

# The Human-Computer User Interface and Patient Safety: Introducing New Technologies in Healthcare Effectively and Safely

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**Abstract**—Health information technology (HIT) promises to modernize healthcare, lead to efficiencies and to reduce medical error. However, the literature has shown that if HIT is not designed and tested properly, systems such as electronic health records (EHRs) and personal health records (PHRs) may actually inadvertently introduce new types of errors that are termed technology-induced errors. Such error may result from the complex interplay of health professional, patients and the HIT deployed in the healthcare system and currently they may not be easily detectable until systems are deployed. In order to deal with this, in this paper we describe a framework for detecting and rectifying technology-induced errors before they are propagated in the healthcare system and for implementing systems in a safe and effective manner. It is argued that in order to do this, it will require a layered approach to system design and testing involving application of usability testing methods along with application of clinical simulations. The paper describes a promising approach that involves multiple methods for ensuring system safety in healthcare.

**Keywords**—Health and Wellness, Digital Media

## I. INTRODUCTION

The safety of health information technology (HIT) has become a critical issue in recent years. After many initial studies showing how HIT such as electronic health records (EHR) can lead to a decrease in medical error, new studies began to emerge showing how if systems are not carefully designed they can add a completely new class of error, now known as technology-induced error [1]. Technology-induced errors can be defined as those errors that emerge from interactions between health professionals and patients while using information technology [2]. Technology-induced errors also include interactions between differing types of HIT used in health care. In this paper we outline a framework for designing, testing and trialing HIT for technology-induced errors so that the technologies that are deployed are safe and do not introduce new types of errors into health care processes.

## II. REVIEW OF THE LITERATURE

HIT has played a significant role in reducing medical errors. With the introduction of the electronic health record and decision support systems, we have seen the number of medical errors decrease. Electronic health records are eliminating medical errors associated with illegible handwriting and transcription of medical orders and medications. Decision support technologies such as automated rules, alerts and reminders as well as drug-drug, drug-allergy and drug-food interaction checking has also decreased the number of cases of medical errors that have occurred [3]. In addition, technologies targeted to consumers, such as personal health records and eHealth applications have also been found to lead to errors in information entered into systems, with implications for decision making [1]. In as much as these technologies have benefited the recipients of health care they have also introduced new technology-induced errors. In 2005, the first published reports of technology-induced error began to emerge in the HIT literature [1, 2]. These early works demonstrated how electronic health records and decision supports systems could lead to medical errors such as the wrong medication being prescribed to a patient, the wrong dose of a medication being prescribed and the wrong frequency of the medication being prescribed [2]. Since these early reports several studies have been published documenting technology-induced errors and the rates of their occurrence in hybrid [4] and fully electronic settings [5]. In 2011 the Institute of Medicine published a report on HIT safety that documented the extent of the problem and called for methods that could be used to reduced the occurrence of these types of errors [6]. In 2015 the Institute of Medicine published a follow-up report outlining how technology could contribute to medical errors in their report on Diagnostic Error in Health Care [7].

Although there are a number of causes for technology-induced errors user interface design and the workflows that are associated with user interface design have been specifically documented in the published literature as contributing to technology-induced errors [1, 2, 6]. For example, research by Kushniruk and colleagues documented

how specific user interface features and functions could lead to a technology-induced error such as patient information going into the wrong electronic record, navigational issues leading to inability to find allergy information in an EHR (leading to potential patient death) and health professionals attending to the wrong default drug information [1]. In this work and subsequent publications by other researchers it has become clear that technology-induced errors are a source of significant concern and have their origins in user interface design [1, 3]. This issue will become greater as the number of applications and type of end user of these applications (including not only health professionals but consumers) continues to grow and diversify [8]. To address user interface design issues several user interface design standards have been developed for use in health care, with some having a specific focus on safety [9].

### III. TOWARDS A FRAMEWORK FOR ENSURING SYSTEM SAFETY IN HEALTHCARE IT

A framework to consider technology-induced error in HIT comes from consideration of the system development life cycle (SDLC). The standard SDLC describes a series of activities and phases that are required to develop an information system, from initial systems analysis to system design, testing and final deployment. In our work we propose that the SDLC be extended to include the use of user interface standards developed to improve the safety of HIT, the testing of designed user interfaces and then their trialing in real-world settings [10].

This three stage process begins with the use of guidelines developed to enhance user interface design safety in HIT. Example of such guidelines include guidelines from the National Health Service in the United Kingdom that were derived from the Common User Interface (CUI) project having the aim to develop standards for developing effective and safe user interfaces to EHRs. The user interface guidelines were developed as part of a joint partnership between the National Health Service and Microsoft with the intent to improve the safety of user interface features and functions [9]. Our prior work suggests that the static and dynamic elements of a user interface also need to be tested once the design of the interface has been completed [11,12].

In the second stage there is a need to conduct usability testing with the newly designed interface to determine if either the static or dynamic elements of the interface could lead to a technology-induced error [1, 2, 11, 12]. Here, we recommend testing the user interface with representative users performing representative tasks which using the system. For example, a patient may be asked to book an appointment with a physician, re-order their medications and review their medical information on a patient portal. As the usability testing takes place there is a need to identify not only those system features and functions that are unusable but also those that may lead to an individual making an error. Data during this part of the testing should be collected in the form of audio data (of the patient thinking aloud) and computer screen recording data (of the interactions between the user and the user interface). It must be noted that users are known to be able to identify some types of user interface issues that may lead to a technology-induced error in other cases users [1]. Other examples of users

using the HIT and an error may be only identified through fine grained analysis of the computer screen recording data in the context of user verbalizations [1,13]. For example, a user may identify that it is difficult to read medication information on the computer screen, but they may not identify when a field is populated with a default value for the dose of the medication that is not specific to their current context or needs [2].

After usability testing is complete and identified problems rectified the next level of testing (the third stage) recommended is the application of near live testing involving clinical simulations. Clinical simulations can be considered an extension of usability testing where representative users are recorded while they use systems doing representative tasks under representative or real conditions (i.e. in the real setting of use, which may range from the clinical setting to the home in the case of homecare applications). This layer of testing is needed in order to ensure systems will function correctly and not lead to error when real users interact with the system under the complex conditions and settings of healthcare [11,12]. Examples include the work of Li and colleagues who conducted near live testing of clinical guidelines embedded in and EHR prior to their widespread release. The clinical simulation resulted in the identification of workflow issues and usability problems that were not identified in the earlier two stages (i.e. not identified by applying guidelines or doing standard usability testing) [14]. In addition, applications targeted to other types of users (e.g. consumers), will also need to be tested under realistic conditions of use [8].

### IV. CONCLUSION

Health information technology promises to improve healthcare and streamline health processes. However, increased consideration needs to be placed on developing effective methods for ensuring that such systems and applications do not inadvertently lead to technology-induced error.

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