

**CLINICAL DECISION SUPPORT SYSTEMS: IMPLICATIONS FOR PHYSICIANS
AND MEDICAL PRACTICE**

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INTRODUCTION

As early as the 1990s, healthcare organizations used information technology to capture, store, analyze, and use clinical and research data in delivering care to patients. The movement to base diagnosis, treatment, and prognosis decisions on these aggregated datasets, known as “evidence-based medicine” (Guyatt et al., 1992), gained momentum in recent years due in part to major political and technological changes. In the United States, the 2009 Health Information Technology for Economic and Clinical Health (HITECH) Act provided healthcare organizations an estimated \$26 billion in incentive payments for the adoption of electronic medical records (EMR). These technologies allow the various practitioners treating a patient to record his or her medical data in a centralized, controlled, and secure location. Furthermore, under the federal mandate, adopters must “meaningfully use” EMR technologies to continue receiving full reimbursement for services rendered to Medicare and Medicaid patients. In other words, adopters of EMR technologies are financially penalized if they do not use the technologies to meet the goals of the federal mandate. One key component of “meaningful use” is the implementation of tools that analyze research and patient data to guide practitioners in making decisions about patient care, commonly referred to as clinical decision support systems (CDSS). These systems are typically built into and accessed through the EMR and are accessible to many members of the healthcare team.

Non-physician access to CDSS tools is particularly important to the goals of lowering healthcare delivery costs while maintaining high-quality care. For example, several states recently passed legislation enabling “expanded scope of practice” for nurse practitioners and other non-physicians with the aim of reducing costly physician time spent on certain medical services. CDSS tools assist nurse practitioners, nurses, technicians, and other non-physicians in delivering many of these medical services that might otherwise require physician care. However, expanded scope of practice and the tools that enable it have already been met with opposition. For example, the American Medical Association, led by physicians, argued that nurse practitioners do not have adequate training to diagnose patients (PricewaterhouseCoopers Health Research Institute, 2014). Furthermore, physicians engage in incomplete or improvisational use of CDSS tools that can curtail the accuracy and usefulness of these tools (e.g., Gupta, Raj, and Khorsani, 2014). Physicians’ practices, then, are central to the success of CDSS implementations and their associated outcomes.

In this paper, we provide an overview of the policies, technologies, and practices associated with CDSS implementation. We then review medical informatics studies investigating physicians’ use of CDSS or associated tools, showing how physicians seem to most commonly avoid or work around CDSS tools that are highly prescriptive. We suggest that these practices reflect broader conflicts happening in the field of medicine—namely, those over professional status and those over the changing nature of medical practice. Future analyses of CDSS implementations, then, could offer insight into how healthcare practitioners respond to the emergence of new paradigms in the practice of medicine. We discuss how CDSS enable new practices that move medicine closer to long-held goals, but also have been met with resistance that highlights conflicts between these goals and the traditional practice of medicine.

“MEANINGFUL USE” POLICIES AND CDSS

Beginning in 2015, practices that do not demonstrate “meaningful use” of EMR will be penalized via reduced Medicare and Medicaid reimbursements. The Centers for Medicare and Medicaid Services (CMS) defines meaningful use of EMR as use that improves quality, safety,

and efficiency, enhances coordination, makes patients more active consumers of health information, improves public health, and maintains the patients' privacy. Within these focus areas, CMS enforces meaningful use by providing "core" and "menu" objectives for users to meet, the number of which depends on whether the organization is an independent provider or a hospital. Hospitals, for example, must meet 16 objectives in Stage 1 and 19 objectives in Stage 2. Some examples of these objectives are listed in Table 1. Additionally, all providers must also attest to the functionality of 5 CDSS tools (CMS, 2014a). These tools, all aimed at assisting practitioner decision-making, include computerized alerts and reminders, clinical guidelines, and condition-specific order sets, documentation templates, diagnostic support, and contextually relevant reference information (CMS, 2014b).

Insert Table 1 here

CDSS: A DESCRIPTION

CDSS offer multiple tools for analyzing, interpreting, and using patient and research data in healthcare delivery decisions. In an examination of 11 CDSS (seven vendor-provided and four internally-developed systems), Wright et al. (2011) noted 53 types of CDSS tools. The most common tools across these 11 CDSS involved medication dosing and order support. Other tools concerned point-of-care alerts, displays of relevant information, expert systems, and workflow support. Considerable variability exists among CDSS in terms of the tools they include (Mann, 2011). Figure 1 orders some of the most common tools along a continuum of physician autonomy, with greater autonomy permitted at the bottom of the figure with descriptive, user-initiated tools and less autonomy at the top of the figure with prescriptive, system-initiated tools.

Insert Figure 1 here

Beginning at the top of the continuum in Figure 1, the most prescriptive tools call for users to take specified action or provide a rationale for deviating from a directive. For instance, alerts and reminders, also called "point of care electronic prompts" (Schwann et al., 2011: 869) appear in pop-up style windows, alerting physicians to errors or reminding them to order periodic screening exams. Both alerts and reminders require user acknowledgment before further action is permitted. Documentation templates and clinical protocols are less intrusive than alerts and reminders, but still constrain and direct user action. Clinical protocols, for example, consist of action sequences for managing a specific patient condition, such as post-operative care for hip surgery. The protocols often include multi-disciplinary instructions, allowing nurses and allied health professionals to take physician-sanctioned actions without waiting for a direct order. The normative tools are less intrusive than the prescriptive tools, often appearing in a sidebar or in the appropriate section of the EMR. These tools offer guidance in the form of best practice recommendations, but do not require user action. Order sets include lists of the diagnostic tests, medications, and nursing interventions considered appropriate for patients' diagnoses. Decision trees, often in flowchart form using yes/no questions or if/then statements, help physicians make diagnostic or treatment decisions given a patient's circumstances. Similar to order sets, clinical guidelines reflect the current standard of care for a particular diagnosis (Timmermans & Mauck, 2005), typically established by one of the professional associations, such as the guidelines for treating congestive heart failure published by the American College of Cardiology. Currently, local policies determine how much latitude physicians retain in following or deviating from these clinical guidelines, but shifting payment structures and increasing calls for physician and hospital

performance metrics suggest that application of the guidelines will become increasingly prescriptive (Foote and Town, 2007; Miller, Brennan, and Milstein, 2009). Finally, at the descriptive end of the continuum are various reference tools that display information at the physician's request. These tools are often accessed via contextually-sensitive hyperlinks or buttons in the EMR and include data displays, which allow a physician to view patient parameters (e.g., lab test results) in graphical form; reference tables, such as medication dosages organized by patient weight; and links to the research literature.

We conducted a literature review of studies in medical informatics to identify other practices physicians engage in to use, avoid, or work around CDSS tools. We were particularly interested in the use of tools outlined in Figure 1 and how use differed as the level of prescriptiveness changed. In other words, we wanted to know:

RQ: How does physician use of a CDSS tool, as documented in the medical and medical informatics literatures, vary depending on the prescriptiveness of the tool?

METHODS

To answer this question, we reviewed articles from a variety of medical informatics journals, but most discussion of physicians' use of CDSS takes place in the Journal of the Medical Informatics Association, International Journal of Medical Informatics, and BMC Medical Informatics. We conducted a table of contents review on these three journals and their associated conference proceedings to identify relevant issues being discussed in the defined time frame. To ensure that our approach represented discourses taking place in other medical informatics outlets, we conducted keyword searches using variations of phrases like "electronic medical records," "electronic health records," and "health information technology" in other relevant journals and conference proceedings. We ranked the relevant articles by citation count using Thomson Reuters Web of Science to get a sense of the most popular discourses in the medical informatics community. We chose a roughly equal number the top articles from each year spanning 1994 to 2000, 2001 to 2007, and over-sampled articles from 2008 to September 2014 (to account for the increase due to the 2009 HITECH Act). As we read the articles on this list, we took notes on all that applied from the following categories: topic, variables being measured, method, results, implications for research, and implications for practice. We then performed qualitative coding (Corbin & Strauss, 1990; Miles & Huberman, 1999) on these notes and each article's abstract to identify themes among the studies, revising each theme as we read more articles.

FINDINGS

Even prior to federal legislation and massive investment in EMR and CDSS, medical informatics scholars extensively studied information technology implementations in medical settings and attempted to draw guidelines for future design, implementation, and use of these technologies. However, the HITECH Act rapidly intensified medical informatics researchers' interest in the factors and practices that underlie successful EMR and CDSS implementations. These studies most often defined "success" as practitioners' uniform and complete use of CDSS tools. In many cases, researchers identified context-specific organizational factors, technological features or flaws, or individual user behaviors as facilitators of or barriers to successful system implementation (Jha et al., 2009; Lluch, 2011; McGinn et al., 2011; Gagnon et al., 2012).

In measuring success, researchers have observed physicians' use of many of these CDSS tools in practice and noted that individuals tend to differ from one another in completeness and

accuracy of use. We found that accounts of doctors' use of prescriptive tools varied more often than use of normative or descriptive tools. One major area of concern, for example, was physicians' treatment of alerts. Because alerts (a prescriptive tool) disrupt a physician's workflow, they can lead to "alert fatigue," causing practitioners to ignore or override alerts on the grounds that the alerts are too frequent or intrusive (Jenders et al., 2007). As Gupta et al. (2014) observed, physicians may strategically enter patient data incorrectly to avoid frequent alerts. Incomplete or inaccurate information in the CDSS database can prompt incorrect CDSS alerts and reminders or fail to prompt necessary ones—outcomes that might detract from patient care or increase physician skepticism. Tiwari et al. (2013), for example, documented a CDSS failure to issue an interaction alert for a heart transplant patient who subsequently experienced a drug interaction. Afterwards, the institution reviewed possible drug-drug interactions for the drugs involved. Based on this review, the institution upgraded 62 of 329 possible pairings to more severe alerts in the system. Work continues to determine which drug-drug interactions are severe enough to warrant interruption of a physician's workflow via an alert (Phansalkar et al., 2013). Physicians' use of CDSS deserves greater research attention, particularly because their behaviors have important implications for healthcare in the U.S. We discuss two of these implications—occupational outcomes and the nature of medical practice—below.

DISCUSSION

Occupational Outcomes. CDSS portend a number of possible implications for healthcare professionals. One possible implication concerns physicians' autonomy, providing some explanation for physicians' resistance to prescriptive CDSS tools. Many studies of implementation have noted physicians' resistance to tools such as alerts and reminders, tools that lie on the prescriptive (top) end of Figure 1 (Seidling et al., 2011; Gupta et al., 2014). Currently, CDSS implementation is in its early stages, which means many organizations have largely only introduced descriptive CDSS tools (beginning at the bottom of Figure 1). As organizations shift to normative and eventually prescriptive tools, physicians will find that their normal workflow will be interrupted and their normal decision making autonomy may be reduced. Studies already indicate that physicians have developed workarounds to avoid prescriptive tools such as alerts by, for example, entering incorrect data (Gupta et al., 2014). Recognizing threats to their autonomy, physicians' response may become more strident and more formalized as they seek to limit CDSS that impinge upon their professional domain.

Nature of Medical Practice. At this early stage of CDSS implementation, research examining and explaining the potential changes introduced to healthcare as a result of CDSS use is critical because CDSS arguably pose a much greater challenge to the underlying paradigm of medical practice than has any previous technology. Whereas use of prior medical technologies augmented a practitioner's individual knowledge and skill, reinforcing the reliance on individualized, internalized stores of knowledge and experience, CDSS standardize and externalize medical knowledge, challenging years of hard-earned experience and intuition with transparent and easily accessible checklists and protocols. Such shifts tamper with the balance between art and science in medical practice. Many influential researchers, including Andrew Miles, the former editor-in-chief of the *Journal of Evaluation in Clinical Practice*, caution against disrupting this balance. Miles and Loughlin (2011: 532) note the dangers of tampering with the art-science balance in medicine, arguing that healthcare's emphasis on the science base of medicine comes "at the expense of medicine's essential humanism."

REFERENCES

- Ash, J.S., McCormack, J.L., Sittig, D.F., Wright, A., McMullen, C., & Bates, D.W. (2012). Standard practices for computerized clinical decision support in community hospitals: A national survey. *Journal of the American Medical Informatics Association*, 19(1), 980-987.
- Center for Medicare and Medicaid Services (CMS). (2014a). Eligible Professional Meaningful Use Table of Contents: Core and Menu Set Objectives Stage 1 (2014 Definition). Retrieved from: http://www.cms.gov/Regulations-and-Guidance/Legislation/EHRIncentivePrograms/Downloads/EP_MU_TableOfContents.pdf. Accessed Dec. 21, 2014.
- Center for Medicare and Medicaid Services (CMS). (2014b). Clinical Decision Support: More Than Just 'Alerts' Tipsheet. http://www.cms.gov/Regulations-and-Guidance/Legislation/EHRIncentivePrograms/Downloads/ClinicalDecisionSupport_Tipsheet-.pdf. Accessed Jan. 3, 2015.
- Corbin, J., & Strauss, A. (1990). *Basics of qualitative research: Grounded theory procedures and techniques*. London, England: Sage Publishers.
- Foote, S.B., & Town, R.J. (2007). Implementing evidence-based medicine through Medicare coverage decisions. *Health Affairs*, 26(6), 1634-1642.
- Gagnon, M. P., Desmartis, M., Labrecque, M., Car, J., Pagliari, C., Pluye, P., ... & Légaré, F. (2012). Systematic review of factors influencing the adoption of information and communication technologies by healthcare professionals. *Journal of Medical Systems*, 36(1), 241-277.
- Gupta, A., Raja, A. S., & Khorasani, R. (2014). Examining clinical decision support integrity: is clinician self-reported data entry accurate? *Journal of the American Medical Informatics Association*, 21(1), 23-26.
- Guyatt, G., Cairns, J., Churchill, D., Cook, D., Haynes, B., Hirsh, J. ... & Tugwell, P. (1992). Evidence-based medicine. *Journal of the American Medical Association*, 268(17), 2420-2425.
- Jenders, R. A., Osheroff, J. A., Sittig, D. F., Pifer, E. A., & Teich, J. M. (2007). Recommendations for clinical decision support deployment: synthesis of a roundtable of medical directors of information systems. *AMIA Annual Symposium Proceedings*, 359-363. American Medical Informatics Association.
- Jha, A. K., DesRoches, C. M., Campbell, E. G., Donelan, K., Rao, S. R., Ferris, T. G., ... & Blumenthal, D. (2009). Use of electronic health records in US hospitals. *New England Journal of Medicine*, 360(16), 1628-1638.
- Lluch, M. (2011). Healthcare professionals' organisational barriers to health information technologies—A literature review. *International Journal of Medical Informatics*, 80(12), 849-862.
- Mann, D. M. (2011). Making clinical decision support more supportive. *Medical Care*, 49(2), 115-116.
- McGinn, C. A., Grenier, S., Duplantie, J., Shaw, N., Sicotte, C., Mathieu, L., ... & Gagnon, M. P. (2011). Comparison of user groups' perspectives of barriers and facilitators to implementing electronic health records: a systematic review. *BMC Medicine*, 9(1), 46.
- Miles, M. & Huberman, A. (1994). *Qualitative data analysis: An expanded sourcebook*. Thousand Oaks, CA: Sage Publishers.
- Miles, A., & Loughlin, M. (2011). Models in the balance: evidence-based medicine versus evidence-informed individualized care. *Journal of Evaluation in Clinical Practice*, 17(4), 531-536.
- Miller, T.P., Brennan, T.A., & Milstein, A. (2009). How can we make more progress in measuring physicians' performance to improve the value of care? *Health Affairs*, 28(5), 1429-1437.
- Phansalkar, S., Desai, A., Yoshida, E., Doole, J., Czochanski, M., Tucker, A. D., ... & Bates, D. W. (2013). Criteria for assessing high-priority drug-drug interactions for clinical decision support in electronic health records. *BMC Medical Informatics and Decision Making*, 13(1), 65.
- PricewaterhouseCoopers Health Research Institute. (2014). Top health industry issues of 2015, Issue 8: Physician extenders see an expanded role in patient care. <http://www.pwc.com/us/en/health-industries/top-health-industry-issues/physician-extendors.jhtml>. Accessed Jan. 10, 2015.

- Schwann, N.M., Bretz, K.A., Fry, D., Ackler, F., Evans, P., Romancheck, D. ... McLoughlin, T.M. (2011). Point-of-care electronic prompts: an effective means of increasing compliance, demonstrating quality, and improving outcome. *Anesthesia & Analgesia*, 113(4): 869-876.
- Seidling, H. M., Phansalkar, S., Seger, D. L., Paterno, M. D., Shaykevich, S., Haefeli, W. E., & Bates, D. W. (2011). Factors influencing alert acceptance: a novel approach for predicting the success of clinical decision support. *Journal of the American Medical Informatics Association*, 18(4), 479-484.
- Timmermans, S., & Mauck, A. (2005). The promises and pitfalls of evidence-based medicine. *Health Affairs*, 24(1): 18-28.
- Tiwari, R., Tsapepas, D. S., Powell, J. T., & Martin, S. T. (2013). Enhancements in healthcare information technology systems: customizing vendor-supplied clinical decision support for a high-risk patient population. *Journal of the American Medical Informatics Association*, 20(2), 377-380.
- Wright, A., Sittig, D. F., Ash, J. S., Feblowitz, J., Meltzer, S., McMullen, C., ... & Middleton, B. (2011). Development and evaluation of a comprehensive clinical decision support taxonomy: comparison of front-end tools in commercial and internally developed electronic health record systems. *Journal of the American Medical Informatics Association*, 18(3), 232-242.

Table 1: Meaningful Use of EHR Technologies*

Focus Area	“Meaningful Use” Core and Menu Objectives
Quality, Safety, Efficiency, and Reducing Health Disparities	Computerized Physician Order Entry (CPOE) Electronic Prescribing Maintain Problem, Medication, and Allergy Lists Record Demographics Record Vital Signs Record Smoking Status Drug Formulary Checks Incorporate Lab Results Patient Lists Send Reminders to Patients
Engage Patients and Their Families	E-copy of Health Information Office Visit Summaries Patient Education Resources Timely Electronic Access E-Copy of Discharge Instructions
Improved Care Coordination	Medication Reconciliation Summary of Care at Transitions
Improve Population and Public Health	Immunizations Syndromic Surveillance Reportable Lab Results
Ensure Adequate Privacy and Security Protections for Health Information	Protect Health Information

Adapted from CMS (2014a)*

Figure 1. CDSS tools along a continuum of physician autonomy.*

