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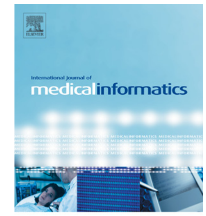

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Advancing cognitive engineering methods to support user interface design for electronic health records

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ABSTRACT

Background: Despite many decades of research on the effective development of clinical systems in medicine, the adoption of health information technology to improve patient care continues to be slow, especially in ambulatory settings. This applies to dentistry as well, a primary care discipline with approximately 137,000 practitioners in the United States. A critical reason for slow adoption is the poor usability of clinical systems, which makes it difficult for providers to navigate through the information and obtain an integrated view of patient data.

Objective: In this study, we documented the cognitive processes and information management strategies used by dentists during a typical patient examination. The results will inform the design of a novel electronic dental record interface.

Methods: We conducted a cognitive task analysis (CTA) study to observe ten general dentists (five general dentists and five general dental faculty members, each with more than two years of clinical experience) examining three simulated patient cases using a think-aloud protocol.

Results: Dentists first reviewed the patient's demographics, chief complaint, medical history and dental history to determine the general status of the patient. Subsequently, they proceeded to examine the patient's intraoral status using radiographs, intraoral images, hard tissue and periodontal tissue information. The results also identified dentists' patterns of navigation through patient's information and additional information needs during a typical clinician–patient encounter.

Conclusion: This study reinforced the significance of applying cognitive engineering methods to inform the design of a clinical system. Second, applying CTA to a scenario closely simulating an actual patient encounter helped with capturing participants' knowledge states and decision-making when diagnosing and treating a patient. The resultant knowledge of dentists' patterns of information retrieval and review will significantly contribute to designing flexible and task-appropriate information presentation in electronic dental records.

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1. Introduction

Providing patient-centered cognitive support in electronic health records (EHR) for clinicians is a significant research challenge in informatics [1]. Clinicians spend a great deal of time and energy searching and sifting through raw data about patients, and trying to integrate these data with their general medical knowledge, as they care for their patients. Multiple shortcomings of EHR, such as usability problems and the resultant loss of time and productivity [2–4], steep learning curves and unintended adverse consequences [5–13], aggravate this situation. As a result, the adoption of health information technology (HIT) to improve patient care continues to be slow, especially in ambulatory settings.

Multiple problems in human–computer interaction design contribute to the often suboptimal support of clinical work by EHRs. For instance, cluttered screen designs and separation of information across multiple screens make it difficult for clinicians to gain a quick overview of the patient's status. As a result, clinicians sometimes miss key information required to make decisions, which in turn increases the chance of errors. Several studies suggest that dentistry, a primary care discipline with approximately 137,000 practitioners in the United States, may have problems similar to those found in medicine [14–19]. Studies conducted in dentistry [15–21] have demonstrated that poor usability and a steep learning curve are major barriers to the use of electronic dental record (EDR) systems. These studies suggest that there is significant room for improvement of EDR systems. Similarly, despite widespread adoption of EDRs at U.S. dental schools, investigators continue to find that many users are not convinced that they improve efficiency and effectiveness [15,19,21]. Users want better design, shorter learning curves, reliable hardware and digital imaging capabilities [15,19].

On the other hand, empirical studies have reported that clinical performance improves when information displays match the users' mental models and their clinical work processes [22–27]. Clinicians are able to focus their attention entirely on patient problems and devote their cognitive resources to clinical reasoning, strategy and treatment planning [28]. These observations have led to the application of techniques and methodologies adapted from applied cognitive psychology to study how HIT can support clinicians' work processes and decision-making activities [24,27,29]. For example, Patel and Kushniruk [24] proposed cognitive engineering methods to study individual interactions of users with HIT, and to understand group processes and interactions among health professionals and HIT using a distributed cognitive framework. The results helped with assessing the clinicians' information needs and understanding the problems they experienced when interacting with clinical systems. They also contributed to redesigning these systems to support clinicians' work.

Few studies have explored how cognitive engineering methods can inform the design of a clinical system [22,30–34]. These studies have typically employed methods such as think-aloud protocols, work-flow observations and semi-structured interviews to understand the cognitive processes and information management strategies of clinicians during patient care. The resulting cognitive models were then used as the basis to design systems. Zhang and colleagues [34–37] developed a human-centered distributed information design framework to study the dynamic interactions among humans, artificial agents and the context in which the system is situated. Preliminary results have demonstrated that these approaches may improve systems' cognitive support during patient care and thus suggest the possibility of improving patient care quality and safety. Recently, investigators identified clinical data presentation that facilitates the clinicians' formulation of a patient's problem as a critical component for improving patient care through HIT [1,38]. However, research is still nascent as many methods have been proposed with little empirical evaluation. It is this gap in knowledge – how cognitive engineering methods can be optimally applied to inform the system design process – that we sought to address in this study.

Existing cognitive engineering studies have mostly focused on information processing and management when users interacted with patient documentation or records or during their clinical workflow [22,31,32,39–41]. They do not reflect the actual patient or the 'clinicians' physical and cognitive interactions with a patient' [38,42,43]. Thus, capturing interactions with records may not necessarily capture the clinicians' knowledge states and decision-making as well as doing so with less abstract representations of patients. In this paper, we adapt the current cognitive task analysis methods to closely simulate activities during an actual patient visit, and to study how dentists access and interact with raw patient data to diagnose a patient. We coded cognitive processes and information accessed in order to learn what information dentists needed and how they used it in diagnosing and treatment planning.

The objective of this study was to document how dentists review information and make decisions during a new patient visit. We focused on the following questions:

1. What information sources do dentists retrieve and in what sequence when examining simulated patient cases of varying complexities?
2. What information do dentists use to make clinical decisions and how do they use it?
3. What cognitive processes characterize a dentists' information management and decision-making activities when examining patients?

2. Methods

Cognitive task analysis (CTA) is the "extension of traditional (behavioral) task analysis techniques to yield information about the knowledge, thought processes and goal structures that underlie observable task performance" [44]. It is typically used to identify the concepts, contextual cues, goals and strategies that contribute to the mental activities of an individual when solving a specific problem or a task. In this study, we conducted a CTA to observe ten general dentists examining three simulated patient cases using a think-aloud protocol. The three simulated patient cases referred here include only patient information and do not include real patients or actors.