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Mobilizing clinical decision support to facilitate knowledge translation: A case study in China

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ABSTRACT

Background: A wide gulf remains between knowledge and clinical practice. Clinical decision support has been demonstrated to be an effective knowledge tool that healthcare organizations can employ to deliver the "right knowledge to the right people in the right form at the right time". How to adopt various clinical decision support (CDS) systems efficiently to facilitate evidence-based practice is one challenge faced by knowledge translation research.
Method: A computer-aided knowledge translation method that mobilizes evidence-based decision supports is proposed. The foundation of the method is a knowledge representation model that is able to cover, coordinate and synergize various types of medical knowledge to achieve centralized and effective knowledge management. Next, web-based knowledge-authoring and natural language processing based knowledge acquisition tools are designed to accelerate the transformation of the latest clinical evidence into computerized knowledge content. Finally, a batch of fundamental services, such as data acquisition and inference engine, are designed to actuate the acquired knowledge content. These services can be used as building blocks for various evidence-based decision support applications.
Results: Based on the above method, a computer-aided knowledge translation platform was constructed as a CDS infrastructure. Based on this platform, typical CDS applications were developed. A case study of drug use check demonstrates that the CDS intervention delivered by the platform has produced observable behavior changes (89.7% of alerted medical orders were revised by physicians).
Discussion: Computer-aided knowledge translation via a CDS infrastructure can be effective in facilitating knowledge translation in clinical settings.

1. Introduction

1.1. The knowledge-practice chasm

Globally, healthcare organizations fail to use evidence optimally. In 1973, Wennberg and Gittelsohn published their landmark article demonstrating substantial variation among different healthcare service providers [1]. Forty years later, this situation has not changed. A large gulf remains between what we know and what we practice. One study in 2003 showed that only 54.9% of US patients received evidence-based care [2]. Similar findings have been reported globally in both developed and developing countries [3].

Several reasons have caused this knowledge-practice gap. First, knowledge grows exponentially. It is estimated that each year 10,000 diseases, 3000 drugs, and 400,000 articles are added to the biomedical domain [4], and every 19 years, the volume of the literature in the biomedical domain is doubled [5]. This explosive knowledge growth has inflicted a heavy cognitive load on clinicians. Second, medical knowledge itself is evolving. Former conclusions can be overturned by the latest evidence. According to a 2001 survey, 50% of guideline knowledge becomes invalid in 5.8 years, and the validity period of 90% guidelines is only 3.6 years [6]. The dynamic nature of knowledge inflicts great pressure on physicians to respond to the latest clinical evidence in a timely manner. Third, the knowledge translation course is long. The course could take as long as 10 years for newly discovered knowledge to enter textbooks [7], and it takes 10–17 years for new knowledge to be transformed into routine practice [8].

1.2. Clinical decision support as a knowledge tool to facilitate knowledge translation

To close the chasm between knowledge and practice, knowledge translation (KT) in healthcare has been widely recognized and studied

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in the past decade. According to the Canadian Institutes of Health Research (CIHR), KT has been defined as "a dynamic and iterative process that includes the synthesis, dissemination, exchange and ethically sound application of knowledge to provide more effective health services and products and strengthen the healthcare system" [9]. Because knowledge accumulates and evolves rapidly, KT is constantly faced with the challenge of synthesizing the vast body of highly dynamic knowledge content and utilizing it at the point of care [10]. To meet this challenge, healthcare organizations need effective knowledge management tools to organize and utilize the vast knowledge content to maintain competitive performance in such a highly dynamic environment [11]. CDS (clinical decision support) is such a tool that a healthcare organization can employ to deliver the "right knowledge to the right people in the right form at the right time" [12]. Many studies [13–19] have demonstrated CDS's capability to improve evidence-based practice and facilitate knowledge translation.

1.3. Needs of CDS mobilization infrastructure

Traditional CDS systems are developed as independent systems by different vendors. They usually target a specific application (such as diagnostic CDS [20], lab test surveillance and alerting [21,22], or drug use checking [23]) and use private knowledge representation and implementation methods. This has led to fragmented, disintegrated and inconsistent knowledge, therefore introducing complexity in developing CDS front ends [24] and managing back-end knowledge content [16]. Because of such heterogeneity, coordinated knowledge content and unified knowledge management cannot be easily achieved in healthcare organizations [25]. As an amendment to traditional CDS systems, the 2000 AMIA symposium recommended "maintainable technical and methodological foundations for computer-based decision support" as a key factor for implementing "evidence-based (i.e., based on timely and latest knowledge)" CDS [26,27]. Therefore, the mission of this study is to design and construct a mobilization infrastructure or foundation where computerized clinical decision support is used as the major knowledge tool that facilitates knowledge translation. The infrastructure should be able to provide centralized knowledge management and efficient knowledge acquisition such that the rapidly changing clinical evidence can be quickly and effectively applied to computerized decision support.

2. Methods

As mentioned above, a CDS infrastructure is a promising alternative to traditional CDS systems in facilitating knowledge translation (Fig. 1). The computer-aided knowledge translation process enabled by computerized decision support tools can be summarized as three procedures: 1. Knowledge representation. Before medical knowledge can be used in various computerized decision support systems, it needs to be represented in a computer-interpretable format. Knowledge representation determines the knowledge base schema and what types of computerized decision supports can be provided. 2. Knowledge acquisition. Knowledge acquisition transforms medical knowledge embedded in the literature and textbooks into computer-interpretable formats determined by knowledge representation formalisms. This procedure is usually performed by knowledge engineers. 3. Knowledge application. Computer-interpretable knowledge contents are applied in healthcare decision making in the form of computerized decision support.

To support knowledge translation better, this paper aims to design a CDS infrastructure that could benefit all of the above three procedures. Implementation of such an infrastructure would entail several distinctive characteristics compared with traditional CDS systems. First, the infrastructure needs a general-purpose knowledge

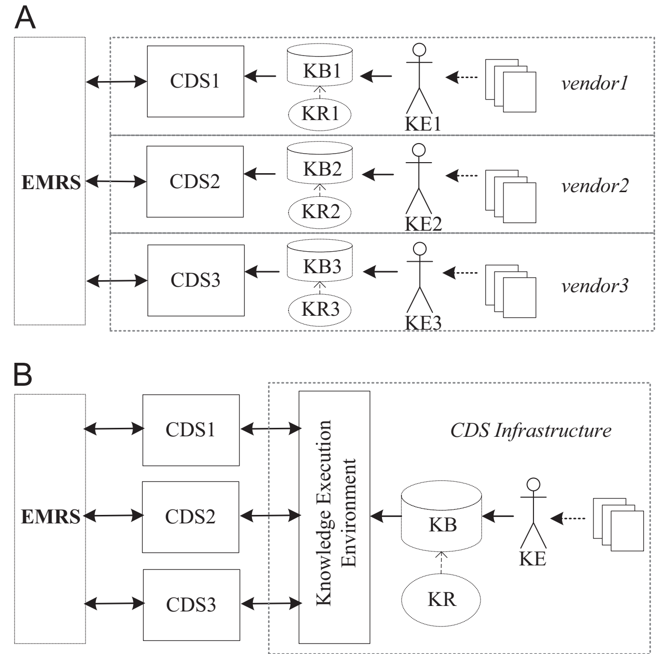

Fig. 1. Computer-aided knowledge translation process by computerized decision support tools. (A) Knowledge translation facilitated by traditional CDS systems deployed in a healthcare organization. (B) Knowledge translation facilitated by a CDS infrastructure. KR=knowledge representation; KB=knowledge base; KE=knowledge engineer.

representation model to cover, coordinate and synergize various types of medical knowledge in computer-interpretable forms, which lays the foundation for centralized knowledge management and subsequent knowledge dissemination via computerized decision support services [28,29]. Second, the infrastructure should provide highly efficient knowledge acquisition and authoring tools to reduce the knowledge acquisition time and cost. Knowledge acquisition is a time-consuming process and can take as much as 50% of the total effort for building a CDS system [30]. Efficient and timely knowledge acquisition ensures that the provided CDS intervention is based on the latest clinical evidence. Third, the infrastructure should provide a mechanism to transfer acquired knowledge contents to evidence-based decision supports efficiently.

To fulfill the above requirements, this paper designs a computer-aided knowledge translation framework as such a CDS infrastructure. As shown in Fig. 2, the framework is composed of five components. The first component is knowledge representation, which defines a unified ontology to cover and coordinate multiple knowledge types. The second component is knowledge acquisition, where knowledge content is acquired and authored using computer-aided methods. The third component is the knowledge base, which stores various types of knowledge and their inter-relationships as defined by the unified ontology. The fourth is a layer of knowledge-driven services such as the inference engine, treatment recommendation, and context-aware knowledge retrieval, which are used as fundamental service modules by diverse CDS applications. The fifth is a layer of CDS applications that interact with end users. The above framework covers the three procedures (knowledge representation, knowledge acquisition and knowledge application) of computer-aided knowledge translation. The framework supports knowledge translation by the following workflow (Fig. 2).

1. Design a knowledge representation model suited for knowledge translation, and construct the corresponding knowledge base. 2. Knowledge content is continuously synthesized, curated and maintained by an expert panel through a knowledge-authoring web portal. 3. In addition to the aforementioned authoring web portal,