – Tapers, which existed in TDS, were not available in SCM. MDs had to calculate each stage, dosage and time to gradually reduce medication. | T=2 (issue identified): Calculation and entry by hand, which increases error risk.<br>T=3: situation improved, with SCM introducing tapers for some medications. However, not everyone was aware of this possibility. | Respondents confirm in the f2f the existence of tapers, mainly for steroids. Availability of tapers for other medications as well is desired though. No other data about this were collected. |
| **5.11 Finding Specific Laboratory Reports (K2)** – MDs had trouble finding lab reports, because of inconsistent titles, long lists of reports, missing reports or search by exact wording was required. | T=2 (issue identified): Lab reports are not concise and not in a coherent format.<br>T=3: Improvement, mainly because the newly designed icons were helpful. | Results are respectively from 2011 and 2012:<br>Inconsistent titles hindered finding lab results at least a few times each week for 44% (R41) and 27% (Q20b) of respondents.<br>Long lists hindered finding lab results at least a few times each week for 62% (R42) and 49% (Q20).<br>Lab results were missing at least a few times each week for 27% (R43) and 33% (Q20c).<br>Poorly designed icons hindered finding lab results at least a few times each week for 22% in 2011 (R44).<br>Finding lab results was difficult because you have to search by exact wording at least a few times each week for 37% (R45) and 27% (Q20a).<br>Another problem which was identified, is that, when scrolling though the result-table, checkboxes indicating a result only appear when the scrolling stops, making it difficult to scan the table for certain results. A respondent noted this makes it very hard to find specific test results. |
| **5.12 Loss of 'now-and-then' orders (L4)** – | T=2 (issue identified):<br>Because the now-and-then order | The now-and-then capability was re-introduced for some medications, but not for all. The IT |

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| Now-and-then orders allowed MDs to enter an immediate order, with a routine schedule of another dosage in the same order screen. This function was not available after the introduction of SCM. | format was no longer available, MDs were forced to put in two separate orders: one with the initial dose, and one with routine schedule after that. This lead to possible confusing instructions about the same medication for the same patient.<br>T=3: No change. SCM had now-and-then capability, but it was not yet implemented. | department indicated this is because it is not thought to be desirable to enable now-and-then functionality for all orders. A respondent noted that for the vast majority of meds it is not possible, thus very annoying. If the order still had to be entered in two different parts, a duplicate alert would be given.<br>In 2011, 80% reported they never or less than once a week had problems with now-and-then orders being on two different screens (R22).<br>38% reported they had to enter an order one-by-one that should have been a single now-and-then order at least a few times each week (R23).<br>In 2012, 41% reported to have problems with now-and-then orders because they were on two different screens or had other problems at least a few times each week (Q8). |
| **5.13 Diluent Options and Errors (O1)** – MDs are required to specify diluents, but are not trained for this task so need advice from pharmacy to do so. | T=1 (issue identified): House staff were unaware of impermissible combinations of diluents and antibiotics. Pharmacists had to catch the errors.<br>T=2: Problem eliminated via predetermined options | *No new data was collected from house staff*<br><br>In an interview with a supervisor at the Central Drug Distribution of HUP it was noted that the predetermined options do not take into account that diabetics can't handle sugary diluents, and fluid-restricted patients shouldn't get saline. At this point it is unclear if this issue poses a problem, but it may have resurfaced. |
| **5.14 Failure to Provide Medications Post-Surgery—Role of Extra Safety Step (O3)** – All medication orders are cancelled automatically when a patient goes into surgery.<br>After surgery, new orders are suspended | T=1 (issue identified):<br>Post anesthesia-care RNs sometimes overlooked the required activation. The extra approval step by MDs was sometimes overlooked as well. This resulted in meds not being provided.<br>T=2: Issue fixed. The extra re-approval step was removed. | *No new data* |

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| until the post anesthesia-care RN activated them. After that, the MDs had to re-approve each one. | | |

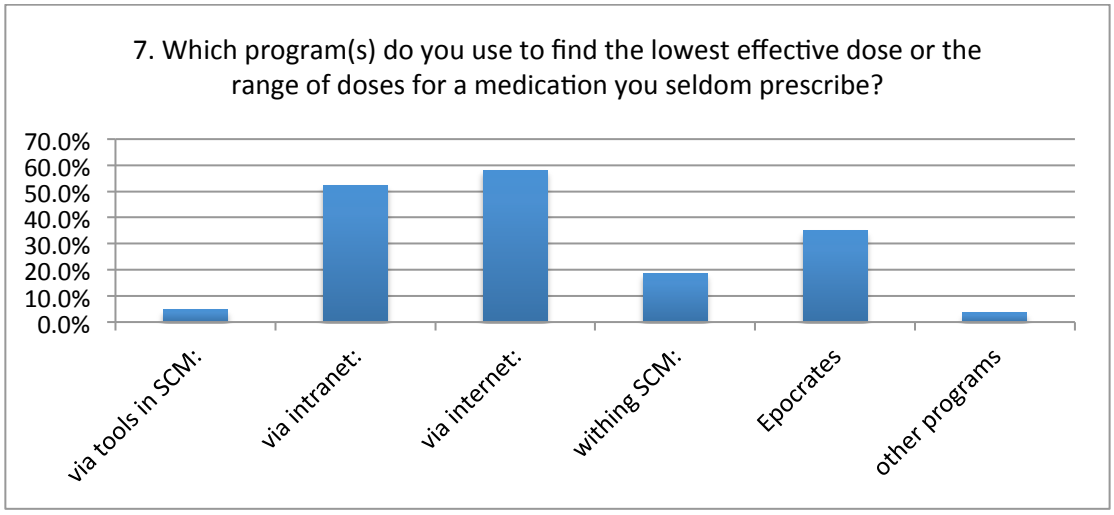


*Figure 4: Results From The REDCap Survey*

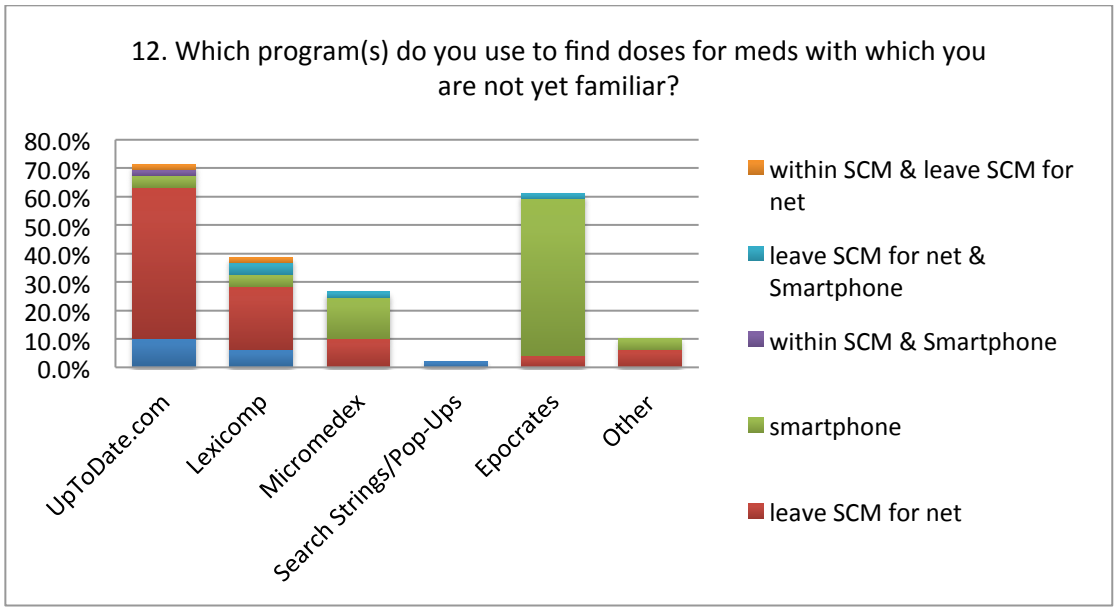


*Figure 5: Results From The Face-to-face Interviews*

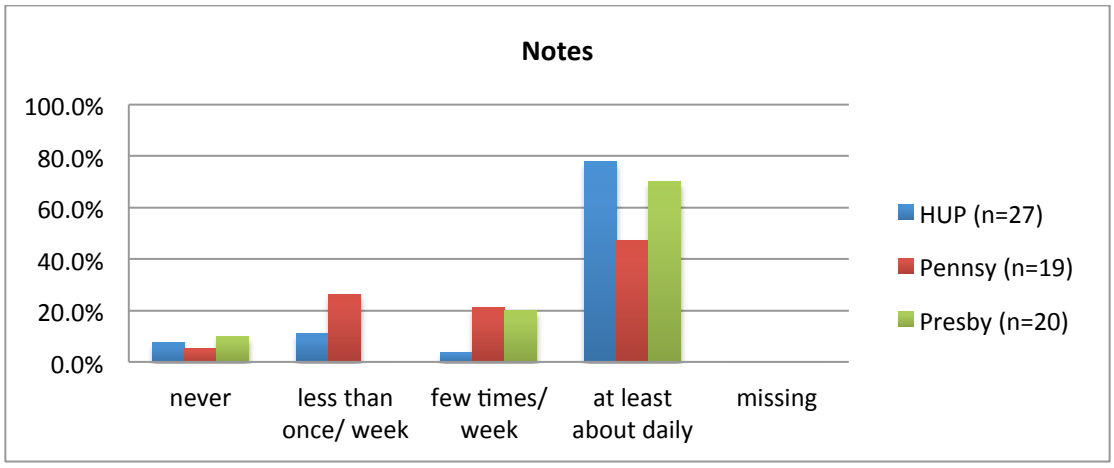


*Figure 6: F2F 11a. How Often Do You Have To Leave SCM To Find NOTES In Other Systems?*

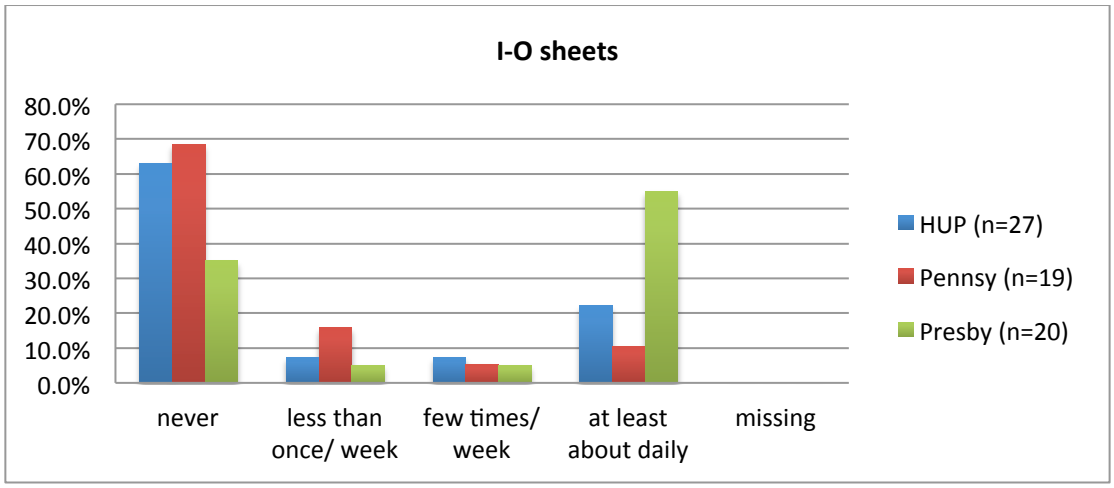


*Figure 7: F2F 11b. How Often Do You Have To Leave SCM To Find I-O SHEETS In Other Systems?*

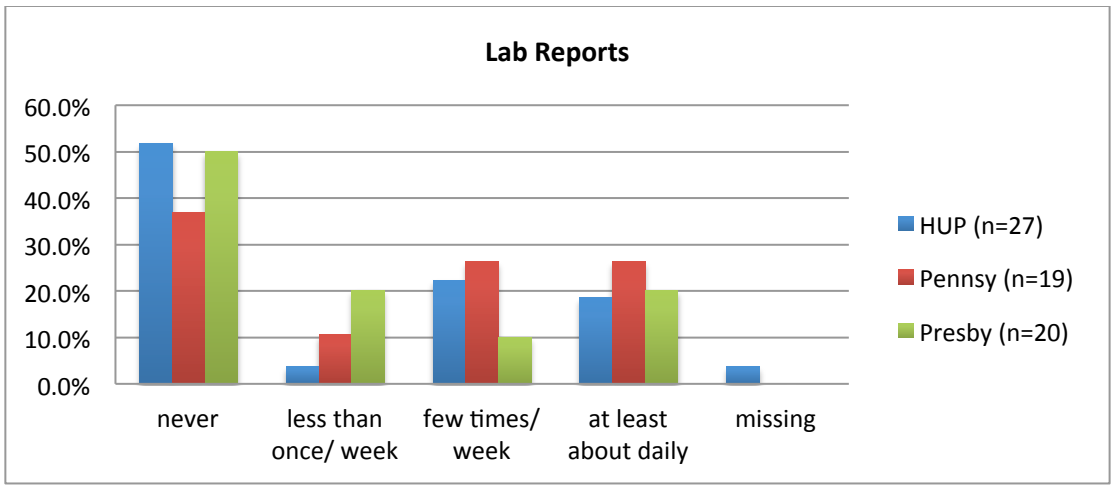


*Figure 8: F2F 11c. How Often Do You Have To Leave SCM To Find LAB REPORTS In Other Systems?*

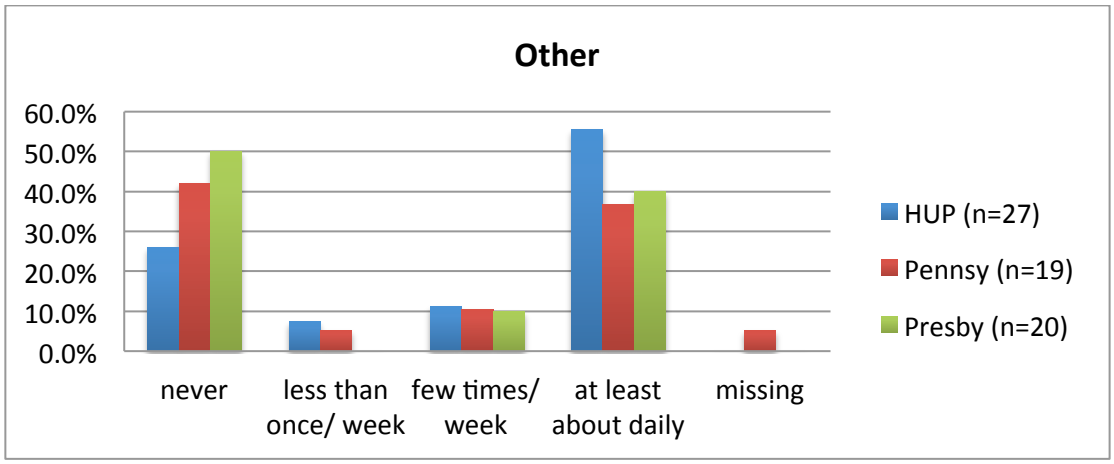


*Figure 9: F2F 11d. How Often Do You Have To Leave SCM To Find OTHER In Other Systems?*

### 4.6 New Issues

The new issues have been split up into two categories. Issue 6.1 through 6.8 are documented well enough to categorize them according to the ISTA model and indicate with some certainty the amount of problems caused by the issue. The second category consists of issues 6.9 through 6.14. These were mentioned by several respondents, but have not yet been documented well enough. Therefore we cannot be certain about their significance or the origin of these issues and their evolution over time.

| *ISTA-category 1:* | |
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| **6.1 Discharge and sign-out documents are not efficient** – All relevant information about the patient's stay has to be entered in these forms. There is no copy paste functionality, and it is not possible to view the patient's file simultaneously while writing the document, making this a very time-consuming process. MDs have to look up information, open the document, write a little, save the document, close it, and look up more information. | In 2011, 34% of respondents indicated the lack of copy paste functionality never forces them to re-input orders in a discharge order. Another 31% does experience this, but only less than once a week. The other 31% does, at least a few times each week. 4% of results were missing (R30). In 2012, 51% found themselves re-inputting orders for discharge orders at least a few times each week because of the lack of copy paste functionality. For inpatient orders, this was 54% (Q21).<br>A respondent noted I-O information should be available in sign-out documents. Another respondent wondered why fields like 'lab results' and 'medications' are not auto-populated, since the information is present in the system already. These measures should decrease the time needed to fill the documents greatly. |
| **6.2 Unintended consequences when modifying existing orders** | In 2011, 36% of respondents observed duplicate orders occurred at least a few times a week when existing medication orders were modified (R18). In |

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| – When modifying existing medication orders, duplicate orders may result or unintentional dose changes may occur.<br><br>Q5, Q6, R18, R19 | 2012, this was 34% (Q5). The system does always give an alert when a duplicate order is created, so this issue is reported never to cause problems. In 2011, only 8% observed unintentional dose changes more than once a week when modifying existing orders (R19). In 2012, this was 12% (Q6). One respondent specifically encountered this issue when entering a vitamin D order.<br>A respondent noted 'modify' is hardly used, because in SCM it is easier to cancel and reorder. |
| **6.3 Error Inducing Default Options** – Some fields are filled with default information. This information is not always correct, so some fields have to be changed every time. If one is missed, this may endanger patients. | Some examples of fields that have to be adjusted by default:<br>- When an order is cancelled and reordered, the re-order may be started somewhere in the future, based on the stop-date of the old order. In 2012, 32% of respondents found an order to start too far in the future by default at least a few times each week (Q26).<br>- The stop date of orders is filled to be after one month by default. It seems more practical to leave this up to the judgment of the MD.<br>- Narcotics orders are standing by default, but they should be PRN.<br>- PTN is set to 'central' by default, which can cause dangerous situations. |
| *ISTA-category 2:* | |
| **6.4 Parallel Systems** – The use of multiple systems next to each other increases the risk of losing or missing important information and notes. The most important other systems are paper if SCM doesn't suffice, and EPIC, Medview, a system for Radiology, and some others to store information that cannot be conveniently stored in SCM. | SCM lacks functionality, forcing users to make use of parallel systems. Problems can be categorized in issues with entering and issues with retrieval of information.<br>- Enabling users to enter all information in the CPOE in a convenient format, without the need for parallel systems like paper notes.<br>Current problems are: (1) there is often too little space to type, forcing MDs to write part of their notes on paper, and (2) inconvenient fields for notes, causing information to be entered and displayed in a very inaccessible way.<br>There are continued efforts to eliminate the use of paper to store information. In October 2013, an SCM upgrade for the hospitals is planned, which should enable users to enter all information digitally. Part of this upgrade is pre-configured templates for fields for progress notes, etc., developed by the vendor to better fit daily practice.<br>- Enabling users to retrieve all information from the CPOE in a convenient format, without having to leave SCM, disturbing the workflow.<br>Current problems are: (1) some imaging systems (Medview&Singo) are |

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| | reported to be inaccessible on some workstations and for some users, (2) the imaging-tab (Medview) in SCM is not connected for everyone, so some users always have to leave SCM to view imaging, (3) imaging loaded into a tab in SCM is stored in a lower color-scale and bit-rate than the original, causing the image shown in SCM to be not reliable for diagnosing and forcing MDs to switch to the imaging-system, (4) EPIC is not approachable from SCM, so users have to switch between systems to consult outpatient information, (5) one of the hospitals uses paper prints of echo-reports, and has one single workstation for the whole hospital if someone wants to view echo's digitally or needs a copy of the report, (6) several respondents report EPIC and SCM do not communicate well, causing home-medication or known alerts not to be displayed in SCM, (7) when a summary of a patient's file is printed on paper, (7.1) vitals are left out, forcing someone to daily spent 3 hours writing them down by hand, and (7.2) only part of the med-list is printed, dropping meds starting with Z first, and X close after that, which are the most important medications, (8) synchronization of data between Medview and Sunrise may take a long time, and (9) only the author of a discharge summary is allowed to print it. If this author left for home, this may delay a discharge by a day.<br>Integration of EPIC data and primary care information into SCM is currently introduced by incrementally making selected data available. Information on allergies is prioritized first. |
| *ISTA-category 3:* | |
| **6.5 15-minute limit to save data** – When a discharge document has been opened for 15 minutes, it becomes impossible to save it, causing a loss of data, and a loss of time needed to re-enter the data. | 21% of respondents (n=47) indicate this issue causes them problems at least a few times each week (Q24). Other respondents indicate this issue does not give them a lot of problems. Because it is a known problem, MDs are taught to save the document regularly, and make sure they close and open it again before the 15 minutes are over. |
| *ISTA-category 5:* | |
| **6.6 Information stored on several places within SCM** – In SCM, some information can be stored in more than one place. | Information is stored both in flowsheets (which are intended for MDs) and the documents-tab (intended for nurses and other professions). Knowledge Based Charting (KBC) was introduced in Oct/Nov 2011, effectuating a change in charting. The documents-tab is now used for patient-oriented |

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| This forces users to spent extra time searching a big part of the system for certain information. | charting, rather than discipline-oriented which was custom on paper charts, so it is filled with reports from all disciplines on a patient's status, causing an enormous amount of notes each day.<br>76% of residents reported to use the documents tab to find information, even though it is not intended for them (Q27). This slows down their search for relevant information greatly, because residents were never trained in the use of this tab, and have trouble finding information here due to the enormous amount of information that is useless for an MD. Respondents reported having trouble finding vitals or respiratory for instance.<br>Filters were created to address this problem, enabling productive use of this tab. Not all residents knew filters existed. Even with filters present, some residents still report problems. One respondent reported it is very hard to find the sign-out document, especially after a long LoS.<br><br>Other issues with unclear location of information: (1) if a patient's weight is not available in his file, it may be auto populated from an unknown source in a heparin-order, (2) there are multiple sources for medication records, and (3) if for pain medication an IV-drop is administered, this may be easily missed due to several possible points of charting. |
| **6.7 Space to type relevant information** – Certain fields were reported to have a maximum of 2000 characters, limiting the amount of information an MD could enter. Different solutions were introduced to increase the available space for entering information. | In 2012, 26% of residents (n=47) indicated they daily find there is not enough space to type needed information in discharge summaries (Q23).<br>As a first solution, additional boxes were added. This generated what was generally a string of empty boxes. The current solution is a possibility to create extra boxes when needed. Not all MDs know about this, so sometimes information is not added, or it is entered but not noticed. Also, this solution is not available for all fields.<br>The problem was reported to be encountered regularly in sign-out documents as well. |
| **6.8 Design obscuring important distinctions** – Design of HIT systems should enable users to notice important information fast. This calls for distinctions to be emphasized by design. | In the list of medications, some of the meds are italicized to indicate these are inactive medications. Respondents indicate this difference used to be indicated more clearly in an earlier version of the system. There was a filter introduced which lists only the active medications, helping MDs find out what medications a patient is receiving.<br>Even with the presence of filters, 30% of respondents (n=47) noted that at least a few times each week they found it to be unclear if an order was active or canceled (Q25). |

***New issues for further study***

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| **6.9 Slow or Freezing System or System Downtime** – A slow or freezing system causes frustration and disables MDs to do some of their work, causing danger to patients. | Respondents in 2012 mostly complained about the system being slow and "laggy", with occasional freezing of the system. This was reported to have gotten worse since the upgrade to version 5.5 in spring 2012. The clinical summary tab is hardly used by one respondent, who argued that 'a lot of scrolling is needed, and the tab is very slow'. The system is reported to be especially slow when operating from the Citrix Environment. It freezes mostly when going between patients.<br>Some respondents complained about too much downtime, but were not specific about exact times.<br>The IT department claimed SCM in UPHS to be very smooth compared to other clients, but this was not confirmed by respondents with experience in other hospital systems that use SCM. |
| **6.10 Issues with Inactive Duplicate Orders** – Several orders cannot be entered if an old, inactive, duplicate order is present. | Telemetry and constraint orders (strapping a patient down) are not allowed if an old, inactive, duplicate order is listed. After a complete order has been entered, a duplicate alert will be displayed, forcing the user to leave the order process, remove the inactive order from the list, and re-enter the new order. |
| **6.11 Improvements needed for tapers** – For tapers, there are a set number of days for which a dose must be calculated. | Tapers are an option that has become available for steroids, but not for many other medications. The problem with the current process is that there are a set number of boxes corresponding with the number of days in which the dose should be reduced to zero. If the dose should be reduced in two days, the system still demands a dose is entered for the remaining days. This increases the error risk and is not very user friendly. |
| **6.12 Daily re-ordering TPN** – TPN orders can only be ordered for a single dose, which may cause MDs to spent a lot of time here every day.<br><br>S4 | Since a change in the system 9 months ago, a TPN-order must be re-entered every time, which is daily in most cases. It is unclear as to why:<br>- MDs say it's because it's expensive, so management want to discourage prescribing.<br>- The IT department says it's because the TPN is compounded by a third party.<br>- The pharmacy thinks the cost-argument plays a role, since it was fast and easy to reorder, which led to over usage.<br>- The best explanations seem to be that docs would repeat orders without careful consideration of components and add-ins, such as electrolytes, insulin, etc. They are now forced to carefully re-think the composition each time. |

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| **6.13 Usability issues** – Several issues concerning usability were mentioned. Some can be considered 'standard' in IT systems, and some are just reported by some users to be preferred. | Reported issues are:<br>- Left-right scrolling is needed to see all fields in one screen for sign-out forms.<br>- Switching between text fields is not possible using the 'tab' key, but has to be done with the cursor.<br>- A patient's weight is needed often, but it takes several clicks to find it. Respondents indicate this should be displayed in the ribbon, next to BMI for instance.<br>- If several labs need to be ordered for 1 patient, they have to be ordered one by one. Respondents would prefer a possibility to select several tests simultaneously.<br>- It is not possible anymore for MDs to delete a patient of their list of patients.<br>- It would be helpful if medical records were displayed next to the order screen.<br>- Sometimes when a discharge document is closed, something goes wrong and access is blocked for 15 minutes. This may also occur when the system freezes or has other problems.<br>- A patient's file becomes unavailable immediately after a patient is discharged. Since GPs regularly call for clarification, it would be convenient if the discharge summary would remain available for a week or so.<br>- RNs always have to select a collaborating physician when entering an order. NPs are allowed to work independently, but still need to pick a physician. SCM does not seem to have a designated profile for NPs. |
| **6.14 Problems with the introduced Now-and-Then Functionality** – As indicated in issue L4, now-and-then orders were not enabled in the new SCM system. Currently, the functionality has been introduced for some medications, mainly antibiotics. Respondents mentioned some issues with the new functionality. | It also is unclear when the NOW-part will be administered, so it is not clear what start-time for the THEN-part should be entered: today, tomorrow, or the day after. A wrong entry here may result in a day missed medication, or a potential double dose.<br><br>Another problem is that the THEN-part can only be administered at certain times, for instance 6am, 12am, 6pm and then 12pm. This may not match if a NOW-order is administered at 9am and a 6-hour gap is vital. |

# 5. Discussion

In this chapter, the results as presented in chapter 4 are summarized, an answer to the sub-questions is formulated, the importance and limitations of this study are discussed, and recommendations for future research are offered.

## 5.1 Summary Of Most Important Results

Our qualitative and quantitative research confirmed the existence of 22 previously identified issues that increase the risk of errors through the use of Sunrise CPOE system. 3 of these were previously reported to be fixed. For the 4 other issues that were reported to be solved in earlier studies, we did not find any evidence of their existence at this point. For 4 previously identified issues, we did not gather new data, so we do not have an update on their state. 8 new issues were identified and confirmed. An additional 6 new issues were mentioned by a small number of respondents. For these 6 issues, further investigation is needed to determine their significance. Because of the nature of the data, it is not possible to determine if issues have improved or deteriorated since the last moment of data collection. Neither can I state if there are issues that are likely to have been completely fixed.

## 5.2 Answering Of The Sub-Questions

In this paragraph I will discuss the sub-questions and try to formulate an answer to them, starting with the first sub-question: '*What taxonomy is suitable as a framework to understand and explain the phenomena that are examined?*'

In the theoretical framework I discussed several possible taxonomies or categorizations for the subject of Unintended Consequences of HIT. Following this discussion, the results of our research are discussed utilizing the ISTA model in chapter 4. The ISTA model depicts complex interactions between HIT and very dynamic environments as can be found in healthcare organizations. Since most unintended consequences are caused by these complex interactions, ISTA is of good use in the study of these phenomena. It points out how UCs may develop and what kind of changes may be expected. It may show a connection between UCs that were previously thought not to be connected, e.g. we found 'alert fatigue' and 'pharmacy dependency' to be connected. ISTA is particularly useful to study the evolution of issues as they develop over time. To utilize this advantage, it is necessary to categorize issues at several points in time, so that transitions between categories may be observed.

However, the ISTA model also has its limitations. It gives limited insight into the status of a UC. An issue may be worsening or getting better. Observed changes over time from one category towards another may be caused by an effort to fix a UC, or it may be caused by an actual fix of the issue. At the same time though, this may depict a developing issue, where a

change in the social system engendered a workaround in the use of the HIT. This addition may be what the model needs to promote its relevance in daily practice.
Also, both the depiction of the ISTA model in figure 2 and in figur 3 have their shortcomings. In our research all identified UCs could be categorized according to the 5 categories from figure 3. However this may not be the case for all UCs identified outside our study. More UCs may be identified if more subcomponents, or more interaction effects between these subcomponents, are added. My interpretation of the model may have limited our findings.
The second sub-question is '*What unintended consequences of the use of Sunrise CPOE system are currently found in UPHS?*', and the third sub-question is '*How do the currently identified unintended consequences compare to unintended consequences identified at UPHS in the past, employing existing taxonomy as an interpretive scheme?*'. These two questions are discussed together below. Even though we studied a total of 38 UCs, many of them have comparable causes. Here follows a list of underlying problems, which are causing many of the studied UCs. This is not to be regarded as an alternative taxonomy, but as a summary of our findings. (1) Information may be available, but is often not found by the user because it is not presented in a clear format. This may be concerning specific information that the user is looking for (e.g. a specific order that needs to be entered), in which case the user may spend extra time to find what is needed, or it may be concerning supporting information that the system should present to the user (e.g. long lists of medication, total dose vs. tablet format), in which case missing the information may cause injuries or deaths. (Ash, Berg, and Coiera 2004, 104-112) found this in their study as well, and stated that both too much structure and too much fragmentation can cause a loss of overview. (2) The way orders are to be entered into the system often does not suit the needs of users. This may be due to a lack of predetermined options, no place to enter the needed information, or other issues. (Ash, Berg, and Coiera 2004, 104-112) stated that 'the act of writing the information is integral to to the cognitive processing of the case'. This underlines the importance of easy entering of information. (3) The system is not always configured to be operated in the disruptful environment that hospitals are. Examples are small or juxtaposing buttons, ordering processes that may not be temporarily interrupted, or are interruptible without reminding a user to finish it later on. This was found before by (Ash, Berg, and Coiera 2004, 104-112), who stated that 'many human-computer interfaces seem to have been designed for workers doing their work by themselves, fully and extensively concentrating on the computer screens', while 'more often than not, different tasks are executed simultaneously, and interruptions by beepers, telephones, and colleagues are endles.' (4) Insufficient integration with other systems. Paper persistence is an example of the use of parallel systems, and was confirmed by (Ash et al. 2009, S69-76). (5) Safety measures which may temporarily disable the needed capabilities of the system. (6) Computerized Decision

Support (CDS) that only bothers users, instead of actually supporting them in making decisions. This is also found by (Ash et al. 2009, S69-76), who found 'over 20% of [identified UCs of CPOE] emanated from issues with CDS', and (Ash, Berg, and Coiera 2004, 104-112), who warn for the destructive effect a CDS system may have on the motivation of users and the pleasure of use of the whole CPOE system. (Wachter RM 2006, 2780-2783) writes about an example showing how difficult it is to get CDS right. (7) Auto-filling of documents, forms and fields from patient's file is desired, whereas auto-filling based on default options should be used more cautiously. (8) A slow or freezing system. (Ash et al. 2009, S69-76) confirmed the danger of overdependence on technology, considering the inevitability of slow or freezing systems.

In chapter 4 I combined results from the older studies with our own data to learn about the development of these UCs over time. I categorised the identified UCs according to the ISTA framework. Here follows a summary of this categorisation.

- 11 UCs were studied where the implemented HIT resulted in unintended changes in the social system. 3 of these were newly identified.
- 2 UCs were studied where the implemented HIT engendered a change in the existing infrastructure. 1 of these was newly identified.
- 5 UCs were studied where an interaction between new HIT and the social system engendered an undesirable deviation in the way the HIT was used compared to its intended use. 1 of these was newly identified.
- 3 UCs were studied where the resulting deviation in use of the CPOE system engendered a subsequent change in the social system. None of these was newly identified.
- 17 UCs were studied where the resulting deviation in use of the CPOE system engendered an adaption of the CPOE design. 3 of these were newly identified.

For 45% of the studied UCs, system redesign has been utilized at some point in an effort to solve the issue. Where Ash et al. says there are 4 ways to address UCs, it seems that 'improvement in system design' is the most utilized in UPHS. The 3 other ways Ash et al. propose are 'improvement in education', 'improvement in implementation process', and 'research' (Ash, Berg, and Coiera 2004, 104-112). Unfortunately, the system redesign has not lead to many fixed issues, as most of these issues are still reported by respondents. It may be useful to make more use of the other ways to address UCs that were proposed.

21% of the studied UCs are newly identified. This is a striking increase in amount of UCs, considering that UCs have been studied at UPHS for almost a decade. There are several possible explanations for this. It may due to the fact that the researcher was new to the research of UCs at UPHS and had so-called 'fresh eyes'. It may be the case that new issues

have developed since the last study, although this doesn't seem to be the case since many newly identified UCs were reported to have been present for a longer time. The most likely explanation is that external researchers will not be able to get to know all the ins and outs of a system through the limited scope of talking to users of the system. This may have lead to an incomplete picture in the earlier studies as well.

## 5.3 Importance Of This Study

The issues discussed in this thesis are the cause of many undesirable effects on all who play a role in healthcare. The actual effects they have on healthcare are not studied, just the potential effects. Some issues may appear to be minor, but their potential effects on the delivery of care may be significant. It has to be kept in mind that CPOE systems are used in very busy environments, with constant interruptions in workflow. Users are easily distracted and often do not have time to enter an order for a second or third time if the first was not accepted by the system. During interviews, the interviewer lost focus with the interviewee at times, because of distractions of all kinds: alarms, monitor sounds, dozens of screens, social interactions with co-workers, patients needing attention, etc. Of course, MDs are used to an environment like this, and are much more adapted to the processing of all these stimuli, but it is easy to forget a half-finished order once it has been interrupted. That is why it is important that continuous efforts are being made to improve HIT, so that our healthcare systems will be more productive, safer, and more efficient.

## 5.4 Limitations Of This Study

Unfortunately, there are limitations to our research, causing limitations to the interpretation of our data and results. Here follow the most important limitations to our research. First, there may be holes in the documentation of UCs and ways errors and error risks have been handled, as they have developed over time. For some issues, this causes uncertainty in the distribution of the issues over ISTA categories, and may leave room for debate on this distribution. Second, the ISTA model argues that many UCs are caused by interactions between HIT and the social system and technical infrastructure, suggesting that the problem may be with both the HIT and the social system or technical infrastructure. Our research focuses mostly on experiences of residents, who are biased in their reporting. They need to adapt to the social system and are therefore not used – and generally not accepted – to being critical about the way the social system functions. They are likely to only report issues with HIT and technical infrastructure. It is perfectly defendable that technical infrastructure and HIT are easier to adapt than a social system, so it is likely that many UCs have been tackled by changes in these two systems. However, issues in which the social system was adapted, or current issues where the social system is the problem and not the HIT, are not likely to be found in our data. Third, since our sample was not representative for the entire

population of SCM users, it was not possible to calculate confidence intervals on our data. This would have improved the value of our data, especially when comparing data with the older studies to study trends over the last decade. Lastly, we kept the survey questions concise to encourage respondents to finish the entire interview. This meant complicated issues often had to be stated in as few words as possible, causing some questions to be ambiguous, retrospectively. I observed this led to misinterpretations of the question by respondents in some cases, and reported this in chapter 4. However, some misinterpretations may not have been observed. Still, because of the nature of our data I do not expect this to be a bias to our results.
Nevertheless, a study of this kind in a real life context, with the CPOE system present and in development, and with cooperation of the leaders of the system, is very valuable and these results are definitely worthy of significant consideration.

## 5.5 Recommendations For Further Research

Following the limitations mentioned in the previous paragraph, there are several interesting findings and subjects that deserve consideration in further research. Future research within UPHS would add a lot of value if the data were collected amongst a representative sample. The data we collected are not conclusive on the question of which issues have been solved, therefore it is not possible to draw conclusions on that question. A sample that is representative for the population should allow for the researcher to confirm an improvement or deterioration of issues in a comparison to earlier or later studies. Also, a continued search for new UCs is validated, considering the new issues that were identified in each of the consecutive studies.

Other interesting focus points of future studies in this field would be the effect of the use of HIT on the costs of healthcare, considering the fact that current findings are not conclusive if this effect is positive or negative. Also, most UCs that were found in previous studies are confirmed in our current research, suggesting only few UCs have been fixed. Research is needed to determine why this is the case. Different approaches that are used to fix UCs should be compared in an effort to find a practical approach in working towards a system that is used the way it is designed to be. The role off vendors in facilitating or sustaining UCs deserves further attention, considering the conflict of interest between generating maximum profit for their shareholders, and submitting a perfect system to the client that doesn't need much support. Also, the demands of MDs, RNs, and pharmacists regarding properties of the system may be conflicting. Dynamics between these groups form an important interaction within the social system of a healthcare system. The role of this interaction on facilitating UCs has not been studied specifically, but may be of interest.

# 6. Conclusion

Over the last decade three previous studies were conducted at UPHS, describing unintended consequences of the design, implementation, and use of CPOE systems. Both the second and the third study reflected on their preceding studies, comparing their own findings to the earlier results. This fourth study follows these studies with a fourth moment of data collection, and an additional comparison with its predecessors. I studied the unintended consequences with the research question '*What unintended consequences of the use of Sunrise CPOE system pose a threat to the quality of care in the University of Pennsylvania Health System in the Summer of 2012?*'

Unintended consequences of the use of CPOE are a serious threat to the quality of care and require serious attention. Several issues that we found potentially endanger the lives of patients. These UCs are mainly caused by complex interactions between the HIT as designed and both the social system and the technical infrastructure. These interactions cause a divergence between the HIT as it was designed and the way HIT is used in practice. Despite significant efforts at UPHS over the past decade to minimize the potential negative effects of these interactions, so far this has proved to be a very difficult task. Our research in UPHS confirms unintended consequences of CPOE are rampant, elevating error risk in the delivery of care. We studied 38 unintended consequences, 8 of which were newly identified. Of the remaining 30, which were identified in the preceding studies, 3 were reported to be fixed in previous studies and for 3 issues we didn't gather new data. The other 24 issues were identified in earlier studies and no conclusive evidence was found that they had been fixed. The ISTA model has proven to be a valuable framework for the interpretation of our data. It helped compare observations from the older studies with our own observations, and thereby led to a better understanding of the unintended consequences that currently pose a threat to the quality of care in UPHS.

Our research shows that many of the earlier identified unintended consequences were still present. After 10 years of adjusting the CPOE to the social system, the state of the system is not satisfying. Rather it is a cause for concern. The match with the technical infrastructure is better, which makes sense since it is not as dynamic as the social system. The promises of HIT, and more specifically CPOE systems, are hopeful. But, as was shown by our research, many challenges need to be addressed to find a better fit between HIT and the social system in which it operates.

# References


Aarts, Jos, Joan Ash, and Marc Berg. 2007. Extending the understanding of computerized physician order entry: Implications for professional collaboration, workflow and quality of care. *International Journal of Medical Informatics* 76, Supplement 1 (0) (6): S4-S13.

AHRQ. 2012 [cited 08/10 2012]. Available from http://healthit.ahrq.gov/.

Ash, J. S., D. F. Sittig, E. Campbell, K. Guappone, and R. H. Dykstra. 2006. An unintended consequence of CPOE implementation: Shifts in power, control, and autonomy. *AMIA ...Annual Symposium Proceedings / AMIA Symposium.AMIA Symposium*: 11-5.

———. 2007a. Some unintended consequences of clinical decision support systems. *AMIA ...Annual Symposium Proceedings / AMIA Symposium.AMIA Symposium*: 26-30.

———. 2009. The unintended consequences of computerized provider order entry: Findings from a mixed methods exploration. *International Journal of Medical Informatics* 78 Suppl 1 (Apr): S69-76.

———. 2007b. Exploring the unintended consequences of computerized physician order entry. *Studies in Health Technology and Informatics* 129 (Pt 1): 198-202.

———. 2007c. Categorizing the unintended sociotechnical consequences of computerized provider order entry. *International Journal of Medical Informatics* 76 Suppl 1 (Jun): S21-7.

———. 2007d. The extent and importance of unintended consequences related to computerized provider order entry. *Journal of the American Medical Informatics Association : JAMIA* 14 (4) (Jul-Aug): 415-23.

Ash, Joan S., Marc Berg, and Enrico Coiera. 2004. Some unintended consequences of information technology in health care: The nature of patient care information system-related errors. *Journal of the American Medical Informatics Association* 11 (2) (March 01): 104-12.

Bates, D. W. 2005. Computerized physician order entry and medication errors: Finding a balance. *Journal of Biomedical Informatics* 38 (4) (Aug): 259-61.

Battles, J. B., and M. A. Keyes. 2002. Technology and patient safety: A two-edged sword. *Biomedical Instrumentation & Technology / Association for the Advancement of Medical Instrumentation* 36 (2) (Mar-Apr): 84-8.

Bobb A, Gleason K, Husch M, Feinglass J, Yarnold PR,Noskin GA. 2004. The epidemiology of prescribing errors: The potential impact of computerized prescriber order entry. *Archives of Internal Medicine* 164 (7) (April 12): 785-92.

Bush 2004. *Executive Order no. 13335* (2004).

Campbell, E. M., D. F. Sittig, J. S. Ash, K. P. Guappone, and R. H. Dykstra. 2006. Types of unintended consequences related to computerized provider order entry. *Journal of the American Medical Informatics Association : JAMIA* 13 (5) (Sep-Oct): 547-56.

Chaudhry, Basit, Jerome Wang, Shinyi Wu, Margaret Maglione, Walter Mojica, Elizabeth Roth, Sally C. Morton, and Paul G. Shekelle. 2006. Systematic review: Impact of health information technology on quality, efficiency, and costs of medical care. *Annals of Internal Medicine* 144 (10) (May 16): 742-5.

Coiera, Enrico. 2000. When conversation is better than computation. *Journal of the American Medical Informatics Association* 7 (3) (May 01): 277-86.

Cordis. 2011. *Reducing the adverse drug event death toll*.

de Mul, M., M. Berg, and J. A. Hazelzet. 2004. Clinical information systems: CareSuite from picis. *Journal of Critical Care* 19 (4) (Dec): 208-14.

FDA. 2012 [cited 08/10 2012]. Available from http://www.fda.gov/Drugs/ResourcesForYou/Consumers/ucm143553.htm.

Garg, A. X., N. K. Adhikari, H. McDonald, M. P. Rosas-Arellano, P. J. Devereaux, J. Beyene, J. Sam, and R. B. Haynes. 2005. Effects of computerized clinical decision support systems on practitioner performance and patient outcomes: A systematic review. *JAMA : The Journal of the American Medical Association* 293 (10) (Mar 9): 1223-38.

Goodman, John C., Pamela Villarreal, and Biff Jones. 2011. The social cost of adverse medical events, and what we can do about it. *Health Affairs* 30 (4) (April 01): 590-5.

Halamka, John D. 2006. Health information technology: Shall we wait for the evidence? *Annals of Internal Medicine* 144 (10) (May 16): 775-6.

Harris, Paul A., Robert Taylor, Robert Thielke, Jonathon Payne, Nathaniel Gonzalez, and Jose G. Conde. 2009. Research electronic data capture (REDCap)—A metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of Biomedical Informatics* 42 (2) (4): 377-81.

Harrison, M. I., R. Koppel, and S. Bar-Lev. 2007. Unintended consequences of information technologies in health care--an interactive sociotechnical analysis. *Journal of the American Medical Informatics Association : JAMIA* 14 (5) (Sep-Oct): 542-9.

HealthIT.gov. ISTA-workflow. 2012 [cited 08/22 2012]. Available from http://www.healthit.gov/unintended-consequences/content/understand-unintended-consequences.html (accessed August 22, 2012).

HRSA. 2012 [cited 08/10 2012]. Available from http://www.hrsa.gov/healthit/about/index.html.

Institute of Medicine (U.S.). Committee on Improving the Patient Record, R. S. Dick, and E. B. Steen. 1991. *The computer-based patient record: An essential technology for health care*National Academy Press.

Kanjanarat, P., AG Winterstein, TE Johns, RC Hatton, R. Gonzalez-Rothi, and R. Segal. 2003. Nature of preventable adverse drug events in hospitals: A literature review. *American Journal of Health-System Pharmacy* 60 (17) (September 01): 1750-9.

Kaushal, R., K. G. Shojania, and D. W. Bates. 2003. Effects of computerized physician order entry and clinical decision support systems on medication safety: A systematic review. *Archives of Internal Medicine* 163 (12) (Jun 23): 1409-16.

Kensaku Kawamoto, Caitlin A Houlihan, E Andrew Balas, and David F Lobach. 2005. Improving clinical practice using clinical decision support systems: A systematic review of trials to identify features critical to success. *BMJ* 330 (7494) (BMJ Publishing Group Ltd): 765.

Khajouei, R., and M. W. Jaspers. 2010. The impact of CPOE medication systems' design aspects on usability, workflow and medication orders: A systematic review. *Methods of Information in Medicine* 49 (1): 3-19.

Khan, Ahmed S., and Tim Healy. 2012. The unanticipated consequences of technology. In , 155-172.

Kies, Christopher. 2009. Unintended consequences of information technology in healthcare, A review of the literature.IUPUI.

Koppel R, Metlay JP, Cohen A,et al. 2005. Role of computerized physician order entry systems in facilitating medication errors. *JAMA: The Journal of the American Medical Association* 293 (10) (March 9): 1197-203.

R. Koppel and others, "Comparing Medication Prescribing Errors with a New Computerized Physician Order Entry (CPOE) System to those with an Older CPOE System: Direct and Longitudinal Analyses" (Article, 2008).

Kraaijenbrink, E. C. S. 2011. Unintended consequences of health information technology implementation: A temporal analysis. Master of Science., institute of Health Policy and Management, Erasmus University Rotterdam.

Landrigan, Christopher P., Gareth J. Parry, Catherine B. Bones, Andrew D. Hackbarth, Donald A. Goldmann, and Paul J. Sharek. 2010. Temporal trends in rates of patient harm resulting from medical care. *N Engl J Med* 363 (22) (11/25; 2012/07): 2124-3.

Laudon, K. C., and J. P. Laudon. 2010. *Management information systems: Managing the digital firms*. 11th ed. New Jersey: Pearson Education.

Leapfrog Group, The. 2010. *Leapfrog group report on CPOE evaluation tool results.* Internet: .

Merton, R. K. 1936. The unanticipated consequences of purposive social action. *American Sociological Review* Vol. 1 (No. 6) (Dec., 1936): pp. 894-904.

Moniz, B. 2009. Examining the unintended consequences of computerized provider order entry system implementation. *Online Journal of Nursing Informatics (OJNI)* 13, (1) (February 2009), http:ojni.org/13_1/moniz.pdf.

Nebeker, JR, JM Hoffman, CR Weir, CL Bennett, and JF Hurdle. 2005. High rates of adverse drug events in a highly computerized hospital. *Arch Intern Med* 165 (10) (05): 1111-6.

Shulman, Rob, Mervyn Singer, John Goldstone, and Geoff Bellingan. 2005. Medication errors: A prospective cohort study of hand-written and computerised physician order entry in the intensive care unit. *Critical Care* 9 (5): 516-R521.

Sinsky, C. A. 2008. E-nirvana: Are we there yet? *Family Practice Management* 15 (3) (Mar): 6-8.

Sittig, D. F., E. Campbell, K. Guappone, R. Dykstra, and J. S. Ash. 2007. Recommendations for monitoring and evaluation of in-patient computer-based provider order entry systems: Results of a delphi survey. *AMIA ...Annual Symposium Proceedings / AMIA Symposium.AMIA Symposium*: 671-5.

Sveiby, K. E., P. Gripenberg, B. Segercrantz, A. Eriksson, and A. Aminoff. 2009. Unintended and undesirable consequences of innovation. http://www.sveiby.com/articles/UnintendedconsequencesISPIMfinal.pdf. Vienna.

Tsai, T. L., D. B. Fridsma, and G. Gatti. 2003. Computer decision support as a source of interpretation error: The case of electrocardiograms. *Journal of the American Medical Informatics Association : JAMIA* 10 (5) (Sep-Oct): 478-83.

Wachter RM. 2006. EXpected and unanticipated consequences of the quality and information technology revolutions. *JAMA: The Journal of the American Medical Association* 295 (23) (June 21): 2780-3.

# Appendix A: Questionnaires

*Confidential*



## Survey

Dear Resident,

We need your help to improve the CPOE system here at Penn. We know there are functions that could be more efficient or less cumbersome. The best way to make it more responsive to your and your patients’ needs is by telling us about the challenges you’ve encountered. Please understand our CPOE system is always evolving. Only you can provide the information to guide that evolution. Please complete this on-line questionnaire. It’s absolutely anonymous and confidential. Your participation not only contributes to patient safety, but also helps all of us practice better and more efficient medicine.

Please note that you are under no obligation to complete this survey. It is entirely voluntary, but we certainly hope you will help in this effort. Most find the questions very interesting. And it only takes about 6 minutes. If you have any questions or comments about this survey, please feel free to contact Dr. Ross Koppel at rkoppel@sas.upenn.edu.

Thank you.

**A. Background**

| | | |
|---|---|---|
| 1 | Your PGY Level (Your current PGY level) | _____ |
| 2 | Years in the Penn Medical School | _____ |
| 3 | Selected Specialty (if any) | _____ |
| 4 | Is this your last year of training? | ☐ Yes<br>☐ No |
| 5 | How often do you use Sunrise CPOE/SCM? | ☐ All the time<br>☐ Frequently<br>☐ Only Occasionally<br>☐ Never (Please skip to section D) |
| 6 | What other CPOE systems have you used? | ☐ None: this is my first and only CPOE system<br>☐ I'm now using other CPOE systems AND this one<br>☐ I've used CPOE systems before |
| 7 | Which program(s) do you use to find the lowest effective dose or the range of doses for a medication you seldom prescribe? (check all that apply) | ☐ Via Tools in SCM: uptodate.com/ Lexicomp/ Micromedex<br>☐ Via intranet: Lexicomp/ Micromedex<br>☐ Via internet: uptodate.com<br>☐ Within SCM: (string) search/pops ups during ordering<br>☐ Epocrates<br>☐ Other programs |
| 7B | Please specify which programs | _____ |
| 8 | What Percentage of alerts about drug allergies do you override/ignore because they are not relevant? | ☐ 100% - 50%<br>☐ 49% - 25%<br>☐ 24%-10%<br>☐ 9%-1%<br>☐ < 1% |



*Appendix A 1: Questionnaire REDCap Survey 2011*

*Confidential*



9 What percent of drug-drug interaction alert do you override/ignore because they are not relevant?

- ☐ 100% - 50%
- ☐ 49% - 25%
- ☐ 24%-10%
- ☐ 9%-1%
- ☐ < 1%

10 (Skip to 11) Do you ever receive dosage alerts?

- ☐ Yes
- ☐ No

11 What percent of computer alerts about dosage levels do you override/ignore because they are not relevant?

- ☐ 100% - 50%
- ☐ 49% - 25%
- ☐ 24%-10%
- ☐ 9%-1%
- ☐ < 1%

12 Who do you ask for help when it is difficult to input/specify medications orders? (check all that apply)

- ☐ I ask another MD
- ☐ A nurse
- ☐ I call the pharmacy
- ☐ I call the IT helpdesk
- ☐ Other

12B Please specify whom you ask for help. _____

**B. Unwanted Occurrences**

**How often have you...**

13 observed a gap in antibiotic therapy because of an unintended pause in re-approval of an antibiotic?

- ☐ Never
- ☐ Less than 1/ wk
- ☐ A few times/ wk
- ☐ About daily
- ☐ A few times/ day

14 observed a gap in antibiotic therapy because antibiotics were removed when expired?

- ☐ Never
- ☐ Less than 1/ wk
- ☐ A few times/ wk
- ☐ About daily
- ☐ A few times/ day

15 delayed ordering because the computer system was down?

- ☐ Never
- ☐ Less than 1/ wk
- ☐ A few times/ wk
- ☐ About daily
- ☐ A few times/ day

16 delayed ordering because a convenient terminal was unavailable?

- ☐ Never
- ☐ Less than 1/ wk
- ☐ A few times/ wk
- ☐ About daily
- ☐ A few times/ day

17 found the system to be inflexible, e.g., difficulty specifying a medication; problems ordering off-formulary?

- ☐ Never
- ☐ Less than 1/ wk
- ☐ A few times/ wk
- ☐ About daily
- ☐ A few times/ day

18 observed duplicate orders occurring when modifying existing medication orders?

- ☐ Never
- ☐ Less than 1/ wk
- ☐ A few times/ wk
- ☐ About daily
- ☐ A few times/ day



*Appendix A 1 (continued): Questionnaire REDCap Survey 2011*

*Confidential*



| | | |
|---|---|---|
| 19 | observed unintentional dose changes when modifying existing medication orders? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |
| 20 | observed that when tests or procedures were canceled associated medications/contrast agents were not stopped in time (i.e., incorrectly administered)? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |
| 21 | observed medications or labs be delayed because a patient was recently moved to a different unit? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |
| 22 | had problems with "Now and Then" orders because they are shown on two different screens? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |
| 23 | been obliged to submit orders one-by-one that should have been "Now and Then" orders? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |
| 24 (&another;25) | canceled or discontinued NOW medications via clumsy or unusual ordering routines? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |
| 25 | how often (if ever) did this result in unintended or missed medications on subsequent days? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |
| 26 (&another;27) | had problems ordering or discontinuing PRN medications because of clumsy or unusual ordering routines? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |
| 27 | how often (if ever) did this result in unintended or missed medications on subsequent days? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |
| 28 | observed duplicate orders because of ordering stat and daily orders? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |
| 29 | ordered meds for the wrong patient, at least temporarily? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |



*Appendix A 1 (continued): Questionnaire REDCap Survey 2011*

| | | |
|---|---|---|
| 30 | found yourself re-inputting orders, because the system does not allow you to copy and paste DISCHARGE ORDERS? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |
| 31 | observed the CPOE automatically canceling lab orders? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |
| 32 | obliged to estimate a patient's weight to order a medication? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |

**C. Finding Information**

**How often have you...**

| | | |
|---|---|---|
| 33 | been uncertain about the complete listing and dosages of a patient's medications because it was difficult to see all of the patient's medications at one time (on one screen)? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |
| 34 | not discontinued - even for an hour or so -- a patient's medications because it was difficult or cumbersome to see all of the patient's medications on one or two screens? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |
| 35 | found the list of possible "reasons" for a test's selection does not reflect the actual reasons and thus been obliged to pick the "best possible listed option" rather than a more accurate match to justify a test? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |
| 36 | found that other clinicians cannot see medications you have ordered but which have not yet been approved/validated by pharmacists? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |
| 37 | been uncertain about exact administration time for time-sensitive drugs -- because of possible uncertainties/delays in medication charting? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |
| 38 | had to leave the Sunrise/SCM system to find information in other systems, e.g. notes, I-O sheets, etc. | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |
| 39 | found difficulties in searching for information because essential data were found in other systems, e.g. lab reports? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |



*Appendix A 1 (continued): Questionnaire REDCap Survey 2011*

| | | |
|---|---|---|
| 40 | found the dose listings within Sunrise/SCM are displayed/presented in a confusing or illogical order? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |
| 41 | experienced difficulties finding laboratory results because the listings had inconsistent titles of results? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |
| 42 | experienced difficulties in finding laboratory results because they were obscured in long lists? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |
| 43 | found laboratory results were missing? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |
| 44 | experienced difficulties finding laboratory results because the listings used poorly-designed icons? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |
| 45 | experienced difficulties finding laboratory reports because you must search by exact wording? | ☐ Never<br>☐ Less than 1/ wk<br>☐ A few times/ wk<br>☐ About daily<br>☐ A few times/ day |

**D. This last section is about both:**

**1. the stress you experienced, and 2. Your perception of medication error risks associated with each of the listed stressors.**

| | | |
|---|---|---|
| 46 | How stressful do you find the long hours at work. | ☐ Not at all<br>☐ A little<br>☐ Moderate<br>☐ Very |
| 47 | How do you think the long hours at work affect your risks of medication errors? | ☐ Not at all<br>☐ Unlikely<br>☐ Possible<br>☐ Very possible |
| 48 | How stressful do you find the work intensity. | ☐ Not at all<br>☐ A little<br>☐ Moderate<br>☐ Very |
| 49 | How do you think the work intensity affects your risks of medication errors? | ☐ Not at all<br>☐ Unlikely<br>☐ Possible<br>☐ Very possible |
| 50 | How stressful do you find the inflexible schedule that makes you stop what you are doing to go on to next scheduled activity (e.g. teaching conference, attending rounds)? | ☐ Not at all<br>☐ A little<br>☐ Moderate<br>☐ Very |



*Appendix A 1 (continued): Questionnaire REDCap Survey 2011*

*Confidential*



51 How do you think the inflexible schedule affects your risks of medication errors?
- ☐ Not at all
- ☐ Unlikely
- ☐ Possible
- ☐ Very possible

52 How stressful do you find the interrupted or insufficient sleep?
- ☐ Not at all
- ☐ A little
- ☐ Moderate
- ☐ Very

53 How do you think the interrupted or insufficient sleep affects your risks of medication errors?
- ☐ Not at all
- ☐ Unlikely
- ☐ Possible
- ☐ Very possible

54 How stressful do you find the number of patents you must treat?
- ☐ Not at all
- ☐ A little
- ☐ Moderate
- ☐ Very

55 How do you think the number of patients affects your risks of medication errors?
- ☐ Not at all
- ☐ Unlikely
- ☐ Possible
- ☐ Very possible

56 How stressful do you find the number and timing of admissions (e.g. all at once, late at night)?
- ☐ Not at all
- ☐ A little
- ☐ Moderate
- ☐ Very

57 How do you think the number and timing of admissions affects your risks of medication errors?
- ☐ Not at all
- ☐ Unlikely
- ☐ Possible
- ☐ Very possible

58 How stressful do you find the number of discharges?
- ☐ Not at all
- ☐ A little
- ☐ Moderate
- ☐ Very

59 How do you think the number of discharges affects your risks of medication errors?
- ☐ Not at all
- ☐ Unlikely
- ☐ Possible
- ☐ Very possible

Did you take this survey last year?
- ☐ Yes
- ☐ No

Thank you very much.



*Appendix A 1 (continued): Questionnaire REDCap Survey 2011*

**Study of Residents' Perceptions of CPOE at UPHS** **Date:_____**

**Hospital: HUP/Pennsy/Presby/GSPP/Other_____** **Unit/location/type of service:**
**PGY1/PGY2/PGY3/Other_____** **DO NOT RECORD NAME OF RESPONDENT**

1. How often have you been uncertain about the complete listing and/or dosages of a patient's medications because it was difficult to see all of the patient's medications on one screen?
   Complete listings? N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
   a) Dosages? N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
   b) How often has this caused a delay? N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
2. How often have you observed a gap in antibiotic therapy because of an unintended pause in re-approval of an antibiotic? N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
   a) Or observed a gap because of antibiotics missing from the med-list?
   N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
3. How often have you found Sunrise to be inflexible? (e.g. difficulty specifying med; problems ordering off-formulary) N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
4. How often have you been uncertain about the actual time of administration for time-sensitive drugs?
   N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
   a) Why? _____
5. How often have you observed duplicate orders resulted when modifying existing medication orders?
   N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
6. How often have you observed unintentional dose changes when modifying existing medication orders?
   N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
7. How often have you observed associated medications/dyes (contrast agents) were not stopped in time when tests or procedures were canceled? N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
8. How often have you had problems with *Now-and-Then* orders because they were on two different screens or had other ordering problems? N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
   a) And how about NOW orders? N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
   b) And how about PRN orders? N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
9. How frequently have you ordered for the wrong patient, at least temporarily?
   N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
10. How often have you found other clinicians cannot see meds you have ordered but which have not yet been approved/validated by pharmacists? N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
    a) How often does this lead to duplicate orders? N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
11. How often do you have to leave the Sunrise/SCM system to find information in other systems?
    - Notes N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
    - I-O sheets N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
    - Lab reports N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
    - Other_____ N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
12. Which program(s) do you use to find doses for meds with which you are not yet familiar?
    _ UpToDate.com How? W/in SCM_ Lv SCM for net_ On Smartphone_ Other_____
    _ Lexicom How? W/in SCM_ Lv SCM for net_ On Smartphone_ Other_____
    _ Micromedix How? W/in SCM_ Lv SCM for net_ On Smartphone_ Other_____
    _ Search (string)/pop-ups *in SCM* during ordering
    _ Epocrates How? Lv SCM for net_ On Smartphone_ Other_____
    _ Other programs, specify:_____
13. What % of *drug-drug interaction alerts* do you override/ignore because they are not applicable/not well targeted? ___%

*Appendix A 2: Questionnaire Face-to-face Interviews 2012*

14. What about overrides of alerts about *drug allergies?* ___%
15. Did you ever receive a dosage alert? Yes_ No_ If yes, what % of *dosage level* alerts do you override/ignore because they are not applicable/not well targeted? ___%
16. How often have you found dose listings are presented in a confusing or illogical order?
    N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
17. Many find problems with Sunrise/SCM order formats for *doses in tablet/dispensed-units* VS *ordering for total dose*. How often do you find these problems? N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
18. How often do you ESTIMATE patient's wt to order meds?
    N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
19. Many CPOE systems require "reasons" for ordering tests. Sometimes the list of "reasons" does not reflect the actual reasons. How often do you pick the first option or "best possible option" rather than a more accurate match to justify a test? N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
20. How often have you had difficulty finding lab results because they were *obscured in long lists?*
    N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
    a) How often…because they *require exact wording?* N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
    b) How often…because they *have inconsitent titles?* N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
    c) How often…because they *were missing*? N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
21. How often have you found yourself re-inputting orders because the system does not allow copy & paste of orders for: Discharge N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
    a) Inpatient N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
    b) Other_____? N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
22. **What questions or problems did we miss that we should have asked?**
23. How often do you find there´s not enough *space to type* needed information in discharge summaries?
    N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
24. How often do you find the 15-minute limit to save discharge summaries causes you problems?
    N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
25. How often do you find it's unclear if an order is active or cancelled when looking at the list of medications?
    N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
26. How often do you find an order's default start date is set too far in the future?
    N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
27. How often do you find the "Documents" Tab is filled with unnecessary information?
    N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
    a) Does this slow down your search for relevant information?
    N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
28. How often have you spend extra time ordering a test because it was hard to find in Sunrise?
    N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_
    a) How often were you obliged to call on (the helpdesk _ / a colleague _ / other _____ ) to help find it? N_ <1/wk_ Few/Wk_ ~Daily_ FewX/day_

*Appendix A 2 (continued): Questionnaire Face-to-face Interviews 2012*

## Appendix B: Results

| | n | never | less than once/ week | a few times/ week | about daily | a few times/ day | (combined:) at least about daily | missing |
|---|---|---|---|---|---|---|---|---|
| 13 How often have you observed a gap in antibiotic therapy because of an unintended pause in re-approcal of an antibiotic? | 84 | 26.7% | 61.6% | 7.0% | 2.3% | 0.0% | 2.3% | 2.3% |
| 14 How often have you observed a gap in antibiotic therapy because antibiotics were removed when expired? | 83 | 16.3% | 60.5% | 17.4% | 2.3% | 0.0% | 2.3% | 3.5% |
| 15 How often have you delayed ordering because the computer system was down? | 84 | 14.0% | 72.1% | 7.0% | 3.3% | 1.1% | 4.7% | 2.3% |
| 16 How often have you delayed ordering because a convenient terminal was unavailable? | 85 | 15.1% | 27.9% | 26.7% | 16.2% | 6.3% | 29.1% | 1.2% |
| 17 How often have you found the system to be inflexible, e.g., difficulty specifying a medication; problems ordering off-formulary? | 85 | 15.1% | 37.2% | 36.0% | 5.3% | 4.2% | 10.5% | 1.2% |
| 18 How often have you observed duplicate orders occurring when modifying existing medicaiton orders? | 84 | 23.3% | 38.4% | 23.3% | 9.3% | 2.1% | 12.8% | 2.3% |
| 19 How often have you observed unintentional dose changes when modifying existing medication orders? | 85 | 44.2% | 46.5% | 5.8% | 1.1% | 1.1% | 2.3% | 1.2% |
| 20 How often have you oserved that when tests or procedures were canceled associated medicaiton/contrast agents were not stopped in time (i.e., incorrectly administred)? | 83 | 43.0% | 41.9% | 9.3% | 2.3% | 0.0% | 2.3% | 3.5% |
| 21 How often have you observed medications or labs be delayed because a patiënt was recently moved to a different unit? | 84 | 17.4% | 37.2% | 32.6% | 7.4% | 2.1% | 10.5% | 2.3% |
| 22 How often have you had problems with "Now and Then" orders because they are shown on two different screens? | 84 | 43.0% | 37.2% | 8.1% | 7.4% | 1.1% | 9.3% | 2.3% |
| 23 How often have you been ovliged to submit orders one-by-one that should have been "Now and Then" orders? | 83 | 31.4% | 26.7% | 19.8% | 10.8% | 4.9% | 18.6% | 3.5% |
| 24 How often have you ordered or discontinued NOW medications via clumsy or unusual ordering routines? | 82 | 31.4% | 33.7% | 18.6% | 6.3% | 4.2% | 11.6% | 4.7% |
| 25 how often (if ever) did this result in unintended or missed medications on subsequent days? | 53 | 10.5% | 40.7% | 5.8% | 2.2% | 2.2% | 4.7% | 38.4% |
| 26 How often have you had problems ordering or discontinuing PRN medications because of clumsy or unusual ordering routines? | 81 | 51.2% | 27.9% | 10.5% | 2.2% | 2.2% | 4.7% | 5.8% |
| 27 how often (if ever) did this result in unintended or missed medications on subsequent days? | 35 | 7.0% | 27.9% | 2.3% | 2.2% | 1.1% | 3.5% | 59.3% |
| 28 How often have you observed duplicate orders because of ordering stat and daily orders? | 83 | 18.6% | 33.7% | 23.3% | 10.6% | 6.7% | 20.9% | 3.5% |
| 29 How often have you ordered meds for the wrong patiënt, at least temporarily? | 84 | 15.1% | 72.1% | 7.0% | 3.4% | 0.0% | 3.5% | 2.3% |
| 30 How often have you found yourself re-inputting orders, because the system does not allow you to copy and paste DISCHARGE ORDERS? | 83 | 33.7% | 31.4% | 17.4% | 8.2% | 4.1% | 14.0% | 3.5% |
| 31 How often have you observed the CPOE automatically canceling lab orders? | 83 | 19.8% | 40.7% | 27.9% | 4.3% | 3.2% | 8.1% | 3.5% |

*Appendix B 1: Results From REDCap Survey 2011*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 32 How often have you obliged to estimate a patiënt's weight to order a medication? | 85 | 5.8% | 44.2% | 38.4% | 9.5% | 0.0% | 10.5% | 1.2% |
| 33 How often have you been uncertain about the complete listing and dosages of a patients medications because it was difficult to see all of the patients medicaitons at one time (on one screen)? | 82 | 23.3% | 33.7% | 15.1% | 13.2% | 5.7% | 23.3% | 4.7% |
| 34 How often have you not discontinued - even for an hour or so - a patients medications because it was difficult or cumbersome to see all of the patients medicaitons on one or two screens? | 81 | 51.2% | 25.6% | 8.1% | 6.4% | 2.1% | 9.3% | 5.8% |
| 35 How often have you found the list of possible "reasons" for a tests selection does not reflect the actual reasons and thus been obliged to pick the "best possible listed option" rather than a more accurate match to justify a test? | 82 | 5.8% | 14.0% | 24.4% | 19.2% | 14.6% | 51.2% | 4.7% |
| 36 How often have you found that other clinicians cannot see medications you have ordered but which have not yet been approved/validated by pharmacists? | 83 | 22.1% | 26.7% | 27.9% | 14.6% | 1.9% | 19.8% | 3.5% |
| 37 How often have you been uncertain about exact administration time for time-sensitive drugs -- because of possible uncertainties/delays in medication charting? | 83 | 7.0% | 25.6% | 39.5% | 13.1% | 6.5% | 24.4% | 3.5% |
| 38 How often have you had to leave the Sunrise/SCM system to find information in other systems, e.g. notes, I-O sheets, etc. | 83 | 5.8% | 12.8% | 22.1% | 14.2% | 21.6% | 55.8% | 3.5% |
| 39 How often have you found difficulties in searching for information because essential data were found in other systems, e.g. lab reports? | 82 | 3.5% | 11.6% | 33.7% | 16.7% | 15.1% | 46.5% | 4.7% |
| 40 How often have you found the dose listing within Sunrise/SCM are displayed/presented in a confusing or illogical order? | 83 | 22.1% | 37.2% | 18.6% | 7.8% | 7.8% | 18.6% | 3.5% |
| 41 How often have you experienced difficulties finding laboratory results because the listings had inconsistent titles of results? | 83 | 14.0% | 38.4% | 23.3% | 11.5% | 5.8% | 20.9% | 3.5% |
| 42 How often have you experienced difficulties in finding laboratory results because they were obscured in long lists? | 83 | 12.8% | 22.1% | 31.4% | 12.5% | 10.7% | 30.2% | 3.5% |
| 43 How often have you found laboratory results were missing? | 81 | 22.1% | 45.3% | 18.6% | 4.3% | 3.2% | 8.1% | 5.8% |
| 44 How often have you experienced difficulties finding laboratory results because the listings used poorly-designed icons? | 82 | 37.2% | 36.0% | 12.8% | 5.3% | 3.2% | 9.3% | 4.7% |
| 45 How often have you experienced difficulties finding laboratory reports because you must search by exact wording? | 81 | 19.8% | 37.2% | 22.1% | 7.1% | 6.1% | 15.1% | 5.8% |

*Appendix B 1 (continued): Results From REDCap Survey 2011*

| | n | never | less than once/ week | few times/ week | about daily | a few times/ day | (combined:) at least about daily | missing |
|---|---|---|---|---|---|---|---|---|
| 1. How often have you been uncertain about the COMPLETE LISTINGS of a patient's medications because it was difficult to see all of the patient's medications on one screen? | 49 | 0.29 | 18.4% | 36.7% | 10.2% | 6.1% | 16.3% | 0.0% |
| 1a. How often have you been uncertain about the DOSAGES of a patient's medications because it was difficult to see all of the patient's medications on one screen? | 49 | 0.29 | 38.8% | 24.5% | 6.1% | 2.0% | 8.2% | 0.0% |
| 1b. How often has this caused a delay? | 49 | 0.37 | 24.5% | 30.6% | 6.1% | 2.0% | 8.2% | 0.0% |
| 2. How often have you observed a gap in antibiotic therapy because of an unintended pause in re-approval of an antibiotic? | 49 | 0.27 | 51.0% | 16.3% | 2.0% | 2.0% | 4.1% | 2.0% |
| 2a. Or observed a gap because of missing antibiotics? | 49 | 0.37 | 44.9% | 14.3% | 2.0% | 2.0% | 4.1% | 0.0% |
| 3. How often have you found the system to be inflexible? (e.g. difficulty specifying med; problems ordering off-formulary) | 49 | 0.06 | 30.6% | 32.7% | 20.4% | 10.2% | 30.6% | 0.0% |
| 4. How often have you been uncertain about exact administration time for time-sensitive drugs? | 49 | 0.29 | 32.7% | 26.5% | 10.2% | 2.0% | 12.2% | 0.0% |
| 5. How often have you observed duplicate orders resulted when modifying existing medication orders? | 48 | 0.27 | 29.2% | 31.3% | 6.3% | 6.3% | 12.5% | 0.0% |
| 6. How often have you observed unintentional dose changes when modifying existing medication orders? | 49 | 0.53 | 34.7% | 10.2% | 2.0% | 0.0% | 2.0% | 0.0% |
| 7. How often have you observed associated medications/dyes (contrast agents) were not stopped in time when tests or procedures were canceled? | 49 | 0.61 | 28.6% | 10.2% | 0.0% | 0.0% | 0.0% | 0.0% |
| 8. How often have you had problems with Now-and-Then orders because they were on two different screens or had other ordering problems? | 49 | 0.27 | 12.2% | 30.6% | 8.2% | 2.0% | 10.2% | 20.4% |
| 8a. And how about NOW orders? | 49 | 0.51 | 22.4% | 24.5% | 2.0% | 0.0% | 2.0% | 0.0% |
| 8b. And how about PRN orders? | 49 | 0.51 | 26.5% | 20.4% | 2.0% | 0.0% | 2.0% | 0.0% |
| 9. How frequently have you ordered for the wrong patient, at least temporarily? | 49 | 0.16 | 46.9% | 30.6% | 6.1% | 0.0% | 6.1% | 0.0% |
| 10. How often have you found other clinicians cannot see meds you have ordered but which have not yet been approved/validated by pharmacists? | 49 | 0.29 | 32.7% | 34.7% | 4.1% | 0.0% | 4.1% | 0.0% |
| 10a. How often does this lead to duplicate orders? | 49 | 0.31 | 44.9% | 16.3% | 2.0% | 0.0% | 2.0% | 6.1% |
| 11a. How often do you have to leave the Sunrise/SCM system to find NOTES in other systems? | 49 | 0.04 | 14.3% | 16.3% | 38.8% | 26.5% | 65.3% | 0.0% |
| 11b. How often do you have to leave the Sunrise/SCM system to find I-O SHEETS in other systems? | 49 | 0.63 | 10.2% | 6.1% | 16.3% | 4.1% | 20.4% | 0.0% |
| 11c. How often do you have to leave the Sunrise/SCM system to find LAB REPORTS in other systems? | 49 | 0.41 | 14.3% | 20.4% | 18.4% | 6.1% | 24.5% | 0.0% |
| 11d. How often do you have to leave the Sunrise/SCM system to find OTHER in other systems? | 49 | 0.43 | 4.1% | 12.2% | 24.5% | 14.3% | 38.8% | 2.0% |
| 16. How often have you found dose listings are presented in a confusing or illogical order? | 49 | 0.39 | 22.4% | 28.6% | 6.1% | 2.0% | 8.2% | 2.0% |
| 17. Many find problems with Sunrise/SCM order formats for doses in tablet/dispensed-units VS ordering for total dose. How often do you find these problems? | 49 | 0.31 | 22.4% | 36.7% | 8.2% | 0.0% | 8.2% | 2.0% |
| 18. How often do you ESTIMATE patient's wt to order meds? | 49 | 0.33 | 30.6% | 26.5% | 6.1% | 2.0% | 8.2% | 2.0% |
| 19. How often do you pick the first option or "best possible option" rather than a more accurate match to justify a test? | 49 | 0.02 | 10.2% | 36.7% | 32.7% | 16.3% | 49.0% | 2.0% |

*Appendix B 1: Results From Residents In Face-to-face Interviews 2012*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 20. How often have you had difficulty finding lab results because they were obscured in long lists? | 49 | 0.12 | 36.7% | 18.4% | 22.4% | 8.2% | 30.6% | 2.0% |
| 20a. How often… because they require exact wording? | 49 | 0.41 | 30.6% | 16.3% | 8.2% | 2.0% | 10.2% | 2.0% |
| 20b. How often… because they have inconsistent titles? | 49 | 0.45 | 26.5% | 14.3% | 10.2% | 2.0% | 12.2% | 2.0% |
| 20c. How often… because they were missing? | 49 | 0.39 | 26.5% | 24.5% | 6.1% | 2.0% | 8.2% | 2.0% |
| 21. How often have you found yourself re-inputting orders because the system does not allow copy & paste of orders for DISCHARGE | 49 | 0.33 | 6.1% | 20.4% | 14.3% | 16.3% | 30.6% | 10.2% |
| 21a. How often have you found yourself re-inputting orders because the system does not allow copy & paste of orders for INPATIENT | 49 | 0.2 | 16.3% | 34.7% | 10.2% | 10.2% | 20.4% | 8.2% |
| 21b. How often have you found yourself re-inputting orders because the system does not allow copy & paste of orders for OTHER | 49 | 0.82 | 0.0% | 4.1% | 2.0% | 4.1% | 6.1% | 8.2% |
| 23. How often do you find there´s not enough space to type needed information in discharge summaries? | 47 | 0.38 | 10.6% | 12.8% | 8.5% | 17.0% | 25.5% | 12.8% |
| 24. How often do you find the 15-minute limit to save discharge summaries causes you problems? | 47 | 0.49 | 17.0% | 12.8% | 6.4% | 2.1% | 8.5% | 12.8% |
| 25. How often do you find it's unclear if an order is active or cancelled when looking at the list of medications? | 47 | 0.34 | 31.9% | 21.3% | 6.4% | 2.1% | 8.5% | 4.3% |
| 26. How often do you find an order's default start date is set too far in the future? | 47 | 0.38 | 25.5% | 21.3% | 8.5% | 2.1% | 10.6% | 4.3% |
| 27. How often do you find the 'documents' tab is filled with unnecessary information? | 41 | 0.07 | 9.8% | 4.9% | 29.3% | 41.5% | 70.7% | 7.3% |
| 27a. Does this slow down your search for relevant information? | 41 | 0.15 | 12.2% | 2.4% | 31.7% | 31.7% | 63.4% | 7.3% |
| 28. How often have you spend extra time ordering a test because it was hard to find in Sunrise? | 21 | 0.05 | 14.3% | 38.1% | 28.6% | 4.8% | 33.3% | 9.5% |
| 28a. How often were you obliged to call on (the helpdesk/a colleague/other) to help find it? | 21 | 0.14 | 0.29 | 0.33 | 0.14 | 0 | 0.142857 | 9.5% |

*Appendix B 2 (continued): Results From Residents In Face-to-face Interviews 2012*

| | n | never | less than once/ week | few times/ week | about daily | a few times/ day | (combined:) at least about daily | missing |
|---|---|---|---|---|---|---|---|---|
| 1. How often have you been uncertain about the COMPLETE LISTINGS of a patient's medications because it was difficult to see all of the patient's medications on one screen? | 17 | 29.4% | 41.2% | 0.0% | 23.5% | 5.9% | 29.4% | 0.0% |
| 1a. How often have you been uncertain about the DOSAGES of a patient's medications because it was difficult to see all of the patient's medications on one screen? | 17 | 41.2% | 29.4% | 11.8% | 11.8% | 5.9% | 17.6% | 0.0% |
| 1b. How often has this caused a delay? | 17 | 35.3% | 35.3% | 5.9% | 11.8% | 5.9% | 17.6% | 5.9% |
| 2. How often have you observed a gap in antibiotic therapy because of an unintended pause in re-approval of an antibiotic? | 17 | 29.4% | 29.4% | 35.3% | 5.9% | 0.0% | 5.9% | 0.0% |
| 2a. Or observed a gap because of missing antibiotics? | 17 | 29.4% | 35.3% | 29.4% | 5.9% | 0.0% | 5.9% | 0.0% |
| 3. How often have you found the system to be inflexible? (e.g. difficulty specifying med; problems ordering off-formulary) | 17 | 17.6% | 35.3% | 17.6% | 11.8% | 17.6% | 29.4% | 0.0% |
| 4. How often have you been uncertain about exact administration time for time-sensitive drugs? | 17 | 23.5% | 29.4% | 17.6% | 17.6% | 5.9% | 23.5% | 5.9% |
| 5. How often have you observed duplicate orders resulted when modifying existing medication orders? | 17 | 11.8% | 29.4% | 29.4% | 11.8% | 17.6% | 29.4% | 0.0% |
| 6. How often have you observed unintentional dose changes when modifying existing medication orders? | 17 | 47.1% | 35.3% | 11.8% | 5.9% | 0.0% | 5.9% | 0.0% |
| 7. How often have you observed associated medications/dyes (contrast agents) were not stopped in time when tests or procedures were canceled? | 17 | 35.3% | 41.2% | 23.5% | 0.0% | 0.0% | 0.0% | 0.0% |
| 8. How often have you had problems with Now-and-Then orders because they were on two different screens or had other ordering problems? | 17 | 29.4% | 23.5% | 17.6% | 0.0% | 11.8% | 11.8% | 17.6% |
| 8a. And how about NOW orders? | 17 | 47.1% | 35.3% | 11.8% | 5.9% | 0.0% | 5.9% | 0.0% |
| 8b. And how about PRN orders? | 17 | 47.1% | 35.3% | 5.9% | 5.9% | 5.9% | 11.8% | 0.0% |
| 9. How frequently have you ordered for the wrong patient, at least temporarily? | 17 | 5.9% | 76.5% | 17.6% | 0.0% | 0.0% | 0.0% | 0.0% |
| 10. How often have you found other clinicians cannot see meds you have ordered but which have not yet been approved/validated by pharmacists? | 17 | 11.8% | 23.5% | 41.2% | 17.6% | 5.9% | 23.5% | 0.0% |
| 10a. How often does this lead to duplicate orders? | 17 | 23.5% | 41.2% | 17.6% | 11.8% | 5.9% | 17.6% | 0.0% |
| 11a. How often do you have to leave the Sunrise/SCM system to find NOTES in other systems? | 17 | 17.6% | 5.9% | 5.9% | 23.5% | 47.1% | 70.6% | 0.0% |
| 11b. How often do you have to leave the Sunrise/SCM system to find I-O SHEETS in other systems? | 17 | 35.3% | 5.9% | 5.9% | 17.6% | 35.3% | 52.9% | 0.0% |
| 11c. How often do you have to leave the Sunrise/SCM system to find LAB REPORTS in other systems? | 17 | 64.7% | 0.0% | 17.6% | 5.9% | 5.9% | 11.8% | 5.9% |
| 11d. How often do you have to leave the Sunrise/SCM system to find OTHER in other systems? | 17 | 23.5% | 5.9% | 5.9% | 17.6% | 47.1% | 64.7% | 0.0% |
| 16. How often have you found dose listings are presented in a confusing or illogical order? | 17 | 41.2% | 41.2% | 17.6% | 0.0% | 0.0% | 0.0% | 0.0% |
| 17. Many find problems with Sunrise/SCM order formats for doses in tablet/dispensed-units VS ordering for total dose. How often do you find these problems? | 17 | 29.4% | 41.2% | 29.4% | 0.0% | 0.0% | 0.0% | 0.0% |
| 18. How often do you ESTIMATE patient's wt to order meds? | 17 | 23.5% | 41.2% | 29.4% | 5.9% | 0.0% | 5.9% | 0.0% |
| 19. How often do you pick the first option or "best possible option" rather than a more accurate match to justify a test? | 17 | 5.9% | 17.6% | 41.2% | 11.8% | 23.5% | 35.3% | 0.0% |

*Appendix B 1: Results From NPs, PAs, And Physicians In Face-to-face Interviews 2012*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 20. How often have you had difficulty finding lab results because they were obscured in long lists? | 17 | 23.5% | 35.3% | 11.8% | 17.6% | 11.8% | 29.4% | 0.0% |
| 20a. How often… because they require exact wording? | 17 | 41.2% | 47.1% | 5.9% | 0.0% | 0.0% | 0.0% | 5.9% |
| 20b. How often… because they have inconsistent titles? | 17 | 35.3% | 41.2% | 23.5% | 0.0% | 0.0% | 0.0% | 0.0% |
| 20c. How often… because they were missing? | 17 | 29.4% | 35.3% | 23.5% | 5.9% | 5.9% | 11.8% | 0.0% |
| 21. How often have you found yourself re-inputting orders because the system does not allow copy & paste of orders for DISCHARGE | 17 | 47.1% | 17.6% | 17.6% | 17.6% | 0.0% | 17.6% | 0.0% |
| 21a. How often have you found yourself re-inputting orders because the system does not allow copy & paste of orders for INPATIENT | 17 | 47.1% | 17.6% | 17.6% | 5.9% | 11.8% | 17.6% | 0.0% |
| 21b. How often have you found yourself re-inputting orders because the system does not allow copy & paste of orders for OTHER | 17 | 88.2% | 5.9% | 0.0% | 5.9% | 0.0% | 5.9% | 0.0% |
| 23. How often do you find there´s not enough space to type needed information in discharge summaries? | 17 | 23.5% | 47.1% | 5.9% | 17.6% | 5.9% | 23.5% | 0.0% |
| 24. How often do you find the 15-minute limit to save discharge summaries causes you problems? | 17 | 47.1% | 29.4% | 11.8% | 5.9% | 5.9% | 11.8% | 0.0% |
| 25. How often do you find it's unclear if an order is active or cancelled when looking at the list of medications? | 17 | 58.8% | 17.6% | 11.8% | 11.8% | 0.0% | 11.8% | 0.0% |
| 26. How often do you find an order's default start date is set too far in the future? | 17 | 35.3% | 29.4% | 29.4% | 0.0% | 5.9% | 5.9% | 0.0% |
| 27. How often do you find the 'documents' tab is filled with unnecessary information? | 13 | 23.1% | 15.4% | 15.4% | 23.1% | 23.1% | 46.2% | 0.0% |
| 27a. Does this slow down your search for relevant information? | 13 | 30.8% | 7.7% | 0.0% | 23.1% | 30.8% | 53.8% | 7.7% |
| 28. How often have you spend extra time ordering a test because it was hard to find in Sunrise? | 0 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 28a. How often were you obliged to call on (the helpdesk/a colleague/other) to help find it? | 0 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |

*Appendix B 3 (continued): Results From NPs, PAs, And Physicians In Face-to-face Interviews 2012*

| | n | not at all | a little | moderate | very | missing |
|---|---|---|---|---|---|---|
| 46 How stressful do you find the long hours at work? | 86 | 7.0% | 32.6% | 36.0% | 19.8% | 4.7% |
| 48 How stressful do you find the work intensity? | 86 | 3.5% | 34.9% | 39.5% | 16.3% | 5.8% |
| 50 How stressful do you find the inflexible schedule that makes you stop what you are doing to go on to next scheduled activity (e.g. teaching conference, attending rounds)? | 86 | 17.4% | 37.2% | 26.7% | 14.0% | 4.7% |
| 52 How stressful do you find the interrupted or insufficient sleep? | 86 | 7.0% | 36.0% | 30.2% | 20.9% | 5.8% |
| 54 How stressful do you find the number of patients you must treat? | 86 | 7.0% | 32.6% | 40.7% | 15.1% | 4.7% |
| 56 How stressful do you find the number and timing of admissions (e.g. all at once, late at night)? | 86 | 5.8% | 26.7% | 34.9% | 27.9% | 4.7% |
| 58 How stressful do you find the number of discharges? | 86 | 20.9% | 34.9% | 24.4% | 14.0% | 5.8% |
| | | | | | | |
| | n | not at all | unlikely | possible | very possible | missing |
| 47 How do you think the long hours at work affect your risks of medication errors? | 86 | 5.8% | 23.3% | 45.3% | 20.9% | 4.7% |
| 49 How do you think the work intensity affects your risks of medicaiton errors? | 86 | 4.7% | 22.1% | 47.7% | 20.9% | 4.7% |
| 51 How do you think the inflexible schedule affects your risks of medication errors? | 86 | 15.1% | 26.7% | 39.5% | 14.0% | 4.7% |
| 53 How do you think the interrupted or insufficient sleep affects your risks of medication errors? | 86 | 7.0% | 16.3% | 44.2% | 27.9% | 4.7% |
| 55 How do you think the number of patients affects your risks of medication errors? | 86 | 4.7% | 19.8% | 44.2% | 25.6% | 5.8% |
| 57 How do you think the number and timing of admissions affects your risks of medication errors? | 86 | 7.0% | 12.8% | 45.3% | 29.1% | 5.8% |
| 59 How do you think the number of discharges affects your risks of medication errors? | 86 | 16.3% | 16.3% | 34.9% | 27.9% | 4.7% |

*Appendix B 1: Results From REDCap Survey 2011, Questions On Experienced Stress*

| What percentage of alerts about drug allergies do you override/ignore because they are not relevant? | | | | | | | |
|---|---|---|---|---|---|---|---|
| | n | missing | 100% - 50% | 49% - 25% | 24% - 10% | 9% - 1% | < 1% |
| 2011 Redcap | 86 | 1.2% | 52.3% | 36.0% | 9.3% | 1.2% | 0.0% |
| 2012 Residents | 49 | 2.0% | 51.0% | 18.4% | 14.3% | 6.1% | 8.2% |
| 2012 NPs, PAs, physicians | 17 | 0.0% | 58.8% | 11.8% | 17.6% | 0.0% | 11.8% |
| | | | | | | | |
| **What percentage of drug-drug interaction alerts do you override/ignore because they are not relevant?** | | | | | | | |
| 2011 Redcap | 86 | 1.2% | 79.1% | 17.4% | 2.3% | 0.0% | 0.0% |
| 2012 Residents | 49 | 2.0% | 93.9% | 2.0% | 0.0% | 0.0% | 2.0% |
| 2012 NPs, PAs, physicians | 17 | 0.0% | 64.7% | 11.8% | 11.8% | 5.9% | 5.9% |
| | | | | | | | |
| **Do you ever receive dosage alerts?** | n | missing | yes | no | | | |
| 2011 Redcap | 86 | 2.3% | 20.9% | 76.7% | | | |
| 2012 Residents | 49 | 2.0% | 18.4% | 79.6% | | | |
| 2012 NPs, PAs, physicians | 17 | 0.0% | 29.4% | 70.6% | | | |
| | | | | | | | |
| **What percentage of computer alerts do you override/ignore because they are not relevant?** | | | | | | | |
| | n | missing | 100% - 50% | 49% - 25% | 24% - 10% | 9% - 1% | < 1% |
| 2011 Redcap | 20 | 10.0% | 35.0% | 30.0% | 10.0% | 10.0% | 5.0% |
| 2012 Residents | 9 | 10.0% | 20.0% | 10.0% | 30.0% | 0.0% | 30.0% |
| 2012 NPs, PAs, physicians | 5 | 0.0% | 40.0% | 0.0% | 40.0% | 0.0% | 20.0% |

*Appendix B 1: Results On The Handling Of Various Alerts*

| Redcap 2011, q7: Which program(s) do you use to find the lowest effective dose or the range of doses for a medication you seldom prescribe? (n=86 residents) | |
|---|---|
| via tools in SCM: uptodate.com/ Lexicomp/ Micromedex | 4.7% |
| via intranet: Lexicomp/ Micromedex | 52.3% |
| via internet: uptodate.com | 58.1% |
| withing SCM: (string) search/pops ups during ordering | 18.6% |
| Epocrates | 34.9% |
| other programs | 3.5% |

| f2f 2012, q12: Which program(s) do you use to find doses for meds with which you are not yet familiar, and how do you approach them? (n=49 residents) | | | | | | |
|---|---|---|---|---|---|---|
| | within SCM | leave SCM for net | smartphone | within SCM & Smartphone | leave SCM for net & Smartphone | within SCM & leave SCM for net |
| UpToDate.com | 10.2% | 53.1% | 4.1% | 2.0% | 0.0% | 2.0% |
| Lexicomp | 6.1% | 22.4% | 4.1% | 0.0% | 4.1% | 2.0% |
| Micromedex | 0.0% | 10.2% | 14.3% | 0.0% | 2.0% | 0.0% |
| Search Strings/Pop-Ups | 2.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Epocrates | 0.0% | 4.1% | 55.1% | 0.0% | 2.0% | 0.0% |
| Other | 0.0% | 6.1% | 4.1% | 0.0% | 0.0% | 0.0% |

| f2f 2012, q12: Which program(s) do you use to find doses for meds with which you are not yet familiar, and how do you approach them? (n=17 NPs, PAs, physicians) | | | | | | |
|---|---|---|---|---|---|---|
| | within SCM | leave SCM for net | smartphone | within SCM & Smartphone | leave SCM for net & Smartphone | within SCM & leave SCM for net |
| UpToDate.com | 5.9% | 41.2% | 0.0% | 0.0% | 11.8% | 0.0% |
| Lexicomp | 5.9% | 58.8% | 11.8% | 0.0% | 5.9% | 0.0% |
| Micromedex | 0.0% | 11.8% | 0.0% | 0.0% | 5.9% | 0.0% |
| Search Strings/Pop-Ups | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Epocrates | 0.0% | 5.9% | 29.4% | 0.0% | 5.9% | 0.0% |
| Other | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |

*Appendix B 1: Results On The Use Of Programs To Find Normal Doses For Unfamiliar Meds*