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TECHNICAL REPORT

ADVANCING CLINICAL DECISION SUPPORT

Key Lessons In Clinical Decision Support Implementation

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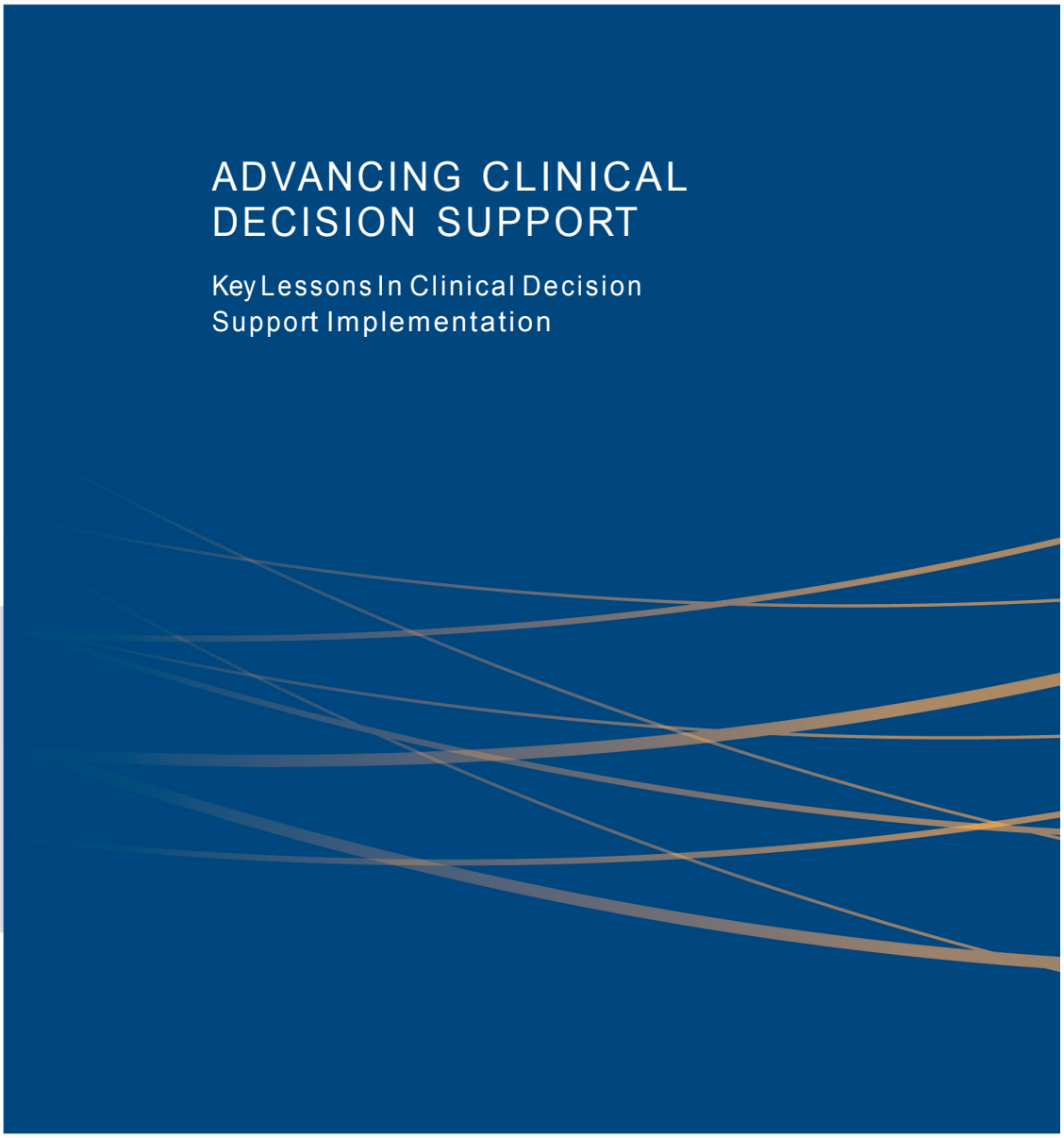

INSIGHT

Improving Health Through
Insightful Use of Technology

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Introduction

Clinical Decision Support (CDS) Background

According to the Clinical Decision Support (CDS) Roadmap project, CDS is "providing clinicians, patients, or individuals with knowledge and person-specific or population information, intelligently filtered or present at appropriate times, to foster better health processes, better individual patient care, and better population health." (1) As noted in the Task Order for this project (HHSP23337009T), CDS brings to daily practice the vast and expanding potential of modern clinical knowledge. CDS builds upon the foundation of an electronic health record (EHR) to provide health professionals and patients with general and person-specific information, intelligently filtered and organized, at appropriate times, to enhance health and health care. As its name implies, the purpose of CDS is to maximize the probability that clinical decisions are evidence-based and customized to the individual patient and specific clinical situation. CDS includes, but is not limited to, computerized alerts and reminders to care providers and patients, methods to bring care into compliance with clinical guidelines/protocols, condition and treatment-focused order sets, patient data reports and summaries, documentation templates, advice to promote more accurate and timely diagnoses, contextually relevant reference information, and other tools that enhance decisionmaking in clinical workflow.

CDS has been shown to lead to significant quality and safety improvements in patient care and improve workflow. (2-5) For example, computerized provider order entry (CPOE) with CDS can improve medication safety and reduce medication-related expenditures because it introduces automation at the time of ordering, a key process in health care. (5, 6) Drug-allergy checking and alerting (DA) is one of the simplest yet most important CDS tools used in electronic order entry systems. A meta-analysis showed that 85 percent of CDS studies demonstrated improved outcomes, including correct dose adjustment of medications in patients with renal impairment, and reduced lengths of stay. (3) Decision support has been found to significantly improve compliance with protocols and guidelines; the percentage of clinicians who responded to patient conditions requiring attention; and appropriateness of certain radiograph orders. (2) CDS systems have the potential to improve health care quality, and also to increase efficiency and reduce health care costs. (7)

Although the use of CDS has been growing, in part due to external financial incentives such as the federal "Meaningful Use" incentive program, CDS is still not widespread. In U.S. hospitals, less than two-thirds of hospitals have any type of CDS. (20) In 2009 it was reported that of the 44 percent of office-based practices that had an EHR, less than half of these practices were using any type of CDS. (21) Furthermore, in general, computerized order entry systems don't include much CDS (22), and the use of CDS in these systems is uneven and often limited. (23)

The American Recovery and Reinvestment Act includes incentives to increase clinicians' use of health information technology including CDS through reimbursement from the Centers for Medicare and Medicaid Services (CMS). Over time, these incentives will evolve into penalties for those who do not meet the "Meaningful Use" criteria. The CMS regulations have the potential to dramatically impact the future of CDS through bonus payments to providers and hospitals that use CDS and also by focusing on the electronic capture of underlying clinical data. Examples include drug-drug, drug-allergy and drug-formulary checks, and the implementation of CDS rules targeting high priority conditions. Eligible providers and hospitals must track compliance with the alerts triggered by these rules. Also included in the incentive program are requirements for CPOE, the use of evidence-based order sets, e-prescribing, and patient reminders for preventive health testing. (8)

Despite these new incentives and the proven benefits of CDS, there are many challenges and barriers to the development and implementation of CDS. Low clinician demand for CDS is an important barrier to

broader CDS system adoption. Clinicians' lack of motivation to use CDS appears to be related to usability issues with the CDS intervention (e.g., speed, ease of use), its lack of integration into the clinical workflow, concerns about autonomy, and the legal and ethical ramifications of adhering to or overriding recommendations made by the CDS system. (7) Over-alerting and high rates of alert overrides have been widely acknowledged as a deterrent to CDS acceptance and appropriate use. (9-14)

Further, a number of recent studies found no improvements from CDS implementation on quality of care (15), very low magnitude improvements (16), or worse, adverse outcomes. One study reported that after a CPOE system with drug-drug and drug-allergy alerts was implemented, the mortality rate unexpectedly jumped from 2.86% prior to implementation to 6.57% post-implementation. (17) Another reported that pharmacy CDS systems perform less than optimally with respect to identifying well-known, clinically relevant interactions. (18)

A response paper by Sittig et al. examines reasons for the findings by Han et al. and discusses some of the problems with the implementation of that particular CPOE system. (19) These problems include workflow disruptions and complex transitions from manual to computer-based methods; too-short implementation periods; requiring patients to be registered in the hospital before medications could be ordered, which caused treatment delays; failure to pilot-test the system on a single unit before implementing hospital-wide; and significant and untested policy changes introduced with the CDS. Sittig et al. discuss other possible unintended consequences from CDS systems such as more or new work for clinicians; extensive system demands; and untoward changes in communication patterns and practices. These consequences can generate new types of errors and adverse outcomes.

Technologies such as CDS, when implemented, are "sociotechnical" interactions between the information technology and the provider's organization's existing social and technical systems—including their workflows, culture, and social interactions. (24, 25) As such, in a sociotechnical system 'many behaviors emerge out of the sociotechnical coupling, and the behavior of the overall system in any new situation can never be fully predicted from the individual social or technical components'. (26) It is very difficult to empirically test which social and technology factors are associated with successful implementation of CDS and other forms of health information technology (health IT). Further, Kawamoto et al. conducted a systematic review of randomized controlled trials of CDS systems and were unable to identify features critical for improving clinical practice. (2)

Clearly, there is a need for more studies and sharing of findings, lessons, and best practices on how to design and implement CDS to improve clinical care and reduce unintended consequences that can potentially cause harm to patients. This information will be particularly important as the number of organizations implementing CDS increases in order to qualify for financial incentives. These later adopters are more likely to have fewer resources than the earlier CDS adopters. This study and report on Lessons Learned in CDS implementation is one of the many ways the ACDS project is helping to advance the effective implementation and use of CDS.

Advancing Clinical Decision Support (ACDS)

As a result of the gap between CDS' potential and current use, there have been calls to advance CDS through national coordinated action and efforts to ensure that "usable and effective clinical decision support is widely used by providers and patients to improve health care." (1, 27-29)

The Office of the National Coordinator (ONC) project, Advancing Clinical Decision Support (ACDS), is timely and consistent with calls and recommendations to accelerate the successful implementation and effective use of computer-based CDS interventions, and facilitate evidence-based clinical practice and meaningful use of health IT. One of the ACDS project goals, and the purpose of this technical report, is to

organize and disseminate best practices in CDS implementation and design, based on research and the collection of evidence-based and experience-based lessons, useful practices, and components for CDS implementation across a range of CDS interventions.

Methodology for Collection of CDS Lessons and Useful Practices

In order to collect and organize important lessons, success factors, best practices (technique or methodology that, through experience and research, has proven to reliably lead to a desired result), and useful practices, the following sources and methods were employed.

Many resources were employed to conduct the research for this study. Topic areas were guided by leading CDS implementation experts and thought leaders (5, 6, 29-42), and implementation resources such as the CDS Roadmap (1), the Agency for Healthcare Research CDS Consortium (43), best practice reports, and implementation guides. (39, 40, 44) A targeted literature review followed. The research covers important activities related to CDS implementation, including CDS intervention planning, change management, workflow integration, stakeholder engagement, communication, implementation management and revision, measuring results, and sustaining the CDS. Inclusionary criteria such as strength of evidence, information gap filled, and adaptability to both inpatient and outpatient care settings aided in the selection of relevant, high quality, current, and useful materials. A related ACDS product, the *Compendium of Exemplary Practices* (45) (Appendix A), was used as a resource and is cross-referenced within this report. Lastly, a CDS implementation schema developed under the ACDS project also informed the selection of important implementation concepts for the collection of resources.

Targeted Literature Review

Many of the CDS implementation lessons and practices discussed in this report were found through a targeted review of the peer-reviewed and trade literature. The literature review was conducted using an iterative process. A search strategy, primarily based on Medical Subject Heading (MeSH) terms that best captured the literature of interest, was developed. (Appendix B). The Oregon State Health University Physician Order Entry Team (POET) bibliography was used to supplement and refine this search strategy. Just over 200 articles resulted from the literature search. After reviewing the initial results, 156 articles were determined to be relevant to CDS implementation practices. (Appendix C) These articles were organized and tagged according to important CDS implementation concepts, based in large part by the CDS implementation schema. The tagging of these articles according to the classification schema first required the derivation of tagging terms to best fit the article content. The reviewers achieved high inter-rater agreement (>90%) across all 25 tagging constructs. Over 120 of the most relevant articles were reviewed for CDS implementation lessons. Lessons, best and useful practices, and tools were extracted from the literature and organized by main implementation area/topic (e.g., stakeholder engagement, training, etc). (See Appendix B for literature search terms and strategy.)

Expert Advisory Committee (EAC) Request for Resources

The project task leads, principal investigators, and Expert Advisory Committee (EAC) were canvassed twice for CDS implementation resources such as CDS tools and best practices, as well as contacts that might provide information and resources. This yielded a few tools, but more important, led to several CDS implementation subject matter experts to contact.

Focused Discussions with Selected CDS Implementers and Other Subject Matter Experts

The subtask team held informative discussions with subject matter experts to identify important CDS implementation lessons, resources, tools, and contacts to supplement what was captured in the review of

existing literature (Table 1). The topics covered in these discussions varied by the subject matter expert's experiences and organizational setting (i.e., practice type). The discussions were held between September 9 and December 2, 2010

Table 1. CDS Implementation Subject Matter Experts Contacted for CDS Implementation Lessons

Implementer/ Subject Matter Expert	Title	Name of Practice	Location	Type of Practice	CDS Implementation Lesson Topic
Dan Degnan, PharmD	Medication Safety Officer	Community Health Network	Indianapolis, IN	Health Network (local)	Pharmacist use of CDS
Gordon Schiff, MD	Associate Director of the Brigham Ctr for Patient Safety Research and Practice	Brigham and Women's Hospital	Boston, MA	Large Academic Medical Center	Inpatient use of CDS; other contacts
Wilson Pace, MD	Director, AAFP's National Research Network	American Academy of Family Physicians	Denver, CO	Small/ Medium Outpatient	Small practice use of CDS
Thomas Payne, MD	Medical Director of Information Technology Services	University of Washington Medical Center	Seattle, WA	Large Academic Medical Center	CDS Challenges; Governance; Committees, Knowledge Management
William Galanter, MD	Medical Director, Clinical Information Services; Chair, CDS Committee	University of Illinois Medical Center	Chicago, IL	Large Academic Medical Center	CDS in Academic Medical Centers
Robert Eidus, MD	Practicing Physician	Cranford Family Practice	Cranford, NJ	Solo Outpatient	Solo practitioner use of CDS
Mary Wisniewski, RN	Assistant Director, Department of Quality & Regulatory Affairs	Stroger-Cook County Hospital	Chicago, IL	Large Inpatient Community-Public Hospital	Nursing role in CDS
Robert White, MD	Chief Medical Information Officer	OSF HealthCare	Peoria, IL	Health Network (local)	Academic Medical Center CMIO Champion

Table 1. CDS Implementation Subject Matter Experts Contacted for CDS Implementation Lessons (continued)

Implementer/ Subject Matter Expert	Title	Name of Practice	Location	Type of Practice	CDS Implementation Lesson Topic
Christine Sinsky, MD	Practicing Physician; Member, EMR Committee	Medical Associates Clinic	Dubuque, IA	Small/ Medium Outpatient	Clinical Acceptance, Workflow
Loran Hauck, MD	Chief Medical Officer; Senior VP, Clinical Effectiveness	Adventist Health System	Orlando, FL	Health Network (national)	CDS Championship in Integrated Delivery System
David Bauer, MD	Family Medicine Residency Program Director	Physician Associates at Sugar Creek (Memorial Hermann)	Sugar Land, TX	Small/ Medium Outpatient	CDS Champions and Buy-in in Outpatient Settings
LuAnn Kimker	Principle Consultant	Arcadia Solutions	Burlington, MA	Health IT Consultant	Small practice implementation issues/barriers
Stephen Tingley, MD	Practicing Physician	Mt. Nittanny Medical Center	State College, PA	Medium Inpatient Community	CMIO as champion perspectives
Jon White, MD	Health IT Director	AHRQ	Rockville, MD	Government Agency	AHRQ funded CDS grantees experiences
Neil Calman, MD	President/ CEO of Institute for Family Health	The Institute for Family Health	New York, NY	Ambulatory Health Network (local)	Community Health Centers, setting CDS priorities
Neil Rawlins, MD	Chief Medical Information Officer	Kaldec Clinic	Richland, WA	Small/ Medium Outpatient	Ambulatory care, group practice use of CDS
Clayton Curtis, MD	Chief Information Systems Architect	VA Boston HealthCare System	Boston, MA	Health Network (national)	Veterans' Health Administration CDS functionality, support/training
Lynn Nemeth, PhD, RN	Professor, School of Nursing	Medical University of South Carolina	Charleston, SC	Medium Outpatient	Nursing, outpatient standing orders for preventive and primary care

Collecting CDS Implementation Resources and Lessons

Generally, the lessons learned were gathered for a range of CDS types (46). These include the following:

1. Documentation forms/templates (e.g., clinical documentation forms, flowsheets, assessment forms);

2. Relevant data presentations (e.g., relevant data for ordering, administration, or documentation);

3. Order/prescription creation facilitators (e.g., order sets, tools for complex ordering);

4. Protocol/pathway support (e.g., stepwise processing of multi-step protocol or guideline);

5. Reference information and guidance (e.g., link from EMR to reference information); and

6. Alerts and reminders (typically unsolicited).

Where the lesson is specific to a type of CDS, it is indicated. The most common types of CDS used and the resulting lessons were for alerts, reminders, and order sets. Most providers in the sources used employed more than one type of CDS, and the lessons were typically generalized across the types of CDS.

The search for and collection of resources providing lessons, best or useful practices, guides and tools also yielded the following key resources:

1. CDS Implementers' Guide

The 2005, 2009, and 2011 CDS Implementers Guides (39, 40, 47) are the definitive sources of CDS implementation guidance, representing the contribution of a team of CDS implementers and other experts who wrote the Guide, which included a large number of tools and case studies. The guides are owned and distributed by the Healthcare Information and Management Systems Society (HIMSS) and provide a wealth of lessons and tools to progressively support CDS implementation. However, because this material is proprietary, the Guide and tools within can be listed and described as an implementation resource, but not included as part of the collection of resources to be delivered to ONC under this project.

2. E-Prescribing Toolkit

The AHRQ-supported toolset for e-prescribing implementation (48) provides practices with knowledge and resources to successfully implement e-prescribing and associated forms of decision support (e.g., drug interaction checking) was obtained. This toolset is currently a pilot version and not publicly available.

3. CDS New Request Form

A form to submit requests from hospital clinicians to add new or revised rules and alerts was obtained. The form requires the requestor to think through and document the new CDS purpose, workflow insertion point, logic, triggers, rationale, guideline or evidence base, and other information.

4. **Sample Alert Logic**

   A sample flowchart for CDS rules, including a recently implemented rule set for clinical alerts related to inpatient pandemic (H1N1) vaccine rule was shared.

5. **CDS Committee Cross-Fertilization Structure**

   The composition of a hospital's CDS Governance and Committee structure was obtained from a large academic medical center.

Lessons in CDS Implementation

Level of Evidence

As indicated above, the evidence for the content in this report was drawn from a literature review and discussions with implementers and subject matter experts. Successful implementation is a complex combination of art and science. As a result, the great majority of recommendations, lessons learned, and useful practices are based on mostly anecdotal and not empirical assessments by the literature authors or subject matter experts.

Empirical studies of CDS interventions often address the impact of a particular intervention on patient outcomes. In many cases, literature authors described implementation lessons learned that they understood to be helpful to achieving a significant improvement in a given quality measure. A paper by Sobieraj et al. provides an example of this type of resource. (49) Although there is often a correlation between the success of an intervention and a successful implementation, the multiplicity of factors involved in implementing CDS make it difficult to empirically correlate any single factor (e.g., hours spent training on a clinical reminder system) to a successful outcome (e.g., increased compliance for HbA1c screening).

The level of evidence within the provided recommendations ranges from anecdotal word-of-mouth (Table 1) to systematic reviews and surveys of implementation factors. Of note, many lessons were pulled from literature compiled by the POET Team. (30, 32-34, 42, 50-52). The multi-year project surveyed multiple sites about the implementation of CPOE and CDS. Systematic reviews also provided the team with robust evidence. (2, 4, 4)

The lessons learned and useful practices provided in the chapters below draw from the types of evidence described above. The means by which a reader will evaluate a given source can depend on many factors. The level or strength of evidence may be one such criterion. In evaluating these lessons learned and useful practices, implementers should ask themselves: Can this lesson be of practical use in implementing CDS for my organization?

Explanation of Report Structure

This report is organized into chapters, each pertaining to important steps or considerations to successful CDS Implementation. Each chapter provides:

Essential Principles. An overview of the essential principles of the given step or consideration, which describes why this implementation area is important to success. The essential principles are sufficiently high level that they can apply to the implementation of a single intervention or the rollout of a new system. These essential principles were also crafted to apply to any practice setting.

Contextual Considerations. General and specific contextual considerations, based on CDS implementation schema, literature, and expert opinion, can affect the way these lessons are applied or adapted. These contextual considerations include practice setting, size, specialty focus, and geographic location. For example, while there are general lessons around engaging clinical champions, champions in a large medical center will be different from those in a group practice. Where they are applicable, considerations or suggestions specific to different factors (usually practice setting or size) are provided.

Useful Practices and Lessons Learned. These are the lessons derived from the literature, exemplary practices, and discussions with subject matter experts, organized into main lesson themes and specific examples below. Most of these lessons are based on implementation experience and expert opinion, not empirical studies which test and validate these lessons. Where there is empirical evidence, this is noted in the discussion. If it applies, the setting from which a lesson or useful practice was derived is noted. Although this lesson may be particularly helpful to the setting indicated, it does not mean that it will not be useful for other settings as well.

Most of the lessons have a citation from the literature. Where there is no citation, the lesson comes from the authors themselves or is the synthesis of a common lesson found in the literature.

Applicable Exemplary Practices. Where exemplary practices had lessons that applied to the lesson chapter, they were referenced with a short description of how they applied the lesson. The full description of the practices cited in the text is included in Appendix A. Other listed practices, not cited within the text, can be found in *The Compendium of Exemplary Practices*. (45)

Other Resources. Point to related studies that applied the lesson or learned the lesson through their experiences. Often, these studies focus on systems related to CDS, such as EHRs and order entry.

The chapters are ordered to reflect progressive phases or steps towards implementing and maintaining a CDS system or intervention. While this approach is helpful for purposes of organization and presentation, the reality is that many of these steps must be constantly considered. In most cases, these steps are cyclical. Within each chapter, the reader will notice that preceding and succeeding chapters are often referenced. The steps or phases covered include the following:

I. Involve Stakeholders and Communicate Goals
II. Assess Readiness for Implementation
III. Assemble the CDS Implementation Team
IV. Select Effective Clinical Leaders and Champions
V. Achieve Clinician Buy-In and Support
VI. Integrate CDS into Workflow
VII. Plan for Successful Rollout
VIII. Train and Support
IX. Monitor and Evaluate CDS's Clinical Impact
X. Knowledge Management

I. Involve Stakeholders and Communicate Goals

Essential Principles: CDS implementation is a systemwide change, and as such, a range of stakeholders' perspectives should be taken into account. Collaboration and communication are the glue that holds a successful CDS implementation in place. Implementation is an ongoing and iterative process. Stakeholders, objectives, clinical knowledge, and technology may change, and a strong communication strategy can help an organization manage change more effectively.

Determining the type of collaboration and communication requires understanding who will be affected by the intervention and what their role will be. (46)(40)(32) This may require mapping workflows (see Ch. VI) to understand each stakeholder's role in clinical processes affected by CDS and also building relationships to understand who will be essential to the implementation team (Ch. III). If possible, every stakeholder should be given the opportunity to weigh in on the goals of the organization and how a CDS intervention might impact him or her. All affected stakeholders should agree upon these goals. No one should feel as though a change is being forced upon him or her without his or her input—this is where communication is imperative.

It is important to recognize how the motivating factors might influence the implementation and acceptance of an intervention or a system. Agreeing and collaborating on specific goals will be easier if these motivations are recognized. There are many different motivators to adopt CDS. Both external and internal factors may push adoption of a CDS system of intervention. (40) Below are some examples of both external and internal motivating factors.

External Motivators: Meaningful Use, Pay-for-Performance, Quality Measures Reporting.

Internal Motivators: Clinical Quality or Safety Goals, Workflow Efficiencies, or other stakeholder uses for CDS interventions.

Contextual Considerations: The goals of CDS implementation may range from implementing a single intervention to improve selected quality areas, to implementing an entirely new CDS system with multiple alerts and reminders. Part of finding agreement in these objectives means understanding the goals of the different stakeholders. The size, structure, leadership, and other aspects of organizational culture can impact communication with stakeholders.

Large Hospital or Health Network: The size of the organization or geographical distance between stakeholders may be a barrier to effective communication and collaboration.

Community Hospital: Successful implementation in community hospitals may depend less on mandating use, which is a common strategy in teaching hospitals that have house officers, and more on the existence and development of an organizational culture of collaboration and trust.

USEFUL PRACTICES and LESSONS LEARNED

Engage essential stakeholders.

- "Meet with key local committees, positions, and individuals engaged in activities pertinent to an organizational CDS initiative, and document their potential goals and objectives for the CDS program." (40)
- Those impacted by the planned interventions should be supporting and championing the intervention. (40)

- "It is essential to engage resistors and detractors in active dialogue—they can be a critical source of feedback about the program and play an important role in its success or failure." (40)

Start by agreeing on goals and clinical objectives for the CDS intervention.

- "Synthesize and validate a unified working list of organizational goals and objectives for your CDS program. Break down each high-level goal into a set of more specific clinical goals, and then break down each clinical goal into measurable clinical objectives. Define baseline and target performance pertinent to each objective." (40) It is most helpful if a clear and compelling clinical problem is recognized within the organization (e.g., patients with hyperkalemia are receiving supplemental potassium leading to complications from excessive potassium.)

- Approach CDS deployment with the "End in Mind"; make the case with stakeholders by focusing on the desired benefits and outcomes from CDS adoption. Implementation should be a culmination of the groundwork laid by excellent planning, communication, and processes. (52, 53)

- "When forced to adopt CDS by external mandate in the absence of common goals, users may actively resist the technology, misuse it, or otherwise not utilize it in the manner intended by its designers. Thus, the gains realized from technology use are likely to be minimal." (54)

Workflow analysis is a critical consideration in implementation (Ch. VI).

- Workflow analyses should identify all impacted processes and people. This is often not obvious until thoughtful analysis of the CDS workflow is undertaken. (55)

- Workflow analyses need to identify both the formal, official workflow, and any mismatches in actual practice such as common work-arounds. The best CDS tool for a workflow that exists only on paper will remain unused by clinicians.

- Workflow implications for different stakeholders need to be considered and addressed in advance of formal implementation—are users following designed workflows and are they comfortable with them and the functionalities that would be impacted by the intervention (e.g., medication reconciliation)? (47)

Facilitate communication within and across health system settings.

- The implementation efforts could be centralized and coordinated across affiliated hospitals, with members from each hospital within the network being represented on the implementation team. This permits the voices of each hospital to be heard, but the overarching QI goals and standardization requirements of the network are achieved. It also promotes local buy-in when representatives can become local champions in later phases of implementation. This strategy works best when each hospital has similar QI/QA goals or the administrative leadership is strong. This centralized approach is also necessary when the Clinical Information System (CIS) and EMR support are extensively shared within the network (56) **Setting: Large Hospital**

- With a strong network culture, centralize implementation with representation from each hospital to achieve a greater standard of care or when using with a centralized CIS.

- In networks where it is especially difficult to facilitate face-to-face or phone conversation, online portals or other methods for collaborative document sharing and commenting have been used to garner stakeholder input. These have the advantage of being asynchronous which allows the user to provide input at their convenience. This is also a disadvantage because there are times when a conversation is more fruitful and feedback is often limited. Networks that have implemented online portals often couple them with occasional phone conversations. These portals are also often used to suggest, vet, or create order sets. (42, 57)

- Cross-pollinating relevant committees can facilitate communication and collaboration. At the University of Illinois Medical Center (Appendix A), it has become a useful practice to have members of the Pharmacy and Therapeutics Committee sit on the CDS Committee. (58) **Setting: Large Hospital**

APPLICABLE EXEMPLARY PRACTICES

Regional/National Health Systems/Networks: Adventist Health System

Adventist will have achieved 100 percent compliance with Meaningful Use criteria. The applicable lessons are their early engagement of stakeholders and online collaboration for CDS vetting.

Inpatient, Academic Medical Center: University of Illinois Medical Center

University of Illinois' organizational structure has been a vital part of the success of its CDS program.

Inpatient, Community Hospitals: Wishard Memorial Hospital

Wishard has found the exchange of ideas outside of the own organization important to the successful use of CDS.

OTHER RESOURCES

Agarwal R, Angst CM, DesRoches CM, Fischer MA. Technological viewpoints (frames) about electronic prescribing in physician practices. J Am Med Inform Assoc. 2010 Jul-Aug;17(4):425-31.

The article categorizes physicians viewpoints of electronic prescribing (eRx). Via physician interviews, the article emphasizes physician viewpoint and involvement in the implementation process.

Ash JS, Fournier L, Stavri PZ, Dykstra R. Principles for a successful computerized physician order entry implementation. AMIA Annu Symp Proc. 2003:36-40.

Ash provides an assessment of the essential principles for effective CPOE implementation. Due to their high level, many of these principles including the section on collaboration can applied to the implementation of CDS.

Degnan D, Merryfield D, Hultgren S. Reaching out to clinicians: Implementation of a computerized alert system. J Healthc Qual. 2004 Nov-Dec;26(6):26-30.

The case study provides a description of the implementation of a CDS system within a local health network.

Harrison MI, Koppel R, Bar-Lev S. Unintended consequences of information technologies in health care--an interactive sociotechnical analysis. J Am Med Inform Assoc. 2007 Sep-Oct;14(5):542-9.

The article uses a conceptual model called the Interactive Sociotechnical Analysis (ISTA) to frame unintended consequences. The authors suggest that although many of the problems associated with health information technology (health IT) implementation derive from technical and design factors, sociotechnical factors play a larger role than generally anticipated.

Jenders RA, Osheroff JA, Sittig DF, Pifer EA, Teich JM. Recommendations for clinical decision support deployment: Synthesis of a roundtable of medical directors of information systems. AMIA Annu Symp Proc. 2007:359-63.

This article is based on a roundtable discussion of CMIOs. It provides practical advice for CDS implementation and highlights the importance of communication and consensus for successful deployment.

Lorenzi NM, Novak LL, Weiss JB, Gadd CS, Unertl KM. Crossing the implementation chasm: A proposal for bold action. J Am Med Inform Assoc. 2008 May-Jun;15(3):290-6.

Lorenzi et al. suggest having a shared audacious goal as a success factor for implementation. An important part of selecting this goal is to understand the context within the practice setting.

Sobieraj DM. Development and implementation of a program to assess medical patients' need for venous thromboembolism prophylaxis. Am J Health Syst Pharm. 2008 Sep 15;65(18):1755-60.

The case study describes the implementation of a VTE Prophylaxis CDS program. The description of the implementation includes collaboration between stakeholders and suggested useful practices. The implementation took place in a large, urban, inpatient setting.

II. Assess Readiness for Implementation

Essential Principles: A readiness assessment is vital to the success of the implementation of a CDS system or intervention because it provides information about the degree to which the organization can adapt to change. A well-executed readiness assessment can provide an understanding of the organizational culture and the viewpoints of end-users and other stakeholders. Importantly, assessment of these factors will point to weak areas that must be addressed. Routinely considering these principles and gaps will help to ensure a meaningful intervention. A formal assessment can also help to understand where each stakeholder stands in regard to the change. (39)

Some factors to be considered while assessing readiness (59):

- *Medical staff experience with existing clinical systems and information technology*

  It is important to recognize the barriers presented by working with current or planned technology. Some clinicians may be using clinical documentation or CPOE at substandard levels, and additional CDS could exacerbate these issues. Once identified, these barriers can be addressed through additional trainings or technical support.

- *Opinions regarding a desirable "future state" for clinical system usage*

  Part of collaborating with stakeholders means coming to a consensus about the desired outcomes of the intervention(s). It is important to reach out to the end-users to discover how they might see a new system being beneficial or detrimental to themselves or the organization as a whole.

- *The characteristics of optimal workflows to support efficient, safe, and cost-effective patient care*

  Knowing the desired workflow for the CDS intervention is an important step in a successful implementation (Ch. VI). The use of CDS may require adjustments to workflow. Any new workflow must fit within the reality of an organization's existing culture and processes, not on wishful thinking about how is it imagined or specified on paper to supposedly or ideally be functioning.

- *Perceptions and experiences with barriers to achieving change and physician buy-in in the organization*

  Understanding an organization's culture and past history surrounding change is an important factor to consider. If psychological barriers to change are identified, it is important to acknowledge the issue and try to alleviate fears.

Contextual Considerations: Factors determining readiness mirror the considerations for facilitating communication. The degree to which a CDS implementer can understand the varying viewpoints and gauge the organizational structures depends on how well the affected organization can be canvassed. The size of the organization and the available resources may affect the robustness of a readiness assessment.

USEFUL PRACTICES and LESSONS LEARNED

Gauge Stakeholder Viewpoints and Acceptance

- Get input from many stakeholders who will be affected by the CDS. Expose a wider spectrum of users to the new intervention(s) prelaunch than might have been engaged at earlier stages; listen carefully to their feedback and its implications for the workflow and other changes that will be needed after launch. (39)

- Determine the extent to which end-users buy-in (Ch. V) to achieving the targets on which the CDS interventions are focused. (39)

- Several tools are useful in setting expectations and assessing institutional readiness. Tools to gather firsthand experiences, such as surveys, interviews, and structured focus groups, form the core of the information capture. (59)

- Some important dimensions to be captured by readiness tools are whether there are specific goals linked to the CDS, previous experience with implementing health information technology, or resources available to support the CDS implementation. Are there sufficient internal and external IT staff to successfully implement and provide technical support? Are there champions and leaders for the CDS? Are practice members committed to a successful CDS implementation? (48)

Take Necessary Actions to Achieve Readiness

- If the assessment reveals lack of readiness, it is advisable to postpone the CDS implementation and work on areas where readiness is lacking. (48)

- If there is initial user resistance to change due to new job roles and definitions, retraining may be required, which may incur costs. (54)

- It may be necessary to spend time building expertise at accomplishing and sustaining change. (60)

OTHER RESOURCES

Agarwal R, Angst CM, DesRoches CM, Fischer MA. Technological viewpoints (frames) about electronic prescribing in physician practices. J Am Med Inform Assoc. 2010 Jul-Aug;17(4):425-31.

The "frames" described in the article categorize the different viewpoints of end-users (e.g., system as efficiency and effectiveness tools, system as necessary evil, system as core to clinical workflow, etc.). The author found framing perspectives helpful to understanding readiness.

Dubenske LL, Chih MY, Dinauer S, Gustafson DH, Cleary JF. Development and implementation of a clinician reporting system for advanced stage cancer: Initial lessons learned. J Am Med Inform Assoc. 2008 Sep-Oct;15(5):679-86.

This case study describes how an academic medical center (University of Wisconsin) implemented a clinical reporting system. The readiness was first assessed by considering seven categories: organizational environment; organizational motivation; technology usefulness; promotion; implementation process; department-technology fit; and key personnel awareness and support.

Harrison MI, Koppel R, Bar-Lev S. Unintended consequences of information technologies in health care--an interactive sociotechnical analysis. J Am Med Inform Assoc. 2007 Sep-Oct;14(5):542-9.

Within the discussion of unintended consequences and their solutions, the authors discuss some of the possible impacts of health IT on workflow and the user. These assessments may be helpful to considering readiness.

Stablein D, Welebob E, Johnson E, Metzger J, Burgess R, Classen DC. Understanding hospital readiness for computerized physician order entry. Jt Comm J Qual Saf. 2003 Jul;29(7):336-44.

This paper provides an extensive look at many of the characteristics of understanding readiness for CPOE. The factors mentioned are high-level enough that they apply to implementation of HIT in general.

Williams RB. Successful computerized physician order entry system implementation. Tools to support physician-driven design and adoption. Healthc Leadersh Manag Rep. 2002 Oct;10(10):1-13.

Apart from also providing steps to readiness, within the article Williams provides tools and surveys related to creating a physician-driven system. Some of these tools are specific to CDS. Large hospitals or health networks may also find his assessments of the organization structures helpful.

III. Assemble the CDS Implementation Team

Essential Principles: Making sure that goals are agreed upon, lines of communication are open (Ch. II), and that a readiness assessment (Ch. III) has been done, are essential to assembling a CDS implementation team composed of clinicians, information technologists, managers, and evaluators to work together to develop, customize and implement the CDS. It is important to understand what support is needed and who is available to provide that support. Selecting this team must be about the role, but also the type of person who fills that role. Stakeholders dedicated to the objectives of an intervention, but flexible enough to consider and implement feedback, can be valuable members of the team. Stakeholders who are held in high regard by the end-users may be particularly helpful to achieving buy-in (Ch. V). (34)

This team must help to align all other stakeholders with the objectives of the intervention. They must be dedicated to managing the rollout (Ch. VII) and the training (Ch. VIII) as well as handling feedback (Ch. IX) and knowledge management (Ch. X). They can be influential in facilitating open communication between themselves and other end-users (Ch. I). Collectively, the team should possess the following knowledge and qualities:

- Understand the workflows and attitudes of the end-users and others affected by the CDS intervention;
- Understand how to adapt the technology as much as able (either by ideally utilizing "out of the box" vendor products, adapting vendor products, or writing in-house rules);
- Have the right degree of flexibility to adapt well, but not lose sight of the objective.

Contextual Considerations: At a high-level, determination of the size and members of the implementation team depends on two key factors: the size of the organization and the robustness of the CDS program. Organizations have found that as the number and complexity of interventions increase, the need for leadership does as well (El Camino, Appendix A). While all role responsibilities listed in the "Useful Practices and Lessons Learned" section likely apply to each setting, the stakeholder's title may vary. Smaller settings may combine multiple roles, while larger settings may find that certain roles can be broken down further across multiple professionals.

USEFUL PRACTICES and LESSONS LEARNED

Understand the stakeholder roles required for successful implementation.

- There are many different roles that must be played in a successful implementation. A possible list of pertinent roles with a description of each is provided below. (23, 34, 36, 37, 39, 40, 46)
  - *Implementation Manager:* The implementation manager is responsible for assigning ownership and tracking completion of the all implementation tasks. This person will report back to the team on how the project is progressing, what challenges have been overcome, and what challenges lie ahead. The team can then plan how to best address those challenges as a whole.
  - *Chief Executive Officer*: At the level of administrative leadership, the CEO is important to providing both vision and support. Ideally he or she must connect well with the staff and take feedback into account in his or her leadership. (34)

- *Chief Medical Information Officer (CMIO)*: At a high level, the CMIO bridges the gap between the clinical and administrative considerations of implementation. A CMIO is often responsible for selecting clinical champions and in some cases may act as a clinical champion. A CMIO helps to translate the vision of the administration to the clinicians. (34)

- *Pharmacy Director* (40): With the pharmacy's role in medication safety, it is necessary for the director or another representative to be closely involved with the implementation. Drug-drug interaction and Drug-allergy (DDI/DA) alerts can be a large source for frustration for both pharmacists and physicians. The pharmacy perspective is a necessary one.

- *VP/Director(s) of Nursing* (40)*:* Although the amount of direct interaction nurses have with CDS varies from setting to setting, their workflow is often affected by many different types of CDS interventions.

- *IT/Informatics Leadership:* A stakeholder who understands the technical limitations of the proposed intervention(s) plays an important role in the implementation of CDS systems. A general knowledge of the clinical information systems, the hardware, and the software might also help to understand the impact a new intervention might have on these systems—and ultimately on workflow.

- *Quality Officer* (40)*:* The quality officer may take a significant role in helping to align CDS with clinical objectives. Implementing CDS based on specific clinical need has been found to be a successful method of selecting specific interventions. (28, 29)

- *Clinical Champion(s)*: The clinical champion is perhaps one of the most significant and important roles in the implementation of CDS. These are individuals who help to fight for the cause and help to rally support for CDS. They may also act as a messenger to the administration to suggest changes in the system or to workflow. The ideal clinical champion is respected as a clinician, but also has substantial knowledge in the field of informatics. The process of selecting clinical leaders and champions will be described in greater detail in the next chapter (Ch. IV).

- *Super-User(s)*: Super-users are those who have become adept at using the new system or interventions. They can assist others who are having difficulty, and like clinical champions, they may help to garner support.

- *Clinical Curmudgeon(s)*: As important as the clinical champion, it is often helpful to involve a clinician who might have misgivings about implementing the new system or intervention. According to Ash et al., these stakeholders can provide useful input and they may turn into the most vocal supporters. Convincing these stakeholders can be key to a successful implementation. (34)

- *Legal Counsel (39)(31):* There will be liability questions and considerations regarding CDS deployment. For example, what if the CDS causes harm to patients? Will alert triggers, messages delivered, and user responses become part of the legal record? Engaging legal counsel early in the CDS project is advised. (39)

- *Patient/Patient Representative* (40) : Although most of the literature concerning CDS Implementation is physician-centric, most systems affect the patient in some way. In

certain circumstances, CDS could detract from the physician-patient interaction. (61) A patient or patient representative might be more cognizant of such potential detractions. In other cases, patients themselves may be the end-users of CDS.

- In the Department of Veterans Affair (VA), a stakeholder role for a person called a "clinical application coordinator"(CAC) was found to be particularly helpful. CACs were dedicated to bridging the gap in between the clinicians and the IT staff. They played the role of dedicated clinical champion/super-user. This stakeholder must be savvy, understand workflow, and be able to bring CDS to the real-world environment. (62) A person functioning in this role can be particularly helpful when a clinical champion or a super-user cannot devote enough of his or her time to fill the need. This person need not be a physician provided he or she has sufficient training to understand both the clinical and informatics complexities. Smaller hospitals may find the finances of hiring this sort of personnel to be a barrier. Ultimately one must be cognizant of the amount of time each sort of stakeholder can devote to his or her respective roles.

Collaborate with outside sources to fill gaps in the implementation team.

- The stakeholders capable of playing these roles might not always be within the practice settings. Although roles like clinical champion, CMIO, and super-users are essential to implementation, vendor user groups and independent consortiums (e.g., Clinical Quality Improvement Consortium) may help to vet and collaborate on order sets and other content (Physician Associates at Sugar Creek [Appendix A]). (63, 64) As discussed throughout this report, no one should have to reinvent the wheel. Reaching out to other organizations or users in similar situations can be invaluable to an organization's success.

APPLICABLE EXEMPLARY PRACTICES

Outpatient, Multispecialty: Physician Associates at Sugar Creek

Sugar Creek belongs to the Clinical Quality Improvement Consortium (CQIC). It has found this a valuable tool in the implementation of CDS.

Inpatient, Academic Medical Center: Department of Veterans Affair (VA) Puget Sound

The VA employs Clinical Application Coordinators who help to bridge the gap between the clinical environment and the implementers.

OTHER RESOURCES

Ash JS, Stavri PZ, Dykstra R, Fournier L. Implementing computerized physician order entry: The importance of special people. Int J Med Inform. 2003 Mar;69(2-3):235-50.

Based on studying three sites (UVA, El Camino, & VA-Puget Sound), Ash et al. provide a description of the types of stakeholders necessary for successful implementation: "Special people were high-level leaders, non-physician clinicians who assisted with the implementation or physicians who played a special role during implementation. Their roles spanned disciplines from administration to information technology to the clinical realm. Because they lived in more than one world and knew the vocabulary of each, they could interpret from one to the other." (p. 240)

Downing GJ, Boyle SN, Brinner KM, Osheroff JA. Information management to enable personalized medicine: Stakeholder roles in building clinical decision support. BMC Med Inform Decis Mak. 2009 Oct 8;9:44.

This article addresses the roles of higher level stakeholders. The article describes the current and potential roles of the government, research institutions, and multi-sector collaborations in the implementation of CDS. Understanding the role of these high-level stakeholders will be helpful to understanding what assistance is available and where the future of field may be headed.

Jenders RA, Osheroff JA, Sittig DF, Pifer EA, Teich JM. Recommendations for clinical decision support deployment: Synthesis of a roundtable of medical directors of information systems. AMIA Annu Symp Proc. 2007:359-63.

Among their many recommendations, Jenders et al. provides a recommendation for encouraging relevant stakeholders to participate: "Organizations reported a variety of mechanisms for encouraging participation in the CDS governance structure. Most organizations pay clinicians to participate in a CDS committee or other governance organization. Of those organizations that do not pay for such participation, non-monetary compensation typically is provided, sometimes by explicit recognition of service as part of the promotion process or by reduction in required clinical practice volume." (p. 361)

Stablein D, Welebob E, Johnson E, Metzger J, Burgess R, Classen DC. Understanding hospital readiness for computerized physician order entry. Jt Comm J Qual Saf. 2003 Jul;29(7):336-44.

As a part of addressing readiness, Stablein et al., address the types of stakeholders necessary for a successful implementation: "Leadership from medical, nursing, and pharmacy is necessary for successful implementation. Making sure all the right people are in place before implementation is critical, or else significant time and money may be dedicated to hiring or outsourcing." (p. 340)

Stevenson KB, Barbera J, Moore JW, Samore MH, Houck P. Understanding keys to successful implementation of electronic decision support in rural hospitals: Analysis of a pilot study for antimicrobial prescribing. Am J Med Qual. 2005 Nov-Dec;20(6):313-8.

Stevenson et al. studied the implementation of antimicrobial decision support tool within five rural hospitals in Idaho. In one of the hospitals, a nurse who was a member of the anti-microbial team, was also director for quality improvement. She had a good relationship with the physicians to whom she reported; the authors suggest this relationship played a role in the particular success of this hospital. (p. 317)

IV. Select Effective Clinical Leaders and Champions

Essential Principles: The CDS implementation clinical champions, usually physician champions (PCs), play a very important role in all organizational sizes and types. The PC helps to "lead the charge" and acts as the "Change Agent" for the CDS intervention, and as the liaison between the end-users and the technical staff. In fact, leadership is widely considered as important as the quality of the technology. (36)

Desired Characteristics of the Champions and Leaders

The champion is usually not a "technical person," but should have a basic understanding of the capabilities and limitations of the system. He or she should also understand the health care environment and be able to identify and understand the goals and priorities of the organization. The most important skill of the PC is to be an effective communicator. The PC should also be clinically active—this will contribute to credibility with the targets of the intervention. Often it is desirable for the PC to have other leadership roles or traits and/or experience in quality improvement activities. The specialty of the PC is less important than having some form of rapport with the target audience. (39, 40)

Clinical leaders and champions may include the chief medical officer and, in academic centers, the department chairs, for support similar to that given at the higher levels. Clinical leaders also include those whose leadership extends to information technology. Opinion leaders, who are respected clinical experts, are also critical. In addition, talented people who speak the languages of both medicine and technology are essential, and there need to be enough of them. These are the staff members who can train, support, and make changes in the system. (30)

Contextual Considerations:

Large Inpatient Hospital: Hospital-employed hospitalists may be able to serve as facilitators of CDS adoption.

Outpatient: Don't limit champions to practice managers; consider ancillary staff.

USEFUL PRACTICES and LESSONS LEARNED

Identify and cultivate champions.

- "Look for champions among formal governance and management leadership, but also consider other opinion leaders in the organization to whom others will listen. This latter group can exert substantial influence over the collective attitude of an organization toward the CDS strategies and tactics. These people may include leading clinicians, others who may have achieved recognition for their work, and prominent patient advocates." (40)
- Successful sites put resources into identifying and sometimes even hiring physicians and other health professionals to socialize the idea of CDS throughout the organization. (30)
- Seek the following characteristics of effective clinical champions, individuals who can:
    - Hold steadfast, and help remind the general users of the downstream CDS benefits, encouraging them to see beyond their immediate frustrations;
    - Influence peers;

- Understand other physicians;
- Act as opinion leaders;
- Provide a balanced view;
- Furnish leadership;
- Employ political skills;
- Occupy both leadership and support positions (33); and
- Are well-respected. (34, 36, 43)

- Clinical opinion leaders must also be convinced and confident that the CDS applies well to their own patient population. One VA center recruited several physicians to assist with review of its guideline implementation in its decision support system (DSS) called ATHENA DSS. In addition to the physician-administrators, one of whom was also the medical center's overall guideline implementation leader, the center recruited the supervisor of the general medical clinics at the Palo Alto site and the primary care chief resident as physician-monitors. The center shared the knowledge rules used in ATHENA DSS, gave the recruits individual training sessions in use of the system, activated the system at the clinics, and encouraged them to comment directly and to use the feedback features built into ATHENA DSS. (24)

- Another hospital official noted how it was important that hospital leaders had to be firm believers in the benefits of CPOE with CDS and had to visibly demonstrate a commitment to the implementation project. They needed to be facile at managing changes that inevitably came with implementation. They also had to feel empowered to mandate use within the hospital. Some managers led by example and were among the first to adopt the new system. (36)

- In smaller organizations, especially private practices, it is important to not limit champions to the clinician-owners of the practice. The multiple roles of the clinician-owner may lead to the staff accepting a system that fits the practice poorly because "that's what the boss wanted." Successful practices often recruit champions to represent the ancillary staff and other office staff members. Some practices even instruct staff members to voice their thoughts without regards to what the clinician-owners might prefer. (Valdez Family Clinic—Appendix A)

Champions should have considerable involvement early in the development of a program or intervention; their concerns should be heard and addressed attentively.

- One CEO, when asked how he would do it differently next time, replied ''I would get the clinical champions in place earlier.'' (34)

- One type of a champion is a clinical guideline champion who fosters greater acceptance of guideline applicability. One VA Medical Center champion facilitated communication between physicians and nurses, and used educational programs and Grand Rounds presentations to implement guidelines. (65)

Champions are necessary throughout all stages of the implementation and often at multiple levels in the organization.

- Successful CDS implementations require effective leadership over extended time periods—in different forms and at multiple levels in the organization. (34)

Ensure that the champions have time and other resources to fulfill this role.

- Ensure that the PC and other clinical champions and leaders have the dedicated time to be successful—time to work with the technical team, time to communicate the impending intervention to the end-users, and time to refine the intervention after implementation. (40)

- The VA has created an important champion role in each VA Medical Center—the Clinical Application Coordinator (CAC). The CAC is usually a clinician who understands workflow and can be a bridge between the clinical environment and implementers. (66)

- When implementing a CPOE system, Loyola University engaged two clinically active physicians to lead the project on a day-to-day basis, with the commitment of financial resources to ensure that the physicians devoted sufficient time to the project. (67)

- Multidisciplinary collaboration and trust between administration and clinicians are necessary conditions. (33) PCs can support the formation of a trusting relationship and help overcome predictable tensions between administrators, IT staff, and clinical staff.

- In a study of five hospitals, all sites appointed people with clinical backgrounds to lead the move to computerization. Financial and human resources were committed over several years at a time with overt recognition that it would take a number of years to reap any benefits. (36)

Effective champions often provide help at the elbow.

- All of the successful sites studies by a team of researchers had help available during implementation all day every day. All continue to have valued assistance easily available. ‘‘We had to track and we knew exactly who these people were that weren’t using the system and we sat down and helped them make their own personal order sets and we just sat down and held their hand.’’(34)

- Sometimes the champions were recruited to help with training on a one-on-one basis: “if you were unsure of what to do, a doctor would sit next to you and you weren’t made to feel that you were incompetent. There was a lot of ‘one-on-one.’” (33)

- This “help at the elbow” can send a strong message to users that the hospital was committed to making CPOE work. It helped to overcome initial implementation barriers. (36)

- One clinician champion would travel far distances to meet one-on-one with physicians, many in small practices. He was also a user of the system and so could understand concerns of the clinicians. He could provide practical steps to improve. He would often suggest which things the clinician could do to support workflow and how the CDS could speed up their documentation. The champion would also give them options for using the CDS selectively. They feel like they have a choice. (63) **Setting: Outpatient, Local Health Network**

APPLICABLE EXEMPLARY PRACTICES

Regional/National Health Systems/Networks: Adventist Health System

Effectively used clinical champions in their implementation across multiple hospitals in various settings.

Regional/National Health Systems/Networks: Memorial Hermann Healthcare System

Inpatient and outpatient settings describe the important role their champions play.

Regional/National Health Systems/Networks: VA Puget Sound

Has a Clinical Application Coordinator and other clinical champions.

Inpatient, Community Hospitals: Multicare Health System

Physician champions played a role in reviewing content for knowledge management.

OTHER RESOURCES

Ash JS, Sittig DF, Seshadri V, Dykstra RH, Carpenter JD, Stavri PZ. Adding insight: a qualitative cross-site study of physician order entry. Int J MedInform. 2005 Aug;74(7-8):623-8.

Ash JS, Stavri PZ, Dykstra R, Fournier L. Implementing computerized physician order entry: the importance of special people. Int J Med Inform. 2003 Mar;69(2-3):235-50. PubMed PMID: 12810127.

These two articles by Ash, Dykstra, and others are highly informative article for helping to identify and understand the roles and characteristics of effective clinical, administrative, and other types of CDS champions and leaders.

V. Achieve Clinician Buy-In and Support

Essential Principles: For CDS to be effective, clinicians must be motivated, excited, and committed to use these systems and take actions to achieve desired results. However, as noted by Berner, (7) many features of the health care environment may decrease, rather than increase, this motivation. Even when efforts are made to engage clinicians and integrate CDS into clinician workflow, clinicians may still resist the use of CDS, especially if the use of CDS exacerbates the increasingly time-pressured patient care process.

Further, CDS implementation may clash with the culture of medicine, which emphasizes individual physician autonomy. Berner points out that system changes are not always well-received if physicians are concerned about maintaining that autonomy. In addition to worries about autonomy, physicians have been concerned about the legal and ethical ramifications of listening to, or overriding, the CDS. (68) Often use of CDS is not currently part of the standard of care and, although the CDS systems can frequently provide useful advice, the advice is not foolproof. Because CDS is still fairly new, many clinicians today have misconceptions about how CDS systems work and may not be interested in using it. However, over time, as CDS is used more, and the legal situation in regard to liability for its use or nonuse becomes clearer, Berner predicts that clinicians' resistance to CDS will lessen. Until the use of CDS is routine, Berner and others feel it is important to be sensitive to resistance to using these systems. (7)

Clinical leaders and experts often facilitate buy-in. Chapter IV discusses how to recruit and cultivate effective clinical champions.

USEFUL PRACTICES and LESSONS LEARNED

Align the goals of CDS development and implementation with organizational priorities and clinical goals and objectives.

- The organizational working environment should foster meaningful EMR usage, including not only software and hardware needs but also the attitudinal changes needed to support adoption.

- "CDS should not be viewed as a technology or as a substitute for the clinician, but as a complex intervention requiring careful consideration of its goals, how it is delivered, and who receives it. To gain optimal benefit, clinician users need to understand its benefits and limitations, and the unique challenges of designing and implementing the different types of CDS." (7)

- The relationship between clinical decision support and clinical quality measurement and improvement goals is important to demonstrate. CDS is a powerful tool for improving performance on quality measures and, conversely, measurement is a powerful tool for evaluating and improving decision support. (69)

- Successful implementation in community hospitals depends less on mandating use, which is a common strategy in teaching hospitals with house officers, and more on the existence and development of an organizational culture of collaboration, trust, and belief that CDS is under their guidance and serving their clinical ends. (33) **Setting: Community Hospital**

Engage well-respected clinician "champions" to lead CDS education, training, and implementation efforts.

- See Chapter IV on clinical champions and leaders.
- For example, an approach that helped to gain physician buy-in was to have a practicing clinician champion work directly with the physicians in the small practices. The physicians were resistant to using the CDS and it helped to provide them practical options as to which CDS they would use and how, how it supported workflow (such as speeding up documentation), and also show them the evidence behind the suggestions. (63) **Setting: Outpatient, Small Practice within Larger Group Practice System**

Design the CDS to integrate with and support clinicians' workflow.

- Developing CDS that directly integrates with their workflow and saves them time facilitated buy-in from physicians in small primary care practices. For example a specialty group was shown how templates reduced the time to search for a medication from 35-40 seconds to 17 seconds. Kaldec Health System monitored CDS use and for those physicians that had low or no use of the CDS, showing them the time savings and usefulness of the CDS with one-on-one contact was very powerful. (63) **Setting: Outpatient, Small Practice within Larger Group Practice System**

Help clinicians understand and perceive the benefit of the CDS system.

- A key to success is for physicians perceive benefit, ability to test (try out) a CDS intervention, and lack of complexity in the CDS system. (59) The real difference between the ready adoption of certain tools and the resistance to others can be found in the benefit obtained by the physician user.
- Physicians must see benefit in the three major areas of their work lives: providing patient care, running their practices, and time management. (59)
- Tools that emphasize the rationale behind new interventions, screen shots of what the intervention will look like, and a listing of user-specific benefits are a step towards building clinician consensus and support for CDS. (39)
- Buy-in can be facilitated by early introduction of the project (i.e., at least a year prior to implementation) and by using materials to promote buy-in. (57, 70) **Setting: Local Health Network; National Health Network**
- Physician buy-in for clinical guidelines should be increased. This is a first step to clinical acceptance of guideline support in CDS. (71) **Setting: Local Hospital**

Understand and address clinicians' resistance to CDS.

- "The most frequently cited resistance is the perceived negative impact on physician workflow, likely from usability flaws contributing to user confusion and increased task duration. The design of CDS, however, is often perceived as a disruption of physician workflow with contextual content that is fundamentally an interruption. Empirical theory regarding primary task performance proposes that interruptions introduce errors, and CDS may introduce cognitive error through this same mechanism." (72)

- The Loyola University Health System (LUHS) used a marketing strategy to reduce resistance to change. (67) The emphasis was on patient safety as a primary goal. LUHS data on intercepted transcribing and prescribing errors and examples of actual, recent errors intercepted by Loyola pharmacists were presented, which appeared to reduce resistance to change and help physicians understand that their work processes were part of both the problem and solution. The expected increase in work for residents was acknowledged. **Setting: Academic Medical Center**

- One Deputy CIO of a large hospital said: "When there were bumps and bruises along the way and some people questioned whether they should be doing this, they would get a friendly call from the CEO that this is the direction we are going in and everyone is going to march in this direction." (34)

Acceptance and buy-in by clinicians may not occur until after implementation.

- In some CDS implementations, the involvement of clinicians during the pre-implementation and design phases was found to be sufficient for their full their acceptance of CDS. Yale conducted a formal needs assessment of the pediatric pulmonology department, and pulmonologists were active in the knowledge transformation and CDS intervention design process. However, this did not translate into their acceptance and use of the CDS intervention. In fact, there was a disconnect between what pulmonologists supported during the design phase and what they found useful once the CDS intervention was implemented. Although the pre-implementation phase design process clearly focused on developing the intervention to support decisionmaking, after implementation it became evident that the pulmonologists are using the CDS intervention for other purposes. (43) **Setting: Academic Medical Center**

- "Similarly, at the University of Virginia, it was not until personal order sets were implemented that the system became acceptable to clinicians." (31) **Setting: Academic Medical Center**

Solicit clinician input for improving the CDS.

- Use input from overridden alerts as a way to solicit input from clinicians. The New York Presbyterian Hospital (NYPH) tracks which alerts are accepted or ignored by physicians in order to ascertain clinician acceptance. They also recognize that ideas for alerts come not just from a committee setting, but from clinician users as well. (New York Presbyterian Hospital—Appendix A) **Setting: Academic Medical Center**

Provide clinician user support and training.

- Organizations found clinician focused help-desks and IT training to be helpful in implementation. Some found it necessary to offer 24/7 IT support. (60) Real time support can clear up many misconceptions and frustrations, particularly when simple answers to problems perceived as broad stroke failures of IT/CDS turn out to be simple matters to fix (either at the end user or system re-designer level).

APPLICABLE EXEMPLARY PRACTICES

Regional/National Health Systems/Networks: Adventist Health System

Adventist introduced the project early to key stakeholders, which helped to facilitate acceptance.

Regional/National Health Systems/Networks: VA Puget Sound

The VA employs Clinical Application Coordinators who serve as a bridge between the IT and the clinicians.

Inpatient, Academic Medical Center: New York Presbyterian Hospital

A committee to facilitate new requests for alerts played a role in clinician acceptance of CDS.

OTHER RESOURCES

Goldstein et al. Translating research into practice: organizational issues in implementing automated decision support for hypertension in three medical centers. J Am Med Inform Assoc, 2004, 11(5), 368-376.

This implementation was guided by a sociotechnical approach, where the integration of new technology into an organization is viewed a ''politically textured process of organizational change'' that must accord primacy to the needs of the users and the organization. The authors describe the integration of a guideline-based decision support system (ATHENA) into geographically dispersed primary care clinics, responding iteratively to organizational input and the interrelated process of attending to the organizational context. Critical to success was obtaining and maintaining endorsement of the project by the organization's administrative and clinical leadership. One effective means to sustain clinician interest was to provide quarterly feedback on guideline-drug concordance for hypertension, which renewed interest in achieving stated. Providing a forum for discussion and questions was important. At the Durham VA Medical Center, this occurred in the monthly clinical staff meetings.

Im EO, Chee W. Nurses' acceptance of the decision support computer program for cancer pain management. Comput Inform Nurs. 2006 Mar-Apr;24(2):95-104.

This article describes nurses' acceptance of a CDS program for cancer pain management and explores the relationships between the nurses' acceptance and their sociodemographic characteristics. There were significant differences in the total scores of user satisfaction by sex, religion, ethnicity, job title, and specialty. The results suggest that nurses do welcome decision support systems and that nurses' sociodemographic and professional characteristics should be considered in the development of decision support systems.

VI. Integrate CDS into Workflow

Essential Principles: The importance of considering workflow issues during the development of decision support cannot be overstated. Studies have identified dimensions of workflow integration as critical to CDS success. (2) Conversely, CDS systems that disrupt the workflow have been shown to be major barriers to acceptance and use. (25, 73) The recognition of workflow as an important aspect to implementing CDS is mirrored by the CDS "Five Rights": "CDS should be designed to provide the right information to the right person in the right format through the right channel at the right time." (7)

This sentiment is essential to integrating CDS into workflow. Workflow is highly contextual to an organization and for that reason it can be difficult to guess the impact of a certain system or intervention. (55) In two similar settings with the same CDS interventions, the impact of the interventions would likely be different due to differences in workflow. Workflow considerations are integral to appropriate rollout (Ch. VII), training and support (Ch. VIII).

In addition, there's a delicate relationship between CDS and workflow. A CDS implementation that simply replicates pre-CDS, paper-based workflows will see little, if any improvements. (43) On the other hand, many CDS implementations fail because the organization tried to change their workflow and adjust to CDS at the same time, which strained the staff and the organization. In addition, it is hard for organizations and their staff to truly comprehend the impact and utility of CDS until it is implemented. Therefore, many "new and improved" workflows looked good on paper during the CDS implementation planning stage, but disappointed users in real life. What many experts advocate now is a two-phase or even multi-phased approach. In the two-phased approach, CDS is first implemented to match the pre-CDS workflow as much as possible. After the users had a few months to adjust to the use of CDS in patient care, they can then participate in a well-informed fashion in the design of new workflows and customization of CDS. The most successful organizations also turn this into an iterative process for continual improvement. (55, 74-77)

USEFUL PRACTICES and LESSONS LEARNED

Workflow considerations need to be an integral part of CDS selection and development

Consider (and minimize) the intrusiveness of the CDS and minimize interruptions unless clinically necessary.

- One implementer attributes much of the success of his organization's outpatient decision support to the fact that "[Our information system]'s CDS capability is relatively unobtrusive, and with so low an annoyance factor people generally are supportive." (69)

It is critical to workflow to know the intended audience/user—the person to whom CDS should be provided.

- The classic paradigm for decision support is notification of physicians (especially primary care providers). However, CDS, such as alerts, can also be delivered to specialists, nurses and, when appropriate, patients themselves. (69)
- By knowing the intended audience, the CDS implementation can anticipate the needs of its users, and deliver timely assistance in real-time that improve the user's workflow. (Brigham and Women's Hospital—Appendix A)

Consider "inline" CDS that does not interfere with clinicians' workflow.

- Ash et al. use the term "inline" to refer to CDS that does not interfere with a clinician's workflow. One type to consider is "background CDS" which works behind the scenes to consider data related to an individual patient along with rules for good care and makes recommendations such as what antibiotic to order. (50)

- Another kind of inline CDS is that which notifies an intermediary such as a nurse or pharmacist rather than a physician. These strategies can be especially effective in community settings where interrupting the physician in private practice can be particularly burdensome and can be quite effective and efficient for flagging problems that can be quickly corrected without interfering with physician workflow. (50)

CDS Implementation Teams should understand workflow.

- These cross-functional CPOE CDS teams at the University of Michigan Health System (UMHS) consisted of experts in system workflow design, clinicians, information technology staff, and configuration experts. (78)

- "If the workflow is successful then the electronic process that mimics that workflow has the greatest likelihood of success. Any change in the pattern of the workflow can create disruption, and therefore requires early involvement of the users, careful planning, validation by physician (and other) champions, and then education and training in advance of the change." (79)

Ultimately, CDS Implementation should improve workflow for its users.

- As a physician champion had stated, "Time is the only thing a physician has to sell. The system must save a physician time." (Cooper Pediatrics—Appendix A) It is not sufficient for a CDS implementation to rest on the promise of "improved clinical outcomes" alone. A good CDS implementation should be able to decrease the cognitive load, simplify the complexity, and ultimately streamline and improve the workflow for its users. Improved workflow and outcome are the best motivators for adoption. (Evans Medical Group—Appendix A)

- For Generations+ (Generations +/Northern Manhattan Health Network—Appendix A), a key performance indicator of its CDS interventions is the impact of staff workflow. This attention to workflow helped them to identify areas for improvement and greatly improve staff morale.

APPLICABLE EXEMPLARY PRACTICES

Regional/National Health Systems/Networks: Generations+/ Northern Manhattan Health Network

Generations+ monitored their inventions in part by paying attention to staff workflow.

Inpatient, Academic Medical Center: University of Illinois Medical Center

University of Illinois works with clinicians to support their workflow, which includes customizing CDS tools when the vendor tools don't fit well.

Outpatient, Multispecialty: Evans Medical Group

Evans established an ideal workflow in their practice and the prospect of using this workflow attracted users to buy-in.

OTHER RESOURCES

Ash JS, Sittig DF, Dykstra R, Wright A, McMullen C, Richardson J, Middleton B. Identifying best practices for clinical decision support and knowledge management in the field. Stud Health Technol Inform. 2010;160(Pt 2):806-10.

The article articulates many useful practices for implementing CDS. The main suggestion for CDS is to avoid interrupting a clinician's workflow if possible.

Karsh B. Clinical practice improvement and redesign: How change in workflow can be supported by clinical decision support. Rockville, MD: Agency for Healthcare Research and Quality; 2009 June

In this highly useful paper, Karsh lays out the essential principles to understanding workflow and its effect on CDS. He touches on situational awareness and mental workload. He also discusses the utility of different types of interventions (e.g., alerts vs. reminders).

Kawamoto K, Houlihan CA, Balas EA, Lobach DF. Improving clinical practice using clinical decision support systems: A systematic review of trials to identify features critical to success. BMJ. 2005 Apr 2;330(7494):765.

In a systemic review, Kawamoto et al. found that effective integration of CDS into workflow to be a key component of success.

Wright A, Phansalkar S, Bloomrosen M, Jenders RA, Bobb AM, Halamka JD, Kuperman GJ, Payne TH, Teasdale S, Vaida AJ, Bates DW. Best practices in clinical decision support: The case of preventive care reminders. Appl Clin Inf. 2010;1:331.

Wright et al. canvassed experts to determine some barriers and best practices related to clinical care reminders. The panelists agreed that disrupting workflow with an alert was a last resort. Using templates and order sets was often preferred.

VII. Plan for Successful Rollout

Essential Principles: Even if the proposed interventions or systems are ideally matched with workflow and vetted by all pertinent stakeholders, these must be rolled out in a manner that fits the organization. The rollout planning of a new system, such as an EMR, CPOE, or a third party CDS system may have different considerations than the rollout of the interventions themselves.

Rolling out an entire system often requires a more substantial change in workflow. At this stage, it is recommended to keep in mind the lessons from the previous sections. The stakeholder roles (Chs. III, IV) and the change environment (Ch. II) factor greatly into the rollout plan. A first step involves testing the system and its impact on workflow. Cognitive walkthroughs, think aloud studies, and heuristic evaluations are some examples of assessment tests. (80) If rolling out a new system means switching from a paper process to an electronic process, it might be helpful to ask: "How will the organization cope if the systems go down?" (81) and "Will keeping the paper version available slow adoption?" Some organizations have found a dual paper/electronic system helpful to easing adoption while others have found it to be a serious hindrance to clinician buy-in.

Many of the same principles mentioned above apply to individual interventions as well. An assessment test is also important to make sure the intervention fires at the right place within the workflow. An essential point for a planning a rollout of a system or intervention is that all stakeholders must not be overwhelmed. A recurring lesson is the finding that when a CDS system is being implemented, interventions should be rolled out in an incremental fashion. (40) Overwhelming the users with many new CDS functions at once, often leads to the turning off of much of the CDS functionality. (82) When possible organizations may want to test alerts "in vitro" modeling how often they would fire at various thresholds and setting and gauging the signal (true positive/helpful) to noise (false positive alerts for erroneous or non-helpful clinical contexts) ratio.

Contextual Considerations: There are many different ways in which an organization could roll out a system or an intervention. Rollout plans have ranged from a slow incremental introduction of CDS functionality, to a "big-bang" rollout where CDS and CPOE have been introduced simultaneously with the expectation of 100 percent compliance. The rollout plan for a specific practice setting often depends on the readiness for change (Ch. II) and what kind of training and support can be offered at go-live (Ch. VIII).

USEFUL PRACTICES and LESSONS LEARNED

Account for differences between intervention types and organizational culture.

- Develop and implement an intervention rollout plan that addresses user communications, training and feedback, as well as responsibility for monitoring implementation status. (46) (40)
- "Careful and complete testing of all new CDS functionality, along with other CDS and CIS systems that might be affected, is essential to ensure that the completed interventions perform as expected. The details of this testing depend on the type of CDS intervention, the nature of the clinical content, and the underlying technology used to create the CDS intervention." (40)
- Context is the environment to which the implementation plan must adapt. A rollout schedule, for example, must take into account the many interdependencies that exist among clinical units as well as organizational changes that are occurring during the implementation. (83)

Consider how rollout timeline affects usage and adoption.

- "Consider the nature of both the CDS intervention and the clinical and technical environment when determining the speed, scope (which clinical units), and order (which interventions or units go first) for rolling out new CDS interventions." (40)

- Institute for Family Health, an outpatient network of clinics in New York prioritizes the rollout of CDS interventions by clinical need. Measuring quality measures can help to prioritize intervention rollout. This type of prioritization focuses the CDS interventions on important clinical goals and, if done thoughtfully, prevents overwhelming the clinician. Not all clinical objectives will be highly relevant to each setting and attempting to achieve them all at once via CDS will likely lead to alert fatigue. (84) **Setting: Outpatient, Local Health Network**

- A 37-location national health network (Adventist Health System—Appendix A) has been implementing CPOE with CDS in each of the hospitals. In an effort to improve patient outcomes and achieve meaningful use criteria, they have used a "big-bang" rollout. After go live, they do not take paper orders. Each hospital is informed of a go live date, a year in advance so that buy-in can be achieved and adequate preparations are made. With mandated pre-go live training and extensive support after, this method has achieved exceptional compliance. (57) **Setting: National Health Network**

Communicate rollout plan to end-users and stakeholders.

- "When new features go live, physicians need to be informed prior to altering their workflow and routines. Even if physicians were involved in the creation of these alerts, the communication to other physicians of the go-live may be inadequate." (79)

APPLICABLE EXEMPLARY PRACTICES

Regional/National Health Systems/Networks: Adventist Health System

Adventist employed a "big-bang" rollout, which it found a successful method for implementation.

Inpatient, Academic Medical Center: Vanderbilt University Medical Center

To test the system prior to deployment Vanderbilt uses model walkthroughs.

Outpatient, Group Specialty: Cardiology Consultants of Philadelphia (CCP)

In their adoption CCP has found it unwise to allow providers to opt out or to delay their adoption. A rollout where all users were required to adopt was more effective.

Outpatient, Multispecialty: Physician Associates at Sugar Creek

Sugar Creek rolled out small numbers of alerts at a time so that each intervention could be assessed adequately.

OTHER RESOURCES

Chaffee BW, Zimmerman CR. Developing and implementing clinical decision support for use in a computerized prescriber-order-entry system. Am J Health Syst Pharm. 2010 Mar 1;67(5):391-400.

The paper describes the implementation of a CPOE system with CDS at an academic medical center (University of Michigan): "The organization used a phased-in approach to collect some basic alert outcomes data and clinician input for modifying rule and alert content before each successive phase." (p. 393)

Lorenzi NM, Novak LL, Weiss JB, Gadd CS, Unertl KM. Crossing the implementation chasm: A proposal for bold action. J Am Med Inform Assoc. 2008 May-Jun;15(3):290-6.

Coupled with many other recommendations for implementation, the authors suggest taking organizational context into account.

Poon EG, Blumenthal D, Jaggi T, Honour MM, Bates DW, Kaushal R. Overcoming barriers to adopting and implementing computerized physician order entry systems in U.S. hospitals. Health Aff (Millwood). 2004 Jul-Aug;23(4):184-90.

The authors interviewed senior management at 26 hospitals to understand barriers to CPOE. The high-level recommendations are applicable to CDS, as alerts and reminders are often part of a CPOE system. Poon et al. highlights the importance of the clinical champion during rollout: "During the rollout of CPOE, champions would remind the general users of its downstream benefits, encouraging them to see beyond their immediate frustrations. Champions would also relay users' concerns to the implementation team and the vendors." (p. 186)

Trivedi MH, Daly EJ, Kern JK, Grannemann BD, Sunderajan P, and Claassen CA. Barriers to implementation of a computerized decision support system for depression: An observational report on lessons learned in "real world" clinical settings. BMC Med Inform Decis Mak. 2009 Jan 21;9:6.

The authors explicate the implementation process at a large academic medical center (UT Southwestern). In describing the barriers to implementing a mental health tool, Trivedi et al. touch upon rollout issues. UTSW tried using the system on only a few patients per day per provider. (p. 6) The authors suggest this may have slowed physician acceptance. At rollout, the system was a hybrid paper and electronic system, the authors suggest that a full switch may have led to a more successful implementation. (p. 7)

VIII. Train and Support

Essential Principles: While CDS designers and developers continue to strive to make CDS as intuitive to use as possible, we are still far from the day when every clinician can instinctively use CDS in an optimal, efficient, or even correct fashion. Therefore, training and supportive activities are critical to CDS success, and must be an integral part of CDS implementation.

However, with the exception of some CDS interventions, such as documentation forms and templates, CDS usually does not have distinct and isolatable training and support activities. Alerts and reminders, which account for the majority of CDS interventions, are usually considered a part of the underlying EMR or order entry system, and are not covered separately in training.

It is important to recognize that training is not a goal in and of itself. Ultimately, the successful training approach leads to successful user adoption, system implementation, and improved patient outcomes. As discussed in the review of nonclinical CDS systems, CDS efforts may fail if users are not properly trained on how to use the system, do not understand their roles and responsibilities, or the inappropriate or non-use of a CDS tool. (85) The success of the CDS training is dependent on both individual and organizational strategies. At the individual level, the training program must be tailored to the need of the user. In clinical settings, this is often accomplished through the help of a physician champion who understands local clinical practices, and can help to customize the content to relevant local context and preferences. At the organizational level, there needs to be widespread commitment to the CDS adoption from the top level down. Optimal CDS use and adoption do not occur by accident, they require intentional effort from the user; organizational resolve and commitment is one major source of motivation for the user.

Contextual Considerations: For the clinical users, CDS is exactly what its name suggests—a tool to support their clinical decisionmaking. As such, it can be awkward to try to make a "supportive task" take the center stage of training. Therefore, CDS training materials needed to be integrated into the context of EHR and CPOE training, rather than a standalone activity. Clinicians are also extremely mindful of their time and availability. As such, many organizations have found traditional multi-day, in-classroom training to be poorly received. Successful organizations have found ways to both demonstrate the importance of CDS training and to make the training as convenient for the clinicians as possible. And of course, requirements for lengthy training should serve as a red flag for warning that functionality is overly complex, non-intuitive, and/or poorly designed into logical clinical workflow.

System end-users should be trained in the proper use of clinical applications, including correct data placement on electronic forms, why standardized data entry can improve data reliability and interoperability (and how to use system tools provided for entering these data), and methods for ensuring clinical orders are actually completed in a timely fashion. (81)

USEFUL PRACTICES and LESSONS LEARNED

Integrate CDS fully into EHR training with specific training documents and illustrative case examples.

- Lessons from decision support (DS) in non-clinical settings apply. The user training process could encourage appropriate use of DS by informing users about the reliability of the decision aid to encourage appropriate levels of trust; instructing users on the nature of change and teaching them new behaviors in order to "unfreeze" them from old ways of thinking about DS; and encouraging continuous learning about the CDS. (85)

Training is not "one size fits all"; therefore consider multiple methods and channels of training.

- Large institutions and health networks need to accommodate diverse groups of providers, who often have divergent needs and schedules. Modern EHR systems are also complex and often require significant training to reach true competency. One obvious point of differentiation is house-staff residents who will spend most of their working hours interacting with information systems and CDS versus attending physicians who may rarely enter orders directly into systems themselves or interact with computerized information retrieval or ordering. Rather than requiring prolonged, multi-day training sessions, some organizations have had better success by mixing group instruction in the classroom, one-on-one training, and on-the-job training (Queens Health System—Appendix A). **Setting: Local Health Network**

- Training does not need to be in-person and in the classroom. Clinicians appreciate and enjoy the flexibilities of online self-paced modules and alternatives to classroom trainings. However, if there is not sufficient dedicated time for a focused and even hand-held walkthrough, this strategy could backfire and point to a need for dedicated sessions.

  As a physician pointed out, "time is the only thing a physician has to sell." (Cooper Pediatrics—Appendix A) Traditional in-classroom didactic training sessions that require trainees to set aside large blocks of time away from their clinical responsibilities are particularly disruptive to clinical practices. Many providers have found online, self-paced training materials to be very helpful. Small practices have also used remote screen-sharing technologies to conduct 1-to-1 trainings to providers during their lunch time or other less-disruptive parts of their schedule (Valdez Family Clinic—Appendix A). Private 1-to-1 training sessions for clinicians can also help to tailor and customize aspects of the system, such as documentation templates, to the clinician to further enhance productivity.

Internal resources, such as physician champions and super-users, can contribute significantly to the success of the implementation.

- As discussed earlier, physician champions and other clinical staff who are familiar with the local context and workflow can really help to customize the training program to enhance relevance and retention for the staff. Talented staff members who can speak the language of both medicine and technology are also essential. These are the core staff members who can help to train, support, and make changes in the system, and there must be enough of them. In addition, internal resources also offer the significant advantage of persistence. As opposed to consultants, vendors, and temporary staff, internal staff will be around months to years after the initial implementation. As CDS experts have noted, "most successful implementations have had more post- go-live support than pre- go-live support." (60)

Clear organizational stance on the importance of EHR and CDS competency.

- It is critical for the organization to clearly demonstrate its full support of CDS. The organizational messages need to explicitly recognize EHR and CDS is an integral part of modern health care, and no less important than mastery of basic clinical skills, CPR training, or even clinical licensing. Incorrect use of EHR and CDS could just as easily lead to patient harm as the incorrect use of medication or medical instrumentations. Successful organizations have made EHR and CDS training required for all clinical staff (Eastern Maine Medical Center—Appendix A), a requirement for staff privilege (Multicare Health System—

Appendix A) or access to the EHR and patient records. (VA National—Appendix A) **Setting: Local Health Network**

- Without clear organizational commitment, some providers simply opted out of use by delegating responsibility to subordinates. Others complained about processes that were clearly better than the paper-based alternative but not yet optimal in their minds. In these types of settings, it might be beneficial to reorganize groups and/or offer more extensive training. (54)

APPLICABLE EXEMPLARY PRACTICES

Regional/National Health Systems/Networks: VA National

The VA has developed online training and podcasts, which help to train new clinicians on the use of CPOE with CDS. VA online training of VISTA and CDS may be accessed at http://www.vehu.va.gov/vehu/WBTPages/WBT08.cfm?ClassNum=157 and http://www.myvehucampus.com/

Regional/National Health Systems/Networks: Multicare Health System

Multicare Health System maintains excellent compliance with CDS by requiring training in order to maintain staff privileges.

Regional/National Health Systems/Networks: Queens Health System

Queens makes use of multiple training strategies including regular updated documents, formal classroom training, and informal instruction.

Inpatient, Community Hospitals: Eastern Maine Medical Center (EMMC)

Competency with technology is demanded of all staff. EMMC utilizes a highly flexible training program.

Outpatient, Solo: Valdez Family Clinic (VFC)

VFC uses screen sharing technology to assist with training.

OTHER RESOURCES

Ash JS, Fournier L, Stavri PZ, Dykstra R. Principles for a successful computerized physician order entry implementation. AMIA Annu Symp Proc. 2003:36-40.

Ash et al. provide descriptions of essential principles for CPOE implementation. Many of these lessons apply to CDS as well. The article emphasizes the importance of the "at the elbow" support and pre- and post- go-live training.

Campbell EM, Sittig DF, Guappone KP, Dykstra RH, Ash JS. Overdependence on technology: An unintended adverse consequence of computerized provider order entry. AMIA Annu Symp Proc. 2007:94-8.

Campbell et al. emphasize the importance of training to avoid unintended consequences. Correct data entry is important to CDS. The information must be coded so that it can be usable.

Lai F, Macmillan J, Daudelin DH, Kent DM. The potential of training to increase acceptance and use of computerized decision support systems for medical diagnosis. Hum Factors. 2006 Spring;48(1):95-108.

The study developed a brief Web-based "demystifying" tutorial employing case-based training and evaluated the effectiveness of that tutorial in changing self-reported attitudes and behaviors. Clinicians using the tutorial reported greater understanding of how to use the ACI-TIPI score appropriately and increased confidence in the score. The results of this study indicate that there is a potential for a relatively brief tutorial to increase acceptance and use of decision support tools for medical diagnosis.

Sobieraj DM. Development and implementation of a program to assess medical patients' need for venous thromboembolism prophylaxis. Am J Health Syst Pharm. 2008 Sep 15;65(18):1755-60.

This case study describes the training program used in the implementation of a tool for VTE prophylaxis.

Stablein D, Welebob E, Johnson E, Metzger J, Burgess R, Classen DC. Understanding hospital readiness for computerized physician order entry. Jt Comm J Qual Saf. 2003 Jul;29(7):336-44.

Organizations found clinician-focused help desks and IT training to be helpful in implementation. Some found it necessary to offer 24/7 IT support.

IX. Monitor and Evaluate CDS's Clinical Impact

Essential Principles: An important component of CDS implementation is monitoring and evaluating CDS interventions after they are deployed and improving them continuously. Osheroff and colleagues use the acronym METRIC, which stands for Measure Everything That Really Impacts Customers—clinicians, administrators, patients, and other stakeholders. (7)

First, measures of clinical content are important, and may include the following: percentage of clinical content reviewed in a time period; number of order sets available; number of alerts in production; alert logic and suggestions; reference information available; reports of clinical content usage available; and median number of participants in specific CDS intervention discussions. (42)

Monitoring the intervention's impact on clinical objectives such as quality measures and on clinician workflow helps to answer several very important questions: Is the CDS achieving the clinical objectives? How do end-users perceive the CDS's usefulness, impact on care, and impact on workflow? Is the CDS integrated with and does it support workflow? Are there unintended consequences of the CDS? (9) The answers to these questions will help determine if the CDS intervention should be changed. The design or selection of interventions should take feedback mechanisms into account. (86) The lessons and principles provided in the previous sections (Chs. I-VIII) significantly inform end-user feedback and monitoring as well.

Monitoring the system and responding to feedback with ongoing and effective communication strategies reinforces the CDS goals and leads to a more successful CDS intervention (Ch. I). Monitoring and feedback also helps the implementation team gauge and address clinician buy-in (Chs. II,V).

Indeed, a review of decision support in non-health care settings also noted the importance of continual improvement. (85) It is important for systems to be flexible and adaptive, and to avoid perpetuating rules or data that are inaccurate or outdated. Decision support systems should be continually re-evaluated and fine-tuned. Systems should not be viewed as final, since they must be adapted to suit advances in clinical knowledge and the changing needs of users and the environment. Decision support development should follow a three-part cycle—initiation, analysis, and delivery—which should be continued once interventions are rolled out. (87) This practice of continuous review and adjustment signals to the end-users that CDS designers are listening and responding to user's issues.

Contextual Considerations: Monitoring the impact of these systems requires that the systems be designed in such a way to provide knowledge management tools, data, and techniques. The IT resources and finances of a given organization may be a barrier to gathering and reporting on CDS performance.

USEFUL PRACTICES and LESSONS LEARNED

Develop Regular CDS Feedback Mechanisms

Assess CDS use and usability on an ongoing basis.

- Continually enhance the value to users as well as the impact on goals and objectives of individual CDS interventions and the overall CDS program. Surveys and interviews can be useful for this purpose. (12, 42, 88-94)

- "Log files and other approaches to tracking intervention use can be helpful for monitoring intervention effects. Details of interest include: when and how the intervention was invoked,

where the user and patient were at the time, when in the workflow it happened, and how the information delivered was handled and applied." (39, 40)

- One strategy used by CDS teams is to initially review override rates and later review complaints. Ideally these can be tracked routinely. (86) Monitoring of overriding is said to be necessary to keep the override rate within acceptable limits and to ensure user trust and responsiveness to alerts.

- Selected periods of chart review can provide a deeper understanding of how alerts are really performing in ambulatory practice sites. Periodic prospective review of a selected number of patient charts in small practices can be done by the scheduling personnel or nurses in the practice. It involves taking a few reminders and having everyone focus on them for the next week and see if any were missed from a previous visit of the patient seen in the practice. This can go along with any information in the system or set up by the practice (e.g., overrides, reviewing new medications the patient is on or has received from inpatient care or specialist care) to provide a better understanding of when and how alerts are being used. Such analyses could also be done through retrospective chart review. (86) **Setting: Outpatient**

- One organization found a screen-capture system to be helpful in observing the effects of the system on clinician workflow. Direct observation can often influence the behavior of those who are being observed. If permission is given by the physician to monitor their screen shots, this approach has the dual benefit of allowing remote observation of workflow. (63) **Setting: Outpatient, Local Health Network**

Evaluate intervention performance measured against clinical objectives.

- Key stakeholders and organizational leadership should help establish reasonable measurement intervals and expectations for improvement. Evaluating intervention effectiveness requires both quantitative and qualitative approaches.

- Where CDS performance can be tied to broader quality metrics that are being evaluated by hospital leadership, CDS use and effectiveness can be tracked.

Evaluation and feedback to iteratively refine CDS interventions to improve use and impact.

- Plan on iteratively refining interventions to improve their use and benefits. Opportunities will unfold based on lessons learned and data amassed during each implementation round, evolving capabilities in CIS infrastructure and available CDS tools, new clinical knowledge, and the changing environment in health care. (39)

- "Strongly encourage users to provide feedback and suggestions. If users are involved, they won't be hesitant to call and provide suggestions or solutions to problems." (34)

- The Brigham and Women's Hospital in Boston, MA (Appendix A) allows users to communicate with the system developers regarding alerts. They can click on a "comment" button, which brings up a feedback screen. The developers have created both a structured as well as a free text feedback form. All feedback is sent directly to the specific "rule owner" for each rule. (42)

- Common tools for CDS users to provide feedback regarding CDS interventions are: email addresses for CDS-related feedback, complaint buttons, interventions that have a feedback button and pager number, and tools on the user interface menu to document problems and suggestions via email or production of support remedy tickets. (42)

- "One effective means to monitor, provide feedback, and sustain clinician interest was to provide quarterly feedback on guideline-drug concordance for hypertension. Clinicians are aware of the evidence supporting treatment of hypertension to lower cardiovascular risk; presenting them with their medical center's and their individual rates of adequacy of control of blood pressure appeared to sustain interest. This often stimulated more questions and renewed interest in achieving stated goals or questions about how patients or outcomes were chosen. Providing a forum for these questions was important. At the Durham VA Medical Center, this occurred in the monthly clinical staff meetings." (24)

- Consider removing alerts that are functioning poorly (poor signal; noise; providing minimal meaningful and/or marginal clinical benefit).

Offer users mechanisms to suggest improvements.

- University of Washington Medical Center uses a "change-control" checklist to request new interventions or changes to an existing intervention; the requestor must provide information on how the change fits into workflow. (62) **Setting: Inpatient, Academic Medical Center**

APPLICABLE EXEMPLARY PRACTICES

Regional/National Health Systems/Networks: Geisinger Health System

In its implementation, Geisinger emphasizes the importance of examining the clinical impact of the interventions and also refining these interventions via end-user feedback.

Regional/National Health Systems/Networks: Memorial Hermann Healthcare System

Memorial Hermann has found that CDS is best optimized by having an understanding of how the user interacts with the intervention.

Inpatient, Academic Medical Centers: Brigham and Women's Hospital

Brigham and Women's uses a comment button so that feedback from clinicians can be easily provided.

Inpatient, Academic Medical Centers: New York Presbyterian Hospital

New York Presbyterian Hospital uses a structured alerts request process to prioritize the way in which new interventions or changes are introduced.

Inpatient, Academic Medical Centers: Cincinnati Children's Hospital Medical Center

Cincinnati did not implement any CDS intervention without an associated means by which to measure its effect.

Inpatient, Academic Medical Centers: University of Illinois Medical Center

University of Illinois works well with clinicians to help adapt CDS to workflow. This includes tweaking vendor tools when they do not work as required.

Outpatient, Multispecialty: Southwest Texas Medical Associates, LLP

Tracking quality measures and clinician use was important to Southwest Texas Medical Associates, LLP. Without the ability to track, it is difficult to gauge the effectiveness of the CDS intervention.

OTHER RESOURCES

Del Fiol G, Rocha RA, Bradshaw RL, Hulse NC, Roemer LK. An XML model that enables the development of complex order sets by clinical experts. IEEE Trans Inf Technol Biomed. 2005 Jun;9(2):216-28.

Del Fiol et al. reiterates the importance of physician involvement in the creation of content. While specifically related to order sets, the lesson of the clinician "owning" an intervention or a suggestion is important so that other clinicians know to whom to direct feedback.

Sobieraj DM. Development and implementation of a program to assess medical patients' need for venous thromboembolism prophylaxis. Am J Health Syst Pharm. 2008 Sep 15;65(18):1755-60.

In the implementation of a VTE prophylaxis tool, clinician feedback was solicited on a pilot floor after go live.

Trivedi MH, Daly EJ, Kern JK, Grannemann BD, Sunderajan P, and Claassen CA. Barriers to implementation of a computerized decision support system for depression: An observational report on lessons learned in "real world" clinical settings. BMC Med Inform Decis Mak. 2009 Jan 21;9:6.

In the implementation of a tool for depression, clinician feedback was taken into account via interviews with the director of the project.

X. Knowledge Management

Essential Principles: All CDS interventions have a life cycle that requires an underlying technical and organizational infrastructure. CDS interventions rely on clinical knowledge that is constantly changing and so must be regularly reviewed and updated. Knowledge management is an important focus of successful CDS. (28) There are two types of knowledge management essential to the successful use and deployment of CDS. First, organizations must make sure that the patient information within the EMR is up-to-date and accurate. (7) This activity rests in the hands of those entering clinical information into the EMR. Information cannot be helpful if it is not correctly coded. CDS is essentially only as good as the information entered into the EMR.

In addition, the clinical knowledge that informs the alerts must be updated as often as is necessary. (7) This type of knowledge management is much more difficult to achieve. When the amount of content in an organizational system is small, keeping it current is usually manageable. However, as the amount of content increases, maintaining currency becomes increasingly difficult. Many of the clinical foci for various CDS interventions change quickly: new guidelines are published, new drugs are placed on the market, and new evidence becomes available. These, in turn, necessitate a change in decision support content. Implementing even apparently simple rules can be a significant institutional challenge and requires a commitment to maintain the rules and individuals dedicated to this task. (69) Organizations must either dedicate staff and resources to maintaining clinical knowledge or outsource the activity to commercial vendors or other organizations. In general, good knowledge management depends on skilled IS staff (either in managing outsourced content or working with clinician experts), a well developed and collaborative decisionmaking structure (Ch. I), and appropriate technology to assist. (50)

Contextual Considerations:

Large Inpatient Hospital: Large organizations may have hundreds of CDS alerts, order sets, and rules. Maintaining and keeping these current given changing guidelines may required dedicated staff or services for knowledge management.

Geographical Location: The quality measures or clinical objectives which drive an organization's CDS interventions might be different based on patient population or location. Thus, the knowledge required might be more specific to a region, and therefore more rarified—making outsourcing difficult.

USEFUL PRACTICES and LESSONS LEARNED

Plan for knowledge management early in the CDS initiative.

- Plan knowledge management processes early. Ash et al. found that sites that developed their own CDS struggled to catch up in knowledge management. (50)

- "It is important to have a systematic approach to managing organizational knowledge assets. This includes policies (e.g., covering periodic content review) and infrastructure (e.g., committees and knowledge management tools) to ensure that the quality, currency, and appropriateness of all the content in CDS interventions." (40)

Determine the appropriate point on the spectrum between centralized and local knowledge management

- The AHRQ-funded GLIDES project has built CDS for pediatric asthma and obesity. They have integrated this knowledge at multiple locations within two commercial EMRs. As

Berner states, although these interventions work well within the EMRs, each individual site must update the code, which can be time consuming. (7)

- The Clinical Decision Support Consortium (CDSC) uses a different approach—a web-based repository for knowledge management. The CDSC also integrates CDS at multiple sites. This approach allows updates to the system to be done centrally by the CDSC. Any organization would still be required to integrate the knowledge into its EMR. It can also be difficult to obtain consensus for clinical knowledge, making a centralized system potentially more difficult to manage. (7)

- These and various other approaches illustrate the growing recognition of the difficulty for local organizations to individually dedicate resources needed for CDS knowledge management. A movement toward more national and collaborative approaches may provide CDS knowledge management services to a wider range and greater number of care settings than would otherwise be possible.

OUTSOURCED

- It can be less time consuming and require fewer resources to use commercially available knowledge bases. Many organizations outsource some or all of their CDS content development and maintenance to external suppliers. While generally satisfied with this arrangement, some organizations strongly underscore the need to be able to customize the vendor content for their local needs. Users should also investigate the frequency of updates and the source of the knowledge. (7, 69)

- Organizations may share current CDS rules through vendor user groups or other consortiums. The Clinical Quality Improvement Consortium (CQIC) keeps clinical knowledge up to date by the efforts of each of its individual members. (64)

IN-HOUSE

Use the right tools.

- In a review of six sites, Sittig et al. suggest the most useful tools for knowledge management within successful implementations: (42)

    1. A multidisciplinary team responsible for creating and maintaining the clinical content;

    2. An external repository of clinical content with a Web-based viewer that allows anyone to review it;

    3. An online, interactive, Internet-based tool to facilitate content development and collaboration; and

    4. An enterprise-wide tool to maintain the controlled clinical terminology concepts.

Have a system for keeping interventions and knowledge current.

- "Assigning an "expiration date" to the knowledge components of all CDS interventions can be a useful strategy to help keep the knowledge base current. These time limits should be set to correspond with the anticipated "shelf-life" of the intervention's knowledge and trigger

content review by an appropriate domain expert after a pre-determined time since the last review has elapsed**."** (40) However merely fixing a date, without adequate resources to tackle the never-ending cycles of expiring alerts, will mainly serve to highlight local constraints and vulnerabilities to outdated CDS.

- Many organizations have annual (or otherwise periodic) reviews where content is checked against current practice and updated as needed. Some organizations also use tracking tools to keep content up to date. This best practice is also related to appropriate governance and oversight structures that include mechanisms for prioritizing content review and ensuring that content is kept up to date. (69)

- Rules and knowledge should be owned by clinicians or by a committee, not by the computer. (Wishard Memorial Hospital—Appendix A)

Determine the level of consensus necessary to implement new knowledge.

- While compromise or accommodation may help to achieve consensus, these approaches were thought to produce undesirable outcomes. As one project team member stated, "If you came up with a guideline everyone agreed with, it would be mushy. Thus, determining achievable levels of consensus is key." (43)

- "To address ambiguities in the guidelines and to develop the more specific criteria necessary for creating computer-executable rules, the CDSC project team established a Content Governance Committee. This committee conducts literature reviews to gather evidence and uses the clinical expertise of Bingham and Women's Hospital's clinicians to clarify ambiguities in published guidelines." (43)

Organizations that decide to create or edit their own guidelines should ensure that they are easily translated for use in CDS interventions. (53)

- Include patient-specific factors for disease management when supported by an evidence base.

- Incorporate differences among subsets of patients.

- Translate practice guidelines into machine-readable formats to integrate into CDS tools.

- Work with electronic tool developers to create standard data formats that can be used to structure guidelines for import and use in CDS formats.

- Harmonize measure specifications with EHR standards and requirements.

- Ensure that EHRs are equipped to capture datasets to evaluate quality measures.

APPLICABLE EXEMPLARY PRACTICES

Inpatient, Community Hospital: Portland Providence Medical Center (PPMC)

PPMC was one of the sites studied in the article by Sittig et al. PPMC used an external repository to store the clinical knowledge so that it could be viewed and vetted by clinicians.

Outpatient, Solo: Valdez Family Clinic

The Valdez Family Clinic leverages the Medcin database to gain from the works of thousand of providers.

Outpatient, Specialty: Pediatrics @ the Basin

Pediatrics @ the Basin belongs to a committee called the Rochester Health Commission that represents local insurance companies, IPAs, and hospitals to provide clinical guideline initiatives.

Outpatient, Multispecialty: Physician Associates at Sugar Creek

Sugar Creek belongs to a consortium where clinically relevant CDS is created and the onus of managing clinical knowledge is shared.

Conclusion

As incentive programs such as Meaningful Use spur mainstream adoption of CDS into everyday medical practices, more health care providers than ever before will need to grapple with CDS implementation, optimization, and its impact on care.

The health care community increasingly recognizes the important role that CDS and other health IT systems play in the provision of quality care. Private, federal, nonprofit, academic, and other organizations are all involved in collecting, monitoring, and sharing important knowledge about CDS. However, there is still a significant gap between the potential and actual benefits achieved from CDS. This report provides many important and practical lessons based on real-life CDS experiences that can help guide the next wave of new CDS implementers. In order to truly advance the adoption and use of CDS, it is critical that these lessons are disseminated effectively, in useful formats, and targeted to key audiences such as small- to medium-size practices.

Further, as many more health care providers implement CDS, motivated by the Meaningful Use incentives, it will be important to continue to capture and share their key lessons and best practices.

This report adds to the growing body of knowledge on successes, barriers, and lessons in CDS implementation. When disseminated with the other tools and resources developed under the ACDS project, it can help CDS meet its true potential.

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Appendix A – Applicable Exemplary Practice Summaries

University of Illinois Hospital

Organization Name:	University of Illinois (UIH) Hospital
Organization Address:	1740 West Taylor Street Suite 1400 Chicago, IL 60612 http://www.hospital.uic.edu/
Organization Contact:	William L. Galanter, MD, PhD General Internal Medicine, Department of Medicine billg@uic.edu http://www.uic.edu/com/dom/gim/facpages/Galanter/
Schema Archetype:	Inpatient, Academic Medical Centers
Schema Factors:	Inpatient, >200 Beds, Urban, Academic, Hospital Setting
Organization Summary:	University of Illinois (UIH) Hospital, built in 1982, is a State-owned teaching hospital located in Chicago, IL. UIH has 408 beds.
IT Environment:	UIH has a number of systems that support CDS, including clinical care reminders for clinics. The area that is considered exemplary is medication management in the hospital through CDS. UIH has used the Cerner Corp. EMR since 1999, which is used as the primary source of presentation of all results and orders to clinicians. All medication and laboratory orders are placed using CPOE, predominantly by house staff. Nurses and pharmacists sometimes place medication orders based on a physician's verbal order. There are presets defined by class of clinician (e.g., pharmacist vs. MD). UIH also uses a commercial automated CDS (Discern Expert., Cerner Corp). UIH has had CPOE since 1982 using TDS prior to Cerner. UIH also has some more unique CDS, such as one to prevent verbal orders of dangerous medications and a VTE prophylaxis system. UIH was the alpha site of its second CPOE vendor, and it developed the CDS in-house, starting with order sets already built from the prior system. Thus, there was no formal order set development process. UIH also developed the CDS medication alerts. In 2002, UIH created its first multidisciplinary committee to handle alerts. Most of the work of the committee was medication-related and was done through the Pharmacy and Therapeutics (P&T) committee. When UIH developed its EMR, this CDS committee became a subcommittee of the UIH EMR committee. P&T information feedbacks into CDS and helps keep the CDS up to date with new contraindications and other new issues. The vendor has built in more and more flexibility over time. They are gradually improving the content of drug-drug interactions.

CDS Achievement:	UIH has a long history of CDS use through CPOE and alerts. It regularly updates and maintains its CDS systems through strong CDS governance. UIH developed and implemented CDS alerts to decrease the use of contraindicated medications in patients with renal insufficiency and found that the alerts decreased the likelihood of clinicians completing contraindicated orders and decreased the administration of these medications.
Lessons Learned:	A strong administrative structure to oversee the CDS program has been found to be effective in developing CDS strategy, guiding execution, monitoring progress and results, and addressing challenges. Key persons serve on multiple committees that relate to each other. For example, members of the P&T and documentation committees also serve on the CDS committee. UIH works with clinicians to address how CDS can support workflow. For example, UIH developed alerts that help clinicians fill out problem lists, as it is easier to place problems using the alerts than go to the vendor-provided problem lists.
Awards, Recognitions, and Citations:	This CDS Governance Organization Structure was incorporated into the HIMSS Decision Support Guidebook – Improving Medication Use and Outcomes with Clinical Decision Support: A Step by Step Guide, 2009. Galanter WL, Didomenico RJ, Polikaitis A. A trial of automated decision support alerts for contraindicated medications using computerized physician order entry. J Am Med Inform Assoc. 2005 May-Jun;12(3):269-74. Galanter WL, Thambi M, Rosencranz H, et al. Effects of clinical decision support on venous thromboembolism risk assessment, prophylaxis, and prevention at a university teaching hospital. Am J Health Syst Pharm. 2010 Aug;67(15):1265-73. Galanter WL, Hier DB, Jao C, Sarne D. Computerized physician order entry of medications and clinical decision support can improve problem list documentation compliance. Int J Med Inform. 2010 May;79(5):332-8.

El Camino Hospital

Organization Name:	El Camino Hospital
Organization Address:	2500 Grant Road Mountain View, CA 94040 (650) 940-7000 phone www.elcaminohospital.org

Schema Archetype:	Inpatient, Community Hospitals
Schema Factors:	Inpatient, Urban, >200 Beds, Non-Academic/Community
Organization Summary:	El Camino Hospital-Mountain View is a 395-bed, non-academic hospital located in Silicon Valley. The hospital is an independent, not-for-profit organization that answers to community stakeholders. El Camino is considered a leader in the use of health information technology. The hospital was the site of the first electronic medical record implementation and the first computerized provider order entry implementation.
IT Environment:	El Camino desires to be the "smart" hospital of Silicon Valley. In achieving that goal, the organization has implemented a number of patient safety initiatives. Apart from an EMR and CPOE, some of these implementations include wireless handhelds, bedside drug bar-coding, electronic tablets, and voice-activated communication devices. Interestingly, CPOE usage is at 100% at El Camino.
CDS Achievement:	Clinical pathways and order sets have helped to diminish variation in care. In 2003, there was a major initiative at El Camino to promote medication safety. With the implementation of clinical decision support in CPOE, the time per medication order verification dropped to less than 15 minutes.
Lessons Learned:	In a community hospital where turnover rate is low, permanence can be a helpful factor in overall use and acceptance of CDS interventions. Making technology part of the tradition at El Camino has helped to lead to achievements such as 100% CPOE usage. It is important to immediately train new staff members on the EMR, CPOE, and CDS systems. At El Camino, a new staff member is immediately contacted by a nurse trainer who works in informatics. Training is most effective when it as at the point of use. Although classroom training can be helpful, on-site training is most valuable. This personalized training is helpful to physician adoption. El Camino has 50 clinical pathways which were decided upon by consensus with many stakeholders; these can be modified by physicians to allow more freedom. This has also contributed to clinician acceptance of CDS within El Camino.
Awards, Recognitions, and Citations:	2007 H&HN "100 Most Wired" List Ash JS, Gorman PN, Lavelle M, Payne TH, Massaro TA, Frantz GL, Lyman JA. A cross-site qualitative study of physician order entry. J Am Med Inform Assoc. 2003 Mar-pr; 10(2):188-200. PubMed PMID: 12595408; PubMed Central PMCID: PMC150372.

VA Puget Sound

Organization Name:	VA Puget Sound Health Care System (VAPSHCS)
Organization Address:	1660 South Columbian Way Seattle, WA 98108-1597 http://www.pugetsound.va.gov/
Organization Contact:	W. Paul Nichol, M.D. ACOS/Clinical Information Management Patty Hoey, RPh, CAC; CIM Program Manager
Schema Archetype:	Inpatient/outpatient, Academic Medical Centers, Federal Health Care Center
Schema Factors:	Inpatient/outpatient, Urban, 291 Beds, Academic, Hospital Setting
Organization Summary:	VAPSHCS is a complex two division health care system with a network of community-based clinics, a strong affiliation with the University of Washington, and extensive research programs. VAPSHCS provides primary through tertiary care services and support for multiple clinical programs, which include the following: 291 bed acute hospital with a full realm of medical and surgical specialties, mental health, and extended care programs; radiation therapy treatment and referral center; bone marrow transplantation center; spinal cord injury and rehabilitation center; 131-bed nursing home unit; 60-bed domiciliary, psychiatric rehabilitation, and blind rehabilitation programs; polytrauma and post-deployment health care; five community-based outpatient care centers; a home health care program; and training programs in multiple disciplines and specialties. The medical center serves 65,000 Veteran patients; with approximately 650,000 outpatient visits and 9,000 inpatient admissions annually. VAPSHCS employs approximately 850 physicians, 668 nurses, and numerous health professionals in a variety of other disciplines.
IT Environment:	VA Puget Sound adopted the Computerized Patient Record System (CPRS) starting in 1997. CPRS integrates many applications, including VistA Imaging and M databases that were part of the original Decentralized Hospital Computer Program (DHCP). The system handles the entry of 15,000 orders and 7,300 notes on an average weekday. CPRS was adopted to achieve three aims: improve data accessibility and availability; support integrated care between two facilities that are 40 miles apart; and improve quality of care through automated order entry, order checks, reminders, and collection and storage of medical records. CPRS has 10 main sections: Cover Sheet, Problem List, Medications; Orders, Notes, Consults, Surgery, Discharge Summaries, Labs, and Reports.

CDS Achievement:	The VA Puget Sound utilizes a wide variety of CDS: notifications for lab test results, orders, and documents requiring signature or review; clinical reminders; cumulative lab results and vital signs spreadsheets and graphing; quick orders (i.e., user-defined order sentences)—15,003 quick orders at time of submission; order sets—2,196 up to this time; order checks for drug-drug, drug-disease, drug-food, duplicate orders, imaging-contrast allergy checks, drug-procedure, and many others; note templates; and order standardization.
Lessons Learned:	First, unwavering institutional support was crucial as it enabled all the proper resources to be obtained, helped overcome obstacles, and focused on objectives despite the myriad of changes in funding and delivery of care. Second, Clinical Application Coordinators (CACs) with clinical backgrounds were crucial to helping the staff adopt and use the CDS in a quick and efficient manner. Third, the relatively aggressive implementation timeline (e.g., adopting CPOE on all medical, surgical, and ICU wards) was key as patients didn't have to transfer between wards with and without automated Order Entry. Fourth, extensive involvement of Nursing Service in all aspects of implementation. Lessons learned include known clinician time-saving features such as use of printed rounding notes, quick orders and order sets, templates, etc; investing in mobile workstations; including an evaluation team; focusing on cost containment measures from outset; analyzing and optimizing use of CPRS in outpatient setting to increase speed of use; and involving ward clerks, pharmacists, nurses, and other team members in planning medication order entry.
Awards, Recognitions, and Citations:	Davies Award Winner 2000

Physician Associates at Sugar Creek

Organization Name:	Physicians at Sugar Creek
Organization Address:	14023 Southwest Freeway Sugar Land, TX 77478 (281) 325-4100 phone www.sugarcreekphysicians.org
Organization Contact:	David Bauer, MD
Schema Archetype:	Outpatient, Multispecialty
Schema Factors:	Outpatient, Urban, Office Setting, >10 Providers
Organization Summary:	Physicians at Sugar Creek is a family medicine practice affiliated with Memorial Hermann. The practice has over 50 physicians and a PharmD, a dietician, a psychologist, a patient navigator, and a licensed counselor on staff. Sugar Creek sees approximately 46,000 patients per year. It also acts as a teaching practice and has 14 physicians with faculty appointments and 42 residents who spend time at Sugar Creek. Physicians at Sugar Creek has been recognized by the NCQA as a Patient Centered Medical Home. It has also been recognized by the NCQA for its work improving outcomes for diabetes.
IT Environment:	Physicians at Sugar Creek has used GE Centricity since 1998. Memorial Hermann offers some support for the EHR and CDS, but Sugar Creek works essentially independently. It does not share a database with Memorial Hermann, other than an administrative database for billing purposes. Sugar Creek has been able to customize the drug-drug interactions, drug-allergy, and drug-condition alerts that GE Centricity provides. The evidence-based knowledge in GE Centricity is updated quarterly, so that Sugar Creek has to do little work in terms of updating the evidence behind the alerts.

CDS Achievement

Sugar Creek has called upon a variety of resources to support its robust CDS systems. In particular, it has joined a collaborative known as the Clinical Quality Improvement Collaborative (CQIC) with 25 other practices. It also uses the Clinical Content Consortium (CCC) to help in the design and implementation of CDS.

By focusing specifically on quality, CQIC has created a much more sophisticated group of prompts than has been available via the vendor CDS systems. They provide both clinical knowledge for updating rules and the rules themselves. For instance, CQIC has provided Sugar Creek with an advanced clinical reminder regarding recommended blood pressure (BP) for diabetics. The BP goals vary for different levels of risk. Further, the reminders may use family history such as cancer to individualize the alerts by level of risk. Medication recommendations are also more individualized.

Working with a collaborative group requires effort by all members. Specialists within the group can help to provide guidelines and knowledge to inform the rules. Within this environment, however, practices do not need to adopt the guidelines decided upon by the collaborative.

Sugar Creek is able to achieve the vast majority of updating CDS without involving the vendor or a programmer. The alerts are text-based and readily incorporated into its system.

These robust alerts provided by CQIC and the alerts from Centricity have helped Sugar Creek to become certified as a PCMH and to achieve improved outcomes for diabetes.

The clinical reminders are also used to help train the residents in the practice and build decisionmaking skills.

Lessons Learned:

It is necessary to have a clinical champion who sees the bigger picture and understands that CDS can't be forced upon a user. The clinical champions must take into account both quality improvement and end-user goals.

Sugar Creek rolled out small numbers of alerts at a time so it could aptly judge the user response to each alert.

Belonging to a collaborative group (such as CQIC) can help practices distribute the responsibility of rule building and knowledge management.

As more structured data from the EMR is used to develop CDS, the alerts and reminders can be better individualized to the patient and better improve guideline compliance, care, and outcomes.

Awards, Recognitions, and Citations:	Excellence in Diabetes Care, *Diabetes Recognition Program, National Center for Quality Assurance (NCQA)* Level 3 Physician Practice Connections – Patient-Centered Medical Home (PPC-PCMH), *NCQA*

Valdez Family Clinic

Organization Name:	Valdez Family Clinic
Organization Address:	98 Briggs ST., Suite 800 San Antonio, TX 78224 (210) 927-9500
Organization Contact:	Alicia V. Valdez, MD
Schema Archetype:	Solo Practice
Schema Factors:	Outpatient, Office Practice, Family Medicine, Solo Providers Urban, Non-Academic
Organization Summary:	Valdez Family Clinic is a single-location family practice serving South Antonio, Texas. The practice is in an economically disadvantaged and medically-underserved community. The population is 99% Hispanic, with the majority being covered by Medicare and Medicaid. Approximately 65% of the encounters are pediatric.
IT Environment:	The Valdez Family Clinic selected MedcomSoft Record, which is a suite of software designed for use in medical offices. The MedcomSoft tools include an EHR, computerized physician order entry with clinical decision support, integration with an EKG machine, radiological image management, secure messaging, compliance checking, and other administrative tools. The software also allows staff to specify their own queries and reports of the system data. Valdez Family Clinic chose to implement an EHR that uses the Medcin nomenclature to encode data and prepare it for use by clinical decision support tools. This allowed the practice to capture all clinical information as codified data, including prescribed drugs and laboratory results. Clinical decision support could be applied to all aspects of the patient chart. Dr. Valdez and her staff were able to perform both simple and complex queries using combinations of data elements, including demographic data.

CDS Achievement:	The CPOE system implemented by the Valdez Family Clinic is used for all laboratory and prescription orders. The CPOE system has reduced the time needed to enter orders and organize results. Medical alerts for health and disease management are configured for the patients based on age and condition. The patient chart displays alerts for needed health maintenance evaluations, immunizations, or chronic disease monitoring. The staff of the Valdez Family Clinic contributed to the design of the clinical decision support systems. Medical assistants specified a list of commonly used orders and order sets. Clinicians identified a set of workflows that were commonly used in the clinic. These workflows were integrated into forms and protocols customized for the practice. Valdez Family Clinic was able to integrate training and customization through the use of remote web-based training that was minimally disruptive to the practice. The training was conducted using screen sharing on the desktop of the person being trained. This was greatly advantageous to Dr. Valdez, who could be trained in her office, during her lunch break, while creating custom protocols and forms to match her practice style.
Lessons Learned:	If a practice is interested in optimizing specific, frequently used workflows, discuss those priority workflows with the vendor or IT consultant. Such communications can help a practice optimize the way the clinical decision support fits into the work of the clinic. The active engagement of all staff members can contribute to successful implementation of clinical decision support. Flexibility in the training schedule was advantageous for busy providers.
Awards, Recognitions, and Citations:	2007 Davies Ambulatory Care Award Winner Case Study, MedcomSoft

New York Presbyterian Hospital

Organization Name:	New York-Presbyterian Hospital
Organization	New York-Presbyterian Hospital
Organization Contact:	Robert Green, MD, MPH, Quality and Patient Safety Officer greerob@nyp.org
Schema Archetype:	Inpatient, Academic Medical Centers
Schema Factors:	Inpatient, Hospital Setting, Urban, Academic, >200 Beds

Organization Summary:	New York-Presbyterian Hospital (NYP) was formed in 1999 by a merger between New York Hospital of Cornell University and Columbia-Presbyterian Hospital of Columbia University. The hospital has 2,300 beds at 5 different locations.
IT Environment:	At New York-Presbyterian Hospital, there is a clinical information system with clinical documentation, results management, order management and clinical decision support. This system has been in place since the late 1990s. Currently, NYP is using the Eclipsys Electronic Health Record (EHR) with CPOE. The EHR is interfaced with the pharmacy, nutrition services and the laboratory systems. NYP has order sets, clinical alerts, and a health maintenance dashboard system. In addition there are embedded constructs within order sets which present relevant patient data, such as lab values or most recent medication administration, to clinicians.
CDS Achievement:	NYP uses an extensive clinical alert system. The Clinical Decision Support Committee (CDS Committee) began writing rules for alerts in 1999. In 2003 the Committee created a new process for managing alert requests. This process has prioritized requests for new alerts and helped to ensure that only clinically significant alerts are used within the system. There is a heightened awareness of the potential for 'alert fatigue' resulting from too many alerts being triggered. NYP also tracks which alerts are acknowledged and the order continued (override) versus accepted (decision change due to the alert) by providers in order to ascertain clinician acceptance and utility and to provide feedback at the departmental and provider level. The new committee structure recognizes that ideas for alerts come not just from a committee setting, but from clinician users, including house staff. The nationally recognized House Staff Quality Council at NYP has bi-campus representation on the CDS committee and often generates new clinical decision support initiatives.

Lessons Learned:	The committee found it to be particularly important that every request for a new alert had a sponsoring department and a named requestor. In this case, a new alert will always have a clinical champion. This not only facilitates clinician acceptance, but also ensures that if changes are required there is always an "owner" who can be contacted. The alerts are reviewed on a regular basis to determine their continued relevancy, and the medical logic module (MLM) is appropriately updated with any new changes in practice recommendations or formulary changes. An alert request form was also part of the model. The request form organizes the request process and allows the committee to prioritize the alerts based on clinical significance and relevance. Among other information, the form requires the name of the requestor and sponsoring department, a description of the alert, the rationale for the alert, and to what department the alert might be relevant. Along with this information, requestors are encouraged to provide workflow diagrams or mock screen-shots.
Awards, Recognitions, and Citations:	Appleby, C. (2010). Clinical decision support: Building your clinical IQ. *Scottsdale Institute: InsideEdge, 16*(6), 11/08/10. doi:08/2010 Kuperman GJ, Diamente R, Khatu V, Chan-Kraushar T, Stetson P, Boyer A, Cooper M. *Managing the alert process at New York-Presbyterian Hospital*. AMIA Annu Symp Proc. 2005:415-9. PubMed PMID: 16779073; PubMed Central PMCID: PMC1560425.

Brigham and Women's Hospital

Organization Name:	Brigham and Women's Hospital
Organization Address:	75 Francis Street Boston, MA 02115 USA http://www.brighamandwomens.org/
Organization Contact(s):	David Bates, M.D. David Doolan, MBBS
Schema Archetype:	Inpatient, Academic Medical Centers
Schema Factors:	Inpatient, >200 Beds, Urban, Academic, Hospital Setting

Organization Summary:	Brigham and Women's Hospital (BWH) is a 720-bed tertiary-care hospital and a teaching affiliate of Harvard Medical School. Annual inpatient admissions total approximately 44,000, and the Emergency Department treats about 54,000 patients annually. BWH employs about 3,000 physicians, fellows and residents, more than 1,000 researchers, and 2,800 nurses. The hospital has an integrated hospital information system, accessed via networked desktop personal computers, that provides clinical, administrative, and financial functions.
IT Environment:	In 1989, BWH built the Brigham Integrated Computing System (BICS), a clinical information system running on a network of over 6,000 computers. Physicians, nurses, and administrators use the system to access lab results, discharge summaries, and other clinical data. BWH built a physician order entry system in 1991. Rollout began in May 1993 and continued for 18 months. Physicians enter all patient orders into this application, with the majority being entered in coded form. The information system in general, and the physician order entry system in particular, deliver patient-specific decision support to clinicians in real time. The most active decision support to date has focused on drugs, laboratory testing, and radiology procedures. In addition, a wide array of information is available online for physicians to consult, including literature searching, Scientific American Medicine, and the Physician's Desk Reference.
CDS Achievement:	Drug-drug interaction alerts and drug-allergy alerts are initiated as soon as the physician completes an order. Physician override of the system requires a rationale to be entered. A second round of CDS checks occur at the pharmacy. CDS identifies and pages the physician at any time of day with an alert describing a potentially dangerous situation involving a patient and asking for action. For example, if a lab test indicates a low potassium level and the patient was also taking digoxin, the physician will be alerted. CDS also alerts physicians and staff if medication doses exceed recommended levels. As a result, the percentage of patients with appropriate dosing increased from 30% to 70%. CDS allows "group orders" which significantly reduces time for order entry and greatly improves physician satisfaction with the system.
Lessons Learned:	■ Speed is everything; CDS needs to be easy to use and not time consuming. ■ Anticipate needs and delivery in real time. ■ CDS needs to fit into the user's workflow. ■ Offer alternatives rather than insist on stopping an action. ■ Simple interventions work best (single screen of info). ■ The more data elements requested, the less likely the guideline will be implemented.

Awards, Recognitions, and Citations:	Bates DW, Kuperman GJ, Wang S, Gandhi T, Kittler A, Volk L, Spurr C, Khorasani R, Tanasijevic M, Middleton B. Ten commandments for effective clinical decision support: making the practice of evidence-based medicine a reality. J Am Med Inform Assoc. 2003 Nov-Dec;10(6):523-30. Epub 2003 Aug 4. Doolan DF, Bates DW, James BC. The use of computers for clinical care: a case series of advanced U.S. sites. J Am Med Inform Assoc. 2003 Jan-Feb;10(1):94-107. PubMed PMID: 12509360; PubMed Central PMCID: PMC150362.

Cooper Pediatrics

Organization Name:	Cooper Pediatrics
Organization Address:	3645 Howell Ferry Rd Duluth, GA 30096 (678) 473-4738 www.cooperpediatrics.com
Organization Contact:	Jeffrey D. Cooper, MD, FCOP jeff@cooperpediatrics.com
Schema Archetype:	Solo Practice
Schema Factors:	Outpatient, Office Practice, Pediatrics, Solo Providers Urban, Non-Academic
Organization Summary:	Cooper Pediatrics is a one-site solo practice located in Duluth, GA in the Greater Atlanta area. The practice serves about 12,000 active patients from all social classes, with Medicare patients accounting for approximately 10% of the patient population. Cooper Pediatrics provides Well Child Care, Immunization, Hearing Screenings, Vision Screenings, Minor Injury Management, Sick Visits, and Daycare/School forms.
IT Environment:	The practice adopted an Electronic Health Record (EHR) system on December 4, 1995, and had been paperless since 1997, except for scanning and storing documents. Cooper uses EncounterPro® EHR from JMJ Technologies.

CDS Achievement: When Cooper began using templates, the office wait time from check-in to check-out decreased 42% from 60 to 35 minutes. This new, shorter wait time has remained stable for several years. The documentation templates were configured to Dr. Cooper's preferences, with the workflow conforming to the business processes of Cooper Pediatrics. Dr. Cooper did not have to change his routines to accommodate the HER; *the EHR was configured to meet his needs and preferences.*

Cooper Pediatrics also improved patient care quality with the use of rule-based prompting (allergy alerts, immunization alerts, and automated screen sequencing), note templates, and integrated and aggregated displays of relevant patient data. Dr. Cooper's quality review scores have increased from 90% to a sustained 97%. His immunization rate had increased from 90% to 99%, with more than 99% of his two-year-old patients having up-to-date immunizations.

Dr. Cooper configured and customized his EHR with documentation templates to compress the health care delivery sequence, and minimized wait time at each step of the process. Therefore, in his solo practice, he needed fewer examination rooms and a smaller waiting area than comparable practices.

Lessons Learned: *Time is the only thing a physician has to sell. The system must save a physician time*—Dr. Cooper was not in the market for EHR/CDS and knew little about the technology initially. However, a colleague gave Dr. Cooper a quick demonstration, during which Dr. Cooper used the software himself to chart a visit. Dr. Cooper was amazing at how much time the EHR saved him, and decided to take the risk and deploy the EHR in his office. Since that time, Dr. Cooper remain firmly focused on time savings as the primary issue and the key value of Health IT interventions, since time is the only thing a physician has to sell, particularly in a solo practice.

Awards, Recognitions, and Citations: 2003 Davies Ambulatory Care Award Winner (http://www.himss.org/content/files/davies_2003_primarycare_cooper.pdf)

Evans Medical Group

Organization Name: Evans Medical Group

Organization Address: 465 North Belair Rd, Ste. 1B
Evans, GA 30809

Organization Contact: Robert Lamberts, MD

Schema Archetype: Outpatient Group Practice—Multispecialty

Schema Factors:	Outpatient, Office Practice, Medicine-Pediatrics, <5 Providers Urban, Non-Academic
Organization Summary:	Evans Medical Group is a small multi-specialty group of medicine-pediatrics (med-ped) physicians and pediatricians.
IT Environment:	Evans Medical Group was a beta test site for MedicaLogic's Logician, which provided it with discounted services and training. MedicaLogic provided Evans Medical Group with the *Encounter Form Editor*, which allowed the practice to build custom encounter forms, data display templates, and rules for alerts and reminders.
CDS Achievement:	*Encounter Form Editor* also enabled Evans Medical Group to design custom clinical content using the latest disease management tools and the most current medical evidence to greatly enhance the quality of care. For example, in addition to applying the latest cholesterol and hypertension guidelines, the tool calculated cardiac risks using patient data entered into the Framingham cardiac risk formula. Not only did these forms improve the clinicians' understanding and care of patients, they have also been effective tools for patient education. When patients are shown their cardiac risks with and without smoking, it creates better outcomes than simple smoke cessation education. Similarly, by simulating the benefits of lower blood pressure on the risk calculator, both the patient and the provider were motivated by the potential improvement in health outcomes. This shared understanding greatly helps provider-patient communication, and is much more effective than the provider simply "throwing a pill" at the patient.
Lessons Learned:	Many physicians were semi-interested in health IT, but they were not dissatisfied enough with the current way of doing things that they saw any point in the radical changes needed for the implementation of health IT. However, the physician champion needs to understand these reluctant physicians are often the norm. One of the best ways to move forward is to lead by example. Instead of giving speeches to woo adoption, the physician champion should be using the system so well that other physicians couldn't help but want to use it. *If the physician champion can show his/her colleagues that health IT works better than the old way and truly makes life easier, they often have no problem changing.* This will also help the physician champion to pilot the tool to work out any "bugs" that might otherwise have discouraged early adopters.
Awards, Recognitions, and Citations:	2003 Davies Ambulatory Care Award Winner (http://www.himss.org/content/files/davies_2003_primarycare_evans.pdf) Beta test site for Logician Past President of Logician User Group

Generations +/Northern Manhattan Health Network

Organization Name:	Generations+/Northern Manhattan Health Network
Organization Address:	234 Eugenio Maria De Hostos Blvd. Bronx, New York 10451 (718) 579-5000 building.nychhc.org/Default.aspx?page_id=30&item_id=74
Organization Contact:	Maricar Barrameda NP, MSN, CIO Gregory Almond, MD
Schema Archetype:	Regional/National Health Systems/Networks
Schema Factors:	Inpatient, Outpatient, Community/non-academic, Critical Access/ Uninsured, Hospital Setting
Organization Summary:	The Generations+/Northern Manhattan Health Network (Generations+) comprises three acute care hospitals in New York City representing medically needy and underserved communities in Harlem and the Bronx. There are three Neighborhood Family Health Centers: Morrisania, in the South Bronx; Segundo Ruiz Belvis, in the South Bronx; and Renaissance Health Care Network, in Central Harlem and Northern Manhattan. Each center offers comprehensive community-based medical care. Additionally, thirty-eight family health centers, child health centers, and school-based clinics are strategically located to serve the diverse populations throughout Northern Manhattan, Central Harlem, East Harlem, and the South Bronx. Though these medically and financially distressed communities present daunting challenges to health care delivery, the New York State Department of Health (DOH) ranked the Generations+ Network among the highest in New York City for quality of care to patients based on data tracked by the DOH since 2003.
IT Environment:	Generations+ facilities are equipped with an EHR system with computerized provider order entry (CPOE); laboratory results reporting system; a picture archiving communications system (PACS) for radiological images and reports; and online EKGs.

CDS Achievement:	One of Generations+'s primary goals was to improve patient safety through the use of CPOE. In an early study, conducted at Metropolitan Hospital, there was a 40% reduction in medication errors in the first 12 months after CPOE implementation was reported. Errors due to illegible orders were virtually eliminated. Errors due to incomplete orders were reduced by 70%. The importance of workflow analysis became clear during the implementation of drug-allergy alerts. At first, allergy documentation was not linked to the medication prescribing workflow. This meant that providers did not have to document allergies before being able to access the prescribing screens. As a result, medication errors related to drug-allergy interactions were still occurring at near pre-CPOE rates. The solution to this was to integrate the two functions. Generations+ wrote a prompt for this in 2001, and since then physicians cannot place a medication order unless allergies are first documented. This new workflow requirement led to the desired reduction in drug-allergy medication errors. Physicians, the pharmacy, and nursing staff have closely monitored the effectiveness of an electronic system for the integrated management of medications. All have reported that the system improves medication safety and reduces the likelihood of human error. After implementation of the CPOE and the Integrated Pharmacy, dispensing errors in pharmacy were reduced.
Lessons Learned:	It is helpful to evaluate or monitor the impact of the new technology on a variety of outcomes, including clinical outcomes, staff workflow, and staff satisfaction. Evaluation results can help identify where additional efforts may be needed to attain the desired result of your CDS implementation.
Awards, Recognitions, and Citations:	2006 HIMSS Davies Organization Award Recipient. Award Application available at http://www.himss.org/content/files/davies/2006/HHCGenerations_Davies2006enhanced.pdf

Adventist Health System

Organization Name:	Adventist Health System
Organization Address:	111 N. Orlando Ave. Winter Park, FL 32789 407-647-4400 phone 407-975-1469 fax www.adventisthealthsystem.com
Organization Contact:	Loran Hauck, M.D.
Schema Archetype:	Regional/National Health Systems/Networks

Schema Factors:	Inpatient, Hospital Setting, Rural, Urban
Organization Summary:	Adventist is a large national health network consisting of 37 hospitals based in Orlando, Fl. There are rural and urban hospitals within the network.
IT Environment:	Adventist CDS implementation is managed at the corporate level, with a sharp line of distinction of roles. The CMIO is responsible for medical staff engagement and the CDS build. The CMO and the Office of Clinical Effectiveness are on the quality side and responsible for creating evidence-based content. Adventist began using Zynx Health paper order sets 14 years ago. In 2003, Adventist was the alpha site of an electronic platform Zynx created for authoring order sets [AuthorSpace]. Adventist spent 4-plus years authoring almost 500 order sets. The order sets are created in XML format on the AuthorSpace platform and reviewed by online committees. Adventist uses the Cerner EMR and CPOE products, which easily move the XML file from the Zynx environment to the Cerner production environment. As of early November 2010, 15 of its 37 hospitals have implemented CPOE. Adventist is implementing another hospital every two to three weeks and is on track for the entire network to comply with the Meaningful Use provisions.
CDS Achievement:	Adventist has achieved exceptional compliance within each of the hospitals where CPOE has been implemented. The CDS is "pushed" to the user. By means of the CDS interventions, new guidelines and explanations thereof may be pushed to the users. Each provider uses specialty specific order sets with built-in alerts and reminders. The order sets also provide immediate links to the evidence behind each suggested intervention, so physicians can evaluate the evidence themselves. Some order sets may be updated weekly; all order sets must be reviewed every three years.

Lessons Learned:	As a large health network, Adventist has done an exceptional job implementing clinical decision support in its hospitals. The rollout is hospital-wide with a total switch from paper to electronic. Medical staff engagement in the implementation process starts a full-year before go-live. By providing live demos and presentations, Adventist ensures that each of its providers understand the benefits of implementing CPOE with CDS. It is important to Adventist that each physician can satisfactorily answer the question: "What's in it for me?" Several months prior to go-live, Adventist divides the physicians into three non-exclusive groups: High Risk, those who might have difficulty accepting or using the CPOE system; High Volume, those who treat a significant number of patients; and Low Volume, those who are part-time physicians and will not interact with the system often. The implementation teams address these groups individually. Before go-live each physician is required to complete online training, developed in-house, and attend a 3-4 hour specialty specific computer training class. If this is not completed, some Adventist hospitals have voted to suspend admitting privileges until the required training is complete. They have found that this training requirement is a key factor for a successful hospital CPOE go live. There is extensive support after go-live via clinical champions and super-users who are available for around the clock support. Super-users are easily identified by specially colored T-shirts.
Awards, Recognitions, and Citations:	3 Hospitals within the Adventist Network are on US News "100 Best Hospitals" List Appleby, C. (2010). Clinical decision support: Building your clinical IQ. *Scottsdale Institute: InsideEdge, 16*(6), 11/08/10. doi:08/2010

Queens Health System

Organization Name:	Queens Health Network
Organization Address:	New York City Health and Hospitals Corporation HHC Central Office 346 Broadway, Suite 711 New York, NY 10013 http://www.nyc.gov/html/hhc/qhn/home.html
Organization Contact:	Diane M. Carr
Schema Archetype:	Regional/National Health Systems/Networks
Schema Factors:	Urban, Inpatient, Hospital Setting, >200 Beds, Academic

Organization Summary:	A member of the New York City Health and Hospitals Corporation (HHC) and an affiliate of the Mount Sinai School of Medicine, the Queens Health Network is the major health care provider in the borough of Queens, New York City, employing 6,106 people. Serving a population of 2 million people, Queens Health Network comprises Elmhurst Hospital Center, Queens Hospital Center, 11 free-standing medical clinics and six school-based health centers. Elmhurst and Queens are teaching hospitals, with a combined total of 771 inpatient beds and 41,660 annual hospital admissions. Rotating residents are supervised by attending physicians with faculty appointments. 748 physicians provide more than 1 million ambulatory care visits each year.
IT Environment:	Queens Health Networks implemented the Ulticare/Patient 1 EHR software by Per Se Technologies (formerly Health Data Sciences) in the beginning of 1997 primarily because of the scalability of the product, its patient-centered architectural focus, fail-soft technology, the integrated nature of the application module set and the robustness of the toolkit. The EHR supports a multi-facility care delivery model that characterizes the Queens Health Network's environment, one of the largest municipal hospital systems in the United States. All textual clinical data that has been automated resides in this EHR and is accessible from any of the nearly 3,000 PCs across Queens Health Networks. Clinicians login from their PCs via an enterprise network using redundant local- and wide-area network technologies with auto fail-over to the EHR. Once connected, they can access clinical data from today back to 1997 and also may access data that pre-dates the implementation because it was converted from legacy systems. The computerized patient record deployed in the Queens Health Network supports the clinical activities of 2,800 clinical staff members, including nearly 800 physicians who access the EHR on a regular basis.

CDS Achievement:	A number of CDS achievements were realized with the implementation of the Ulticare/Patient 1 software. For example, when the physician orders a specialty consultation online, the CDS simultaneously provides decision support, communication between services, and support for administrative processes. The CDS integrates the processes of alerting caregivers that they are placing orders for a managed care patient, displays appropriate plan specific rules regarding care, issues a plan authorization number and generates the caregiver's plan identification numbers or name of the primary care provider. They system then prints notification to the Managed Care office. An integral component of the CDS is the ability to check during medication orders for drug-drug interactions, drug-allergy interactions, and correct dosing. Additionally, alerts for duplicate orders are built into the order entry process for departmental tests, medications and specialty referrals. These are knowledge-based and defined in the database on a test-by-test basis. For example, if a caregiver orders a second urine culture test, within an hour he or she is are alerted to the fact that one is already ordered, but multiple orders for MI panels within an hour do not trigger alerts.
Lessons Learned:	The implementation of CDS at Queens Health Network has realized the following lessons. First, the CDS system and the EHR it is associated with should be seen as strategic choices for a competitive health care marketplace, especially in the areas of improving patient safety and reducing costs. Second, there is a need for a strong project manager and a high visibility project team during the implementation of CDS. Third, a partnership needs to be created between the medical staff and the project team, and physician participation in the development to ensure success. Finally, it is important to keep CDS simple and quick, especially for physician order entry functions and received alerts.
Awards, Recognitions, and Citations:	2002 Davies Award Winner

Eastern Maine Medical Center

Organization Name:	Eastern Maine Medical Center
Organization Address:	404 State Street #310 Bangor, ME 04401 (207) 973-7000 phone www.emmc.org
Organization Contact:	Eric Hartz, MD
Schema Archetype:	Inpatient, Community Hospital
Schema Factors:	Inpatient, >200 Beds, Hospital Setting, Urban, Academic

Organization Summary:	Eastern Maine Medical Center (EMMC) is a 411-bed medical center located in Bangor, Maine which serves communities in central, eastern, and northern Maine. EMMC staff includes nearly 400 providers and more than 3,000 clinical and support staff. EMMC provides three-quarters of the primary-care hospital services offered in the greater Bangor area as well as specialty and intensive care services provided to people living in two-thirds of the state of Maine. The hospital is the hub referral hospital for 21 hospitals in rural Maine. Twelve of these rural hospitals function as critical access hospitals and therefore rely heavily on their ability to funnel their patients into EMMC.
IT Environment:	EMMC's inpatient EHR started in 1983 using Cerner Classic primarily for lab and radiology orders. The EHR then evolved over time to include additional functionalities. In 2000, EMMC initiated the Patient First Initiatives (PFI) Program, a tri-fold approach to delivering high quality patient care by transforming care delivery, adopting a patient-focused culture, and implementing a technology plan that supports, but does not drive, the care delivery process. As a result of the PFI initiative, in 2001 the Cerner Classic applications were migrated to Cerner Millennium to create a unified clinical information system for the inpatient care setting. The Cerner applications include pharmacy, lab, radiology, clinical documentation, surgery, intensive care documentation, emergency department, medical records, document imaging, electronic signature, electronic medication administration record, clinical data repository, registration and scheduling. Integration of information from non-Cerner solutions is through the Cloverleaf interface engine.
CDS Achievement:	The use of CDS at EMMC began as far back as 1989 with inpatient CDS in Cerner. This CDS consisted of event-driven rules used in conjunction with the other applications to help clinicians enforce standards of treatment. Order management CDS was incorporated in the inpatient Cerner application in 2007. This consisted of order management of tests, medications, and other services that incorporate decision support engine, clinical documentation, and electronic medication record. The wide array of CDS includes drug-drug interaction, drug-allergy, dose range checking, goals/outcomes per treatment plan, advisors to hard-wire attention to core safety measures (VTE), contrast alerts, and many other types of alerts.

Lessons Learned:	A Command Center structure was put in place to provide on-the-floor, 24x7 support at least during the first 2 weeks of go-live of CPOE. Multiple training strategies were adopted to ensure CPOE implementation, including successful web-based tutorial modules. Subject matter experts and super users provided "at-the-elbow" support to end users. To avoid alert fatigue, the number of alerts was limited. Medical staff voted to mandate CPOE usage in their by-laws, and mandated competency in CPOE was required for all providers. Overall medication incidents decreased by 27% over three years.
Awards, Recognitions, and Citations:	2008 Davies Organizational Award Winner 2008, 2009, 2010 Most Wired Winner 2010 Stories of Success Tier 1 Winner

Multicare Health System

Organization Name:	MultiCare Health System
Organization Address:	PO Box 5299 MS:315-M3-CD Tacoma, WA. 98415-0299 (800) 342-9919 OR (253) 403-1000 phone http://www.multicare.org/
Organization Contact:	Matthew Eisenberg, MD
Schema Archetype:	Regional/National Health Systems/Networks
Schema Factors:	Hospital, Office, Non-Academic, Non-Profit
Organization Summary:	MultiCare is an integrated health delivery network made up of four hospitals, Allenmore Hospital, Good Samaritan Hospital, Mary Bridge Children's Hospital, and Tacoma General Hospital, totaling 818 licensed beds as well as numerous primary care and urgent care clinics, multi-specialty centers, and home health, hospice, and other services.

IT Environment:

MultiCare Connect is an enterprise electronic health record system based on an integrated EPIC platform. MultiCare owns, operates, and maintains the central data system and owns the licensing and support relationship with Epic System Corporation. Care Connect© provides MultiCare's Epic application under an Application Services Provider model to community physicians and their office based staff. The ambulatory care clinics have used Epic since 1998. MultiCare Connect includes orders and order sets for medications, laboratory tests, imaging and patient care orders, with over 330 standard acute care order sets built at go-live in 2008 and just under 400 as of February 2011. CDS is built into the system in various ways such as context-specific information, drug-drug interaction and drug-allergy alerts, drug-dose range checking, and health maintenance alerts. Additional clinical decision support resources and references are available within the electronic health record.

CDS Achievement:

MultiCare has transformed care processes and outcomes, with tremendous improvement in patient safety and quality outcomes. Over 80% of all acute care orders are now entered directly by physicians using CPOE. There was a 13% decrease in adverse drug reactions within a few months of implementing MultiCare Connect.

MultiCare has designed a multimedia training program for their system, including the CDS components. Broad adoption by physicians was supported by requiring training and competency to maintain medical staff privileges.

In the ambulatory care setting, the concept of a Smart User network for providers and other clinical and non-clinical staff was implemented to facilitate efficient use of the system. Physician webinars are hosted by Ambulatory Informatics physicians and held before office hours or during lunchtime.

The EHR generates an individualized list of all relevant health maintenance recommendations with tools to help providers efficiently place orders to comply with them. It is also available to patients who choose to access our patient portal. This effort was led by a workgroup of clinicians.

Lessons Learned:	MultiCare employs a comprehensive physician adoption and change management methodology with the goal of engaging the doctors from the very beginning. This starts with strong medical staff and operational leadership and sponsorship with goals that are focused on safety and quality rather than technology. The methodology includes validation of workflows, order set content, and system design as well as the development of a Physician Advisory Board. Further, a complete physician communication plan helps promote awareness, understanding, enthusiasm, and adoption while minimizing misinformation and rumors. Success was facilitated by many road shows, going into the community to show clinicians the product, asking them for their input, and providing a lot of training and support. Standardized order sets based on current evidence-based care are designed to promote standard care for a wide variety of clinical conditions and medical specialties. An effective process for implementing new clinical content includes review by multidisciplinary teams that include project and departmental physician champions, pharmacists, nursing staff, and other ancillary clinicians as needed. Final review and approval for clinical content is the responsibility of the Medical Staff Leadership.
Awards, Recognitions, and Citations:	HIMSS Davies Organization Award Winner, 2009 (http://www.himss.org/davies/docs/2009_RecipientApplications/MultiCareConnectHIMSSDaviesManuscript.pdf) http://www.chita.org/downloads/0902-CHITA-January-2009-Florence-Chang.pdf

Veterans Affairs, National

Organization Name:	Department of Veterans Affairs
Organization Address:	U.S. Department of Veterans Affairs 810 Vermont Avenue, NW Washington, DC 20420
Organization Contact:	Steven Brown, M.D. Steven.Brown@va.gov
Schema Archetype:	Regional/National Health Systems/Networks
Schema Factors:	Inpatient, Outpatient, Community, Academic, Military health

Organization Summary: The Veterans Administration (VA) Healthcare System, which had 152 medical centers as of January 2011, is one of the largest integrated delivery systems in the U.S. It has an extensive field structure for delivery, which includes 152 Medical Centers and more than 700 Community-Based Outpatient Clinics.

IT Environment: The VA's CDS systems are part of the Veterans Health Information Systems and Technology Architecture (VistA), a rich, automated environment that supports day-to-day operations at local VA health care facilities. VA selected MUMPS as the primary programming language and began developing applications using VA programmers who worked directly with user groups in software prototyping environments. The VA implements software on a national scale supporting integrated health care delivery.

VistA is built on a client-server architecture, which ties together workstations and personal computers with graphical user interfaces at VA facilities, as well as software developed by local medical facility staff. The CDS is embedded in the electronic medical record, called the Computerized Patient Record System (CPRS).

The VA uses BCMA and documentation forms and templates to help facilitate medication safety. There are over 30 national order checks that are performed within CPRS. Drug-drug interactions (DDI) and drug-allergy (DA) alerts are part of the order entry system. Interactions are classified as "significant" or "critical." DDI alerts are presented when an order dialog is accepted and again when the order is signed. Pharmacists are also alerted during the verification process if a prescriber overrides an alert. DDI, DA and duplicate therapy order checks are performed based on enterprise VistA (data from all 129 VistA systems) as well as DoD's electronic health record, not just local data.

The VA National Clinical Reminders Committee identifies components of reminders that will be standardized nationally, ensuring that clinicians are accountable for using clinical reminders to document identified care components.

The medical centers and Veterans Integrated Service Networks (VISNs) are permitted to continue to develop local reminders for items where no national standardization is in place and to determine local practices for those components that are not standardized. Tools are available to write both alerts and reminders, and there are also tools to share reminders.

CDS Achievement:

The VA was the earliest health care system to achieve almost 100% computerized order entry (achieved by 2002). Numerous studies have also documented the VA's high performance on quality measures associated with the use of clinical reminders and the performance incentives tied to this performance. Online and in-person training programs are available to help clinicians use the CPRS and CDS.

The VA supports national and local research, evaluation, collaboration, and development of clinical decision support. (See local VA example: Puget Sound VA). The Quality Enhancement Research Initiative (QUERI), a Health Services Research and Development (HSR&D) program, and the National Clinical Practice Guidelines Committee joined with the Office of Information, (SD&D), to design national reminders and dialogs that promote informed decisionmaking and consistency of care practices.

For example, the Palo Alto VA has been developing, implementing, and evaluating automated CDS systems under the ATHENA-CDS project. These "knowledge-based" systems contain encoded clinical knowledge (typically from VA-DoD guidelines, supplemented by other sources). The encoded Knowledge Bases can be processed with patient EHR data to generate recommendations for clinical management. This has been developed extensively for hypertension and chronic pain management. There are many more examples of local VA research to improve the effectiveness and use of CDS for care management and avoidance of medical errors.

Lessons Learned:

Mandatory and highly supported adoption, the deployment of clinical application coordinators at each VistA site, the linkage of CDS with performance measures and incentives, and readily accessible CDS training tools have all been associated with the high and effective use of CDS.

Facilitating and funding local VA research and collaboration with academic and clinical partners has led to important CDS improvements and knowledge, as well as improved care to veterans.

Awards, Recognitions, and Citations:	Several local VA centers have won Davies and other awards. (see Puget Sound example). The White House has praised the advanced technologies of the VA's VistA system and suggested that it could be widely distributed to private medical practices: http://archinte.ama-ssn.org/cgi/content/full/165/10/1111 The VA won an Innovation Award from the Kennedy School at Harvard: http://www.innovations.harvard.edu/awards.html?id=39711 VA's CDS described in VistA VA's CDS described in VistA Monograph: http://www4.va.gov/vista_monograph/ VA Online training of VISTA and CDS: http://www.vehu.va.gov/vehu/WBTPages/WBT08.cfm?ClassNum=157 The Software Document Library for Clinical Reminders is available at http://www.va.gov/vdl/application.asp?appid=60 There are numerous studies on the CDS systems in the VA as well as studies documenting that the VA has achieved high performance on quality measures related to the use of clinical reminders. Studies show improvement in treatment, prevention, and documentation quality.

Wishard Memorial Hospital

Organization Name:	Wishard Memorial Hospital
Organization Address:	1001 W. 10th St. Indianapolis, IN 46202 (317) 639-6671 www.wishard.edu
Organization Contact:	
Schema Archetype:	Inpatient, Community Hospitals
Schema Factors:	Urban, Inpatient, Hospital Setting, >200 Beds, Academic
Organization Summary:	Wishard Health Services (WHS) is affiliated with the Indiana University School of Medicine and includes a safety-net teaching hospital, a Level 1 trauma center, and a primary care network composed of nine community health centers with integrated mental health services. WHS is run by the county tax-supported Health and Hospital Corporation of Marion County, IN which is also responsible for the county health department. WHS is renowned for its use of technology.

IT Environment:

In partnership with the Regenstrief Institute, Wishard Memorial Hospital has been a national leader in clinical information systems since 1972. Over this 40-year period, its electronic health record has evolved into one of the Nation's most successful health information exchanges, Indiana Health Information exchange, with agreements to share data across more than 70 hospitals. These information systems and clinical data have led to more than 300 peer-reviewed scientific publications.

The IT environment supports research activities in clinical informatics, public health informatics and biosurveillance, bioinformatics, clinical decision support, clinical epidemiology, pharmacoepidemiology and pharmacovigilance, comparative effectiveness research, and health informatics to support prospective clinical research.

CDS Achievement:

Per a 2006 systematic review, Regenstrief investigators and Wishard information systems are among the world's top four systems responsible for high-quality, evidence-based research proving the impact of information technology on the quality of health care.

Through Wishard's relationship with the Regenstrief Institute, investigators also (a) collaborate with the Department of Veterans Affairs (another of the top four health informatics research systems), and (b) participate in the CDS Consortium that also includes Brigham and Women's Hospital, Harvard Medical School, Partners HealthCare Information Systems, the Veterans Health Administration, University of Texas School of Health Information Science, Oregon Health Sciences University, Kaiser Permanente, Mayo Clinic, NextGen, Siemens Medical Solutions, and GE Healthcare.

Lessons Learned:

The results of 40 years rigorously testing the effects of information systems within Wishard's health system are summarized in scores of related published peer-reviewed journal articles.

Landmark findings have included:
1976 – Computer reminders reduce clinical errors, such as those related to hypertension and medications.
1984 – A medical record system integrated with computer reminders increases preventive care in the outpatient setting.
1988 – Displaying prior diagnostic test results reduces test ordering.
1990 – Displaying the charges for diagnostic tests reduces test ordering.
1993 – Inpatient computerized physician order entry (CPOE) lowers hospital costs.
1998 – Computer reminders increase advance directive discussions.
2001 – Computer reminders increases inpatient preventive care.
2002 – Sharing data between institutions decreases Emergency Department charges.
2007 – Computer reminders increases appropriate contact isolation rates and decreased the time to isolation.
2010 – CPOE can reduce adverse drug events by 80% (submitted for publication).

This partnership has also amply demonstrated that not all CDS works, and that workflow, human factors associated with CDS tools, and physicians' attitudes towards computers and guidelines are critical in maximizing its effects.

Awards, Recognitions, and Citations:	National Association of Public Hospitals (NAPH) President's Health Reform Readiness and Leadership Award 2010
	Davies Award Winner 1997
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	Dexter PR, Perkins S, Overhage JM, et al. A computerized reminder system to increase the use of preventive care for hospitalized patients. N Engl J Med 2011; 345:965-970.
	Mamlin BW, Overhage JM, Tierney WM, Dexter PR, McDonald CJ. Clinical decision support within the Regenstrief Medical Record System. Book chapter – Clinical Decision Support Systems—Theory and Practice—Series: Health Informatics, Berner, Eta S. (Ed.) 2nd ed., 2007, 190-214.
	McDonald CJ, Overhage JM, Barnes M, Schadow G, Blevins L, Dexter PR, Mamlin BW. The Indiana network for patient care: a working local health information infrastructure (LHII). Health Affairs Sept/Oct 2005; 24(5):1214-1220.

Appendix B – CDS Targeted Literature Review Search Strategy

After experimenting with a variety of search strategies and MESH terms the following strategy was used:

(Decision Support Systems, Clinical* + Implementation) or (Decision Support Systems, Clinical* + Adoption) or (Decision Support Systems, Clinical* + Training)

The CDS bibliography created by the POET Team (Ash et al.) was canvassed for resources fitting our criteria but not found within our initial search:

http://www.ohsu.edu/academic/dmice/research/cpoe/cds_biblio.php

Appendix C – Results of Literature Review on Clinical Decision Support Implementation

1. Duke University hospital uses rapid deployment to implement CPOE, clinical decision support. Perform Improv Advis. 2005 Apr;9(4):44,6, 37.

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