Assessing and comparing the usability of Chinese EHRs used in two Peking University hospitals to EHRs used in the US: A method of RUA

Lufei Xu [a], Dong Wen [b], Xingting Zhang [b], Jianbo Lei [c],*

[a] Human resource department, Peking University Cancer Hospital & Institute, Beijing, China
[b] Peking University third hospital, Beijing, China
[c] Center for Medical Informatics, Peking University, Beijing, China

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ABSTRACT

Objectives: The objective of this study was to investigate the usability level of Chinese hospital Electronic Health Records (EHRs) by assessing the completion times of EHRs for seven "meaningful use (MU)" relevant tasks conducted at two Chinese tertiary hospitals and comparing the results to those of relevant research conducted in US EHRs.

Methods: Using Rapid Usability Assessment (RUA) developed by the National Center for Cognitive Informatics and Decision Making (NCCD), the usability of EHRs from two Peking University hospitals was assessed using a three-step Keystroke Level Model (KLM) in a laboratory environment.

Results: (1) The total EHR task completion time for 7 MU relevant test tasks showed no significant differences between the two Chinese EHRs and their US counterparts, in which the time for thinking was relatively large and comprised 35.6% of the total time. The time for the electronic physician order was the largest. (2) For specific tasks, the mean completion times of the 2 hospital EHR systems spent on recording, modifying and searching (RMS) the medication orders were similar to those for the RMS radioactive tests; the mean time spent on the RMS laboratory test orders were much less. (3) There were 85 usability problems identified in the 2 hospital EHR systems.

Discussion: In Chinese EHRs, a substantial amount of time is required to complete tasks relevant to MU targets and many preventable usability problems can be discovered. The task completion time of the 2 Chinese EHR systems was a little shorter than in the 5 reported US EHR systems, while the differences in smoking status and CPOE tasks were obvious; one main reason for these differences was the use of structured data entry.

Conclusions: The efficiency of Chinese and US EHRs was not significantly different. The key to improving the efficiency of both systems lies in expediting the Computerized physician order entry (CPOE) task. Many usability problems can be identified using heuristic assessments and improved by corresponding actions.

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1. Introduction

1.1. Research background

With the fast development of world-wide medical information digitalization, EHR, as an innovative method integrating information technologies to clinical practice, plays an increasingly important role in clinical care. According to many research studies, EHRs have been shown to promote medical efficiency, reduce medical errors, assist doctors in achieving clinical resolutions, and improve medical quality [1,2]. The research and popularization of EHR has become a hot topic in the digitalization of global medical information.

As an important research direction in the HCI field, usability is related to useful, usable and satisfying features displayed by the system when a specific user completes specific tasks using a software system [3]. Medical errors have attracted enough attention outside of China. For instance, the US National Institute of Medicine published a milestone report in 1999, 'To err is human', which illustrates the severity of death by medical errors; most of these errors can be avoided by computer systems, among which EHR is the core technology [4]. Although Health Information Technologies (HIT) have been proven to reduce medical errors and improve medical quality, end users have ultimately met obstacles when using computer systems with system design defects, which may conversely

cause medical error. The reasons involve not only human factors but also the design complexity of HIT or insufficient considerations of the User Interface. Beyond China, the medical errors caused by the usability of EHR systems have received extensive attention and have been the subjects of qualitative and quantitative studies on various medical errors caused by various usability problems[5–7]. However, the research in this field in China is almost completely absent.

In 2009, the Office of the National Coordinator for Health Information Technology (ONC) under the United States Department of Health and Human Services established 4 project teams under the Strategic Health IT Advanced Research Programs (SHARP) aimed at reducing medical risks and utilizing the tools and methods of HIT [8]. One project team, NCCD, taking the assessment of EHR system usability as one of its goals, has proposed TURF [3], a theoretical framework aimed at assessing EHR usability. NCCD also established RUA [9] and developed relevant assessment software according to the TURF assessment framework.

The US government established the Health Information Technology for Economic and Clinical Health Act (HITECH) to encourage hospitals and doctors to adopt EHRs that adhere to MU standards in order to use EHR effectively. ONC is responsible for three stages of MU implementation: Stage I, implemented in 2011–2012, focused on enhancing data collection and sharing; Stage II, implemented in 2012–2014, was targeted at optimizing medical service procedures; and Stage III, implemented in 2014–2016, aimed at improving medical quality [10]. During Stage II of MU, the EHR was required to be certified in usability, and the testing and assessment of usability of the EHR were advised to be conducted by SHARP [11]. Stimulated by government guidance, numerous studies on the usability of EHRs were carried out [12–22].

In China, with the commencement of new health reform in 2009, the State Council and the National Health and Family Planning Commission of the People's Republic of China released policies that successively promoted the adoption of hospital information systems, among which EHR is the core. Since then, under the support of the government, EHR systems have undergone rapid development. According to statistics, the practical contract amount for EHR projects of all Chinese hospitals through government purchase was between RMB 100–150 million in 2010. Within 5 years, the market scale of EHRs will exceed RMB 3.5 billion [23]. EHR systems have experienced technical development from simple digitalization of paper health records to preliminary and advanced structuring, from integration of knowledge bases to regional Electronic Health Records, and other development stages. At present, the development of national EHRs in China is imbalanced, and many hospitals are at the preliminary structuring stage [24]. In terms of top-level design and standards, the Standard Health Information Commission of the Center for Statistics and Informatics under the National Health and Family Planning Commission has established a series of policies that are relevant to health systems, EHR data standards, basic framework standards, and other health information standards. These include Basic Schema and Data Standard of Health Record (trial) (2009), Standard of Data Element for Health Record (trial) (2009), Base Framework of Electronic Medical Record and Data Standard (trial) (2009), Functional Specification of Electronic Medical Record System (trial) (2010) and Technical Specification for Hospital Information Platform based on Electronic Medical Record (Edition 1.0) (2011). These policies have provided government support and guaranteed standards for the rapid development of EHRs in China.

However, studies on whether these rapid developments of EHRs have improved the efficiency or, more importantly, whether the wide adoption of HIT introduces new risks and medical errors are basically absent, especially in the field of usability studies in China. According to the knowledge of the authors, this research study is the first formal investigation conducted in China aimed at exploring the methods used to assess the usability of Chinese EHRs, obtaining a baseline level for the usability of Chinese EHRs, and comparing the results to those from the US. We believe that the methodologies, the problems we experienced, and the solutions we proposed in this study will not only open a new research direction in Chinese medical informatics, but will provide beneficial insights to our global colleagues.

1.2. Selection of method: RUA

1.21 Relationship between RUA and TURF

There are a number of approaches used to assess usability, such as user experience analysis, expert judgment, interviews, focus groups, thinking aloud, performance measurements, and others. These approaches are systematically described in TURF, a comprehensive assessment model consisting of four-dimension measurements that include task analysis, user analysis, representation analysis and functional analysis. These approaches can be simply divided into two categories: real world assessments with practical users, and laboratory tests with expert users. As we know, one major problem with any assessment is its resource intensiveness. In the real word, the full scale evaluation of usability is difficult, time consuming, and especially dependent on the environment, leading to the impossibility of comparisons. RUA, which is derived from TURF theory, can be used to assess the usability of an EHR system, namely, the usefulness, usability, and satisfying features of the EHR system. RUA takes two solid criteria for the meaningful use of systems: time on task, and the conformity to proven principles of usability as a core measurement of system performance. Time on task is evaluated and reported by an expert working in a quiet office by using a standard KLM (Keystroke Level Model). The core of this measure is that the results represent the ideal time spent on a task by an expert in a laboratory. This laboratory-based method, which integrates quantification and qualification techniques, can compensate for the substantial amount of time and energy spent on observing and testing by practical users. More importantly, in contrast to the real world testing approach, RUA is able to establish a baseline for system performance under ideal circumstances with one user; thus, RUA is able to set a fair standard for comparing different EHR systems.

The intrinsic complexities and extrinsic difficulties of an EHR system can be inspected and assessed comprehensively by analyzing TURF from above four dimensions. Among these, Intrinsic Complexity refers to the complexity in a working task field and serves as an indicator of a system's usefulness; this parameter includes the complexity of the working contents and the independence of the operating processes. By contrast, Extrinsic Difficulty refers to the complexity of users when completing specific tasks with a specific interface and system; this parameter is the indicator of a system's usability, which is mainly determined by the presentation mode of the interface design and the procedure flow of the task design.

In TURF theory, the RUA focuses on Extrinsic Difficulty and assesses the usability of EHR systems from two dimensions: task analysis (usability test) and representation analysis (heuristic evaluation).

1.22 Three steps for RUA

Step I: Identifying tasks relevant to MU targets

In the US, in order to use EHR systems meaningfully (MU), ONC (Office of the National Coordinator) has cooperated with the National Institute of Standards and Technology (NIST) to develop a standard testing method for EHR system functions (including test process and test data). This method should be used for testing and certifying EHR systems. To be accepted as standard assessment