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Clinical Decision Support Capabilities of Commercially-available Clinical Information Systems

Adam Wright, PhD, Dean F. Sittig, PhD, Joan S. Ash, PhD, Sapna Sharma, MBI, Justine E. Pang, Blackford Middleton, MD, MPH, MSc

Abstract **Background:** The most effective decision support systems are integrated with clinical information systems, such as inpatient and outpatient electronic health records (EHRs) and computerized provider order entry (CPOE) systems.

Purpose: The goal of this project was to describe and quantify the results of a study of decision support capabilities in Certification Commission for Health Information Technology (CCHIT) certified electronic health record systems.

Methods: The authors conducted a series of interviews with representatives of nine commercially available clinical information systems, evaluating their capabilities against 42 different clinical decision support features.

Results: Six of the nine reviewed systems offered all the applicable event-driven, action-oriented, real-time clinical decision support triggers required for initiating clinical decision support interventions. Five of the nine systems could access all the patient-specific data items identified as necessary. Six of the nine systems supported all the intervention types identified as necessary to allow clinical information systems to tailor their interventions based on the severity of the clinical situation and the user's workflow. Only one system supported all the offered choices identified as key to allowing physicians to take action directly from within the alert.

Discussion: The principal finding relates to system-by-system variability. The best system in our analysis had only a single missing feature (from 42 total) while the worst had eighteen.This dramatic variability in CDS capability among commercially available systems was unexpected and is a cause for concern.

Conclusions: These findings have implications for four distinct constituencies: purchasers of clinical information systems, developers of clinical decision support, vendors of clinical information systems and certification bodies.

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Introduction and Background

Clinical Decision Support

Clinical decision support (CDS) systems are a key part of clinical information systems designed to aid clinician decision making during the process of care. While CDS can be delivered via a variety of media, including paper, the term CDS is most widely used for computer-based interventions delivered through clinical information systems. Common types of clinical decision support include drug-interaction checking,[1] preventive care reminders[2] and adverse drug event detection.[3] There is substantial evidence to suggest that clinical decision support systems, when well designed and effectively used, can be powerful tools for improving the quality of patient care and preventing errors and omissions.[4–12]

Challenges in Implementing Decision Support

Although the evidence for the potential effectiveness of well-designed clinical decision support is strong, adoption of clinical decision support has been somewhat limited outside of a relatively small number of academic medical centers and integrated healthcare delivery networks.[13,14] A variety of causes for this limited adoption have been posited, including:

Affiliations of the authors: Partners HealthCare (AW, JEP, BM), Boston, MA; Brigham and Women's Hospital (AW, JEP, BM), Boston, MA; Harvard Medical School (AW, BM), Boston, MA; UT–Memorial Hermann Center for Healthcare Quality and Safety, University of Texas School of Health Information Sciences at Houston (DFS), Houston, TX; Oregon Health & Science University (JSA, SS), Portland, OR.

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Correspondence: Adam Wright, PhD, Partners HealthCare System, 93 Worcester St, Wellesley, MA 02481; e-mail: <awright5@partners.org>.

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- The significant resources required to develop, curate and maintain large knowledge bases of clinical decision support content.[15]
- A lack of technical standards and approaches that facilitate effective sharing of clinical decision support content.[16]
- The difficulty of integrating clinical decision support into clinical workflow effectively and unobtrusively while avoiding alert fatigue.[17]
- Clinician fears of "cookbook" medicine[18]
- A lack of clear business case for use of clinical decision support.[19,20]
- A relatively small number of hospitals and practices that have CPOE or EHRs.[21]

Clinical Decision Support Capabilities of Clinical Information Systems

In addition to challenges relating to decision support content and workflow, many sites have reported significant limitations in the ability of their clinical information systems to accommodate decision support. Although decision support systems can be standalone,[22] the most effective decision support systems are integrated with clinical information systems, such as inpatient and outpatient electronic health records (EHRs) and computerized provider order entry (CPOE) systems.[9] Such integrated systems allow for proactive, data-driven decision support;[22] however, such integration makes significant feature demands on clinical information systems. Consider, for example, a decision support rule regarding monitoring patients for hypokalemia while they are taking digoxin. One might design the rule such that, when a new potassium value is stored in the electronic health record, it is checked against a reference range (to determine whether the patient is hypo-, hyper-, or normokalemic). If hypokalemia is detected, the rule would then check the medication list to determine whether the patient was on digoxin. The system might then page the responsible physician, notify him or her of the situation and offer therapeutic options, such as adding potassium supplementation or reducing or discontinuing the digoxin.

In 2006, we proposed a taxonomy of clinical decision support capabilities in clinical information systems.[23] This taxonomy was based on a comprehensive analysis of the clinical decision support knowledge base in use at Partners HealthCare system. The taxonomy described functional capabilities that could be provided by a clinical information system along four axes:

- "Triggers: The events that cause a decision support rule to be invoked. Examples of triggers include prescribing a drug, ordering a laboratory test, or entering a new problem on the problem list."
- "Input data: The data elements used by a rule to make inferences. Examples include laboratory results, patient demographics, or the patient's problem list."
- "Interventions: The possible actions a decision support module can take. These include such actions as sending a message to a clinician, showing a guideline, or simply logging that an event took place."
- "Offered choices: Many decision support events require users of a clinical system to make a choice. For example, a rule that fired because a physician entered an order for a drug the patient is allergic to might allow the clinician to cancel the new order, choose a safer alternative drug, or override the alert and keep the order as written but provide an explanation."[23]

In addition to identifying the taxa, the taxonomy also indicated the number of rules in use at Partners that depended on each one. The taxa within these four axes are listed in Table 1. The digoxin example above uses the "laboratory result stored" trigger, the "laboratory result/observation" and "drug list" data elements, the "notify" intervention and the "write order", "cancel existing order" and "edit existing order" offered choices.

Table 1 also shows the frequency of usage of each element of the taxonomy at Partners Healthcare System in the columns labeled "Rules" and "Rule Types". The Partners knowledge base contains 181 rule types and 7,120 unique rules. An example of a rule type is "drug interaction checking" while an example of a rule within that rule type would be "co-administration of sildenafil and nitroglycerin is contraindicated."

If particular functional capabilities are not available in a particular EHR, the ability to carry out decision support is necessarily limited to rules that do not require the missing functionality. For example, if a particular EHR system did not support triggering based on new laboratory results, this alert could not run in real time. In many cases, CDS interventions can be modified (for example, the digoxin checking rule could be set to run on demand), but such remediation can yield rules that are less effective. For example, researchers at the University of Pittsburgh Medical Center (UPMC) developed a heart failure decision support intervention in a commercial clinical information system from Cerner (Cerner Corporation, St Louis, MO) that alerted physicians to patients who might have heart failure.[24] The alert asked physicians to review the patient's condition and order an angiotensin-converting enzyme inhibitor (ACEI) or angiotensin receptor blocker (ARB). However, Cerner's system had limited support for "offered choices", so instead of allowing physicians to order the medication directly from within the alert they were asked to simply acknowledge the alert and then subsequently enter the order. Only 62% of physicians who said they would start an ACEI or an ARB actually entered the required order.[24]

The decision support capabilities of commercial EHR systems have not been previously characterized. It is notable, however, that most of the reports of successful decision support systems come from sites that have self-developed rather than commercial EHR systems.[14] In this paper, we describe and quantify the results of a study of decision support capabilities in certification Commission for health information technology (CCHIT) certified electronic health record systems. The CCHIT is a United States-based nonprofit organization which tests and certifies ambulatory and inpatient electronic health record systems that adhere to CCHIT's functional requirements.

Methods

We identified the best-selling clinical information systems in the United States using figures from Klas (Orem, UT) and HIMSS Analytics (Chicago, IL) and contacted the companies that developed the systems as well as their customers by