Chapter 21
The Role of Artificial Intelligence in Clinical Decision Support Systems and a Classification Framework

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ABSTRACT

Clinical decision support systems are meant to improve the quality of decision-making in healthcare. Artificial intelligence is the science of creating intelligent systems that solve complex problems at the level of or better than human experts. Combining artificial intelligence methods into clinical decision support will enable the utilization of large quantities of data to produce relevant decision-making information to practitioners. This article examines various artificial intelligence methodologies and shows how they may be incorporated into clinical decision-making systems. A framework for describing artificial intelligence applications in clinical decision support systems is presented.

INTRODUCTION

As far back as the early 1960's computer technology has been applied to help solve healthcare issues (Saba, Johnson, & Simpson, 1994). Starting in the 1970's, intelligent computer applications to improve healthcare problem solving had arrived (Schwartz, 1970). While Schwartz (1970) incorrectly implied that computers would eventually replace physicians, many of the other forecasts on the impact of computer technology in healthcare, such as improving data availability and improving decision making, have been realized. Nearly four decades later, health information technology professionals continue to advocate for further development of information systems technologies in healthcare to create a nationwide infrastructure for sharing health information to improve patient outcomes and reduce medical costs (Chopra, 2009).

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The advent of electronic health records (EHRs) and health information exchanges (HIEs) have certainly provided a means for more rapid and reliable access to patient information to improve the quality of care (Topaz et al., 2013). EHRs are utilized worldwide to improve health delivery systems (Wager, Lee, & Glaser, 2013).

However, EHRs still experience resistance to use from physicians and staff (McAlearney et al., 2015; Wang et al., 2015). Despite improved information flow afforded by EHRs and HIEs, this resistance has resulted in information overload and the need to find better ways to extract reliable information (Huang et al., 2015). For instance, Pickering et al. (2013) demonstrated that physicians use a relatively small amount of information available in EHRs when determining which patients to admit to an ICU, indicating that often too much information is available for decision making and leading to information overload.

Although there is still a long way to go before the ubiquitous acceptance of healthcare information technologies (HIT), healthcare is becoming an ever more information based and information dependent science (Ikram, Ghani, & Abdullah, 2015). Advances in information and communication technologies have led to the availability and generation of vast amounts of data (Esfandiari et al., 2014), especially in clinical medicine (Bellazzi & Zupan, 2008).

Clinical decision support systems, which are defined as "computer systems designed to impact clinician decision making at the point in time that these decisions are made (Berner & Lande, 2007, pg. 3)," are providing mechanisms for delivering clinical information in a usable format to decision makers (Bellazzi & Zupan, 2008). Improving rates of acceptance of clinical decision support systems may be due in part to the concern of physicians and other medical providers about the quantity of information needed to provide high quality health care and to avoid costly and life-threatening errors (Musen, Shahar, & Shortliffe, 2006).

Research has shown that utilizing artificial intelligence alone (Miller & Brown, 2018) or with EHR technology can improve clinical decision support (El-Sappagh & El-Masri, 2014). There is a tremendous need for incorporating artificial intelligence into clinical decision making to improve clinical outcomes (Park & Han, 2018). Artificial intelligence, which is based on the principal of making machines intelligent so that they can perform at expert human levels or better, enables the rapid assimilation of large amounts of highly complex data into multi-criteria decision-making models that can heuristically determine outcomes to clinical and other healthcare related problems (Callahan & Shah, 2018). Applied research in medicine and healthcare is already showing how to use artificial intelligence to improve decision making for detecting and diagnosing diseases or other healthcare issues, planning treatment, allocating critical healthcare resources, and scheduling and monitoring of patients. Pandey and Mishra (2009) document for the field of medicine: 56 knowledge-based expert systems, 33 artificial neural network applications, and 41 genetic algorithm or fuzzy logic-based systems. Other literature review research of artificial neural network, genetic algorithm, and fuzzy set methods applied in medicine found over 1000 reported applications from 1995 through 2007 (Yardimci, 2009) and for intelligent agents solving various treatment and monitoring problems 20 different applications are reported (Isern, Sánchez, & Moreno, 2010). From 1994 through 2014 across 14 specializations of medicine and health care management, Ghaheri et al. (2015) reported on 72 different healthcare information systems applications of genetic algorithms or genetic algorithms used in combination with artificial neural networks. As an indicator of the growth of artificial intelligence research and practice in medicine, a search conducted on EBSCO using the search terms artificial intelligence, artificial neural network, expert system, knowledge based system, machine learning, genetic algorithm, and fuzzy set combined with the search terms medical, medicine,