Current Issues and Future Trends of Clinical Decision Support Systems (CDSS)

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INTRODUCTION

Computer-based clinical decision support systems (CDSSs) leverage developments in information technology to support healthcare providers with clinical decisions as they relate to the improvement of diagnostic, therapeutic, quality and safety processes and outcomes. In the last 50 years there have been significant advances with CDSSs, and the potential for a substantial role in the future of healthcare delivery remains likely. During this time, there have been three main stimulating factors for the development of CDS: (1) the intellectual challenge, (2) the need to address issues relating to patient safety, quality and access to healthcare, and (3) the business and policy reasons relating to the allocation of limited resources and control of spiraling healthcare costs (Greenes, 2006).

The undeniable intellectual challenge to understand and improve upon the human cognitive process has been and continues to be a major driving factor for the development of CDSSs. The human mind has become the model for developing complex systems capable of broadly interactive decision support. At the same time, efforts to reduce medical errors, and increase quality and patient safety have been championed as potential benefits of CDS. Estimates from a 1999 report, by the Institute of Medicine (IOM) indicated that as few as 48,000 and as many as 98,000 people die each year in the U.S., at a cost of more than $6 billion per year, as a result of medical errors (IOM, 1999). Similarly, a recent 2001 IOM report made a passionate plea for closing the quality gap between best practices and actual practices (IOM, 2001).

In this regard, the objective of the article is twofold: (1) to provide a framework for understanding CDSS and within this framework address a number of the current issues facing CDSS, and (2) to suggest likely directions for future research and clinical application.

BACKGROUND

A number of definitions for CDSS exist in the literature. For example, Peleg and Tu (2006) define CDSS as "any computer program to help health professionals make clinical decisions" while Musen, Shahar, and Shortliffe (2001) refer to CDSS as tools for information management, for focusing attention, and for providing patient-specific recommendations. More specific definitions include CDSSs as computer systems designed to impact clinician decision making about individual patients at the point in time when the decisions are made (Berner & La Lande, 2007) and CDSS as computer-based systems for bringing relevant knowledge to bear on the healthcare of the patient (Greenes, 2006). In effect, a CDSS provides patient-specific alerts and reminders, supports differential diagnosis through the interpretation of clinical results and user input, and provides methods to retrieve intelligently filtered knowledge that is medically relevant to the decision making process. Regardless of a particular definition, it is evident that CDSS are *computer-based* systems that leverage *medical knowledge* and *patient-specific data* to respond to a request for decision support by providing *recommendations* with the ultimate goal of improving the quality of the service provided to the *patient*. Figure 1 depicts the key elements in a CDSS. It should be noted however, that the decision support may be requested by a healthcare professional such as a doctor, a nurse, or a technician, another computer

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system, or the patient. Moreover, while the diagram depicts knowledge and the processing engine as distinct entities, in practice, depending on the underlying technology, the knowledge and the engine may be closely intertwined.

A FRAMEWORK FOR UNDERSTANDING CDSS

In order to synthesize different perspectives on CDSS research, development, and practical issues, we develop a framework (shown in Figure 2) in this section, building on extant literature.

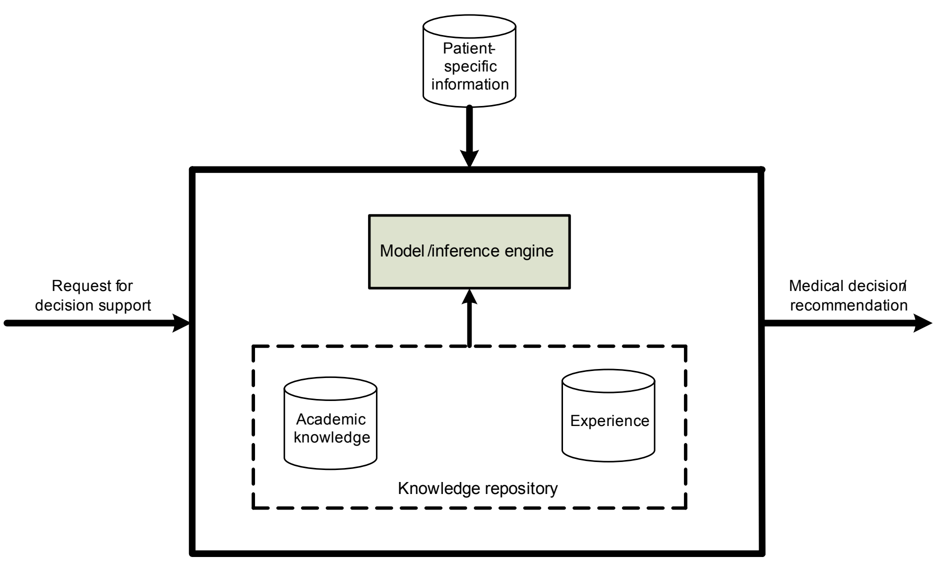
In this framework, CDSS can be characterized along multiple dimensions, such as the type of support and intervention provided by CDSS, and the type of knowledge and methods employed in these systems (Degoulet & Fieschi, 1997). According to Degoulet, there exist two types of support provided by CDSS: (1) support in assessing the patient's state (e.g., in diagnosis or prognosis), and (2) support in suggesting the best course of action (e.g., recommended tests or treatment). Frequently, CDSS in practice may provide both types of support.

CDSS can also differ with respect to the type of intervention ranging from passive systems to active systems (Degoulet & Fieschi, 1997). In passive mode, the user has to initiate the process by providing a request to the system. Such request can be for an advice regarding a particular case, or for feedback (critique) regarding a particular assessment or planned course of action. On the other extreme, active systems can make decisions in an autonomous manner (i.e., independent of the physician or care giver, e.g., dialysis monitors).

CDSS can be further characterized by the type of knowledge or method employed. As noted by Degoulet, Jean, Engelmann, Meinzer, and Jagermann (1995), knowledge utilized for decision support may come from the medical literature encapsulating academic knowledge, and expertise acquired through medical practice. In many cases, systems encapsulate knowledge from both sources. Observations, while not knowledge per se, play a major role in machine learning techniques, and in validating decision models.

A number of methods have evolved over the years as shown in Table 1. Logical methods seek to represent and evaluate logical conditions, and are often used to generate clinical reminders, alerts, and make diagnostic or therapeutic inferences. Research dating back to the late 1950s suggested that the use of these methods as basic building blocks needed to emulate the medical decision-making process (Ledley & Lusted, 1959). Even today, the contemporary clinical system *Retrogram*, founded on the logic-based PRO*forma* application is being widely used in the UK to manage HIV care. Many existing systems in use today typically utilize the evaluation of logical conditions to narrow the range of possibilities as a precursor to applying probabilistic, heuristic, or other methods.

Figure 1. Clinical decision support systems (CDSS)



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