Integrating Clinical Decision Support Tools into Ambulatory Care Workflows for Improved Outcomes and Patient Safety

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Overview

Electronic Health Records (EHRs) are widely viewed as a powerful technology to help clinicians improve quality of care for patients and contain costs. In order for EHRs to reach their potential, complex data must be rapidly accessible and easily understood from within the care team's workflows so that everyone involved in a patient's care can use the information to make better clinical decisions. Clinical decision support (CDS) tools within the EHR should be designed to organize, filter, and present useful information at the appropriate point in time to the person who can use it to make a decision. When implemented properly and used correctly these tools should produce measurable improvement in the clinical decisions made by clinicians, care teams, and patients.

The purpose of this paper is to weave together a number of different key perspectives into a conceptual framework for CDS that results in a concise and practical implementation guide to help clinicians, care teams, and their patients use the information in EHRs to improve outcomes.

This paper first addresses the different kinds of thought processes that clinicians use during the course of their work and shows how different types of CDS tools can be designed to optimize different types of thinking. Second, it summarizes the current best practice for designing the CDS tools and integrating them into clinical workflows. Finally, it reviews the organizational issues required for successful implementation and management of CDS on a scale large enough for it be effective.

Introduction

There are many reasons that healthcare facilities implement electronic health records (EHRs); among those reasons are qualifying for federal incentives and avoiding penalties, participating in value-based reimbursement, a desire to provide better care, and to fulfill a requirement for quality recognition. However, from a policy perspective, the logic for investing in certified EHRs is based upon the assumption that information technology is a prerequisite for measuring and managing both quality and cost.

The 2009 HITECH Act (1) and the 2010 Affordable Care Act (2) were designed as part of a national strategy to improve the quality of care for individuals and the health of populations while reducing the overall costs of healthcare (3). Although the tactics for achieving this Triple Aim largely involve creating and adjusting financial incentives, actual improvements in care and better management of costs almost always take the form of individual decisions made by clinicians, care teams, delivery systems, and patients. For EHRs to meet their potential of measuring and managing quality and containing costs, the information in them must be used to drive better decision-making on a micro-level that cumulatively will achieve the Triple Aim.

This is no small task. The expansion of information for which clinicians and their care teams are responsible presents a huge challenge (4). For EHRs to help inform better clinical decisions, they must be able to display complex information in familiar patterns so that the data can be easily incorporated into the workflow for clinical decisions. EHR features that do this are called clinical decision support (CDS), which can be defined as "the process of providing persons involved in patient care with intelligently filtered and organized information at appropriate times, to enable decisions that optimize healthcare and health outcomes" (5).

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Clinical Decision Support: Integrating Computer Logic with Human Thinking

In 2000, an editorial in the *Journal of American Medical Informatics Association* (6) succinctly described the cornerstones of medical informatics as:

1) Creating structures to represent data and knowledge so that complex relationships can be visualized,
2) Developing methods for data acquisition and presentation that avoid information overload,
3) Managing change so that information use is optimized, and
4) Integrating information into work processes so it can be acted on when it has the greatest effect.

CDS rests squarely on these principles because it is about the process of bringing discrete data from the EHR into clinical setting workflows for decision-making. However, there exists a tension in the exam room between clinicians' efforts to capture key elements of patients' narrative histories in their chart notes and the need for information to be entered as structured data for use in decision support, billing, reporting, and research. The

paradox of CDS is that while only structured data can be used as input for CDS, the output of CDS must be able to integrate seamlessly with the fluid and variable workings of the minds of clinicians, other care team members, and patients in the unpredictable setting of the office visit if it is to have the desired effect.

It would be natural to assume that clinicians spend their workdays using their minds in an intensely analytical mode evaluating probabilities of diagnoses, or weighing the risks versus benefits of various treatment options. For learners and new graduates this is likely the case, however after a number of years of practice, seasoned clinicians invariably experience a subtle shift to a level of thinking in which they can rapidly and usually quite accurately distinguish important information from extraneous data through a combination of pattern recognition and intuition with little cognitive effort. Recent work popularized by the Nobel Prize winning psychologist Daniel Kahneman offers insight into how this mental process works (7).

The fast thought process, which Kahneman calls System 1, runs automatically and involuntarily using memory and experience to guide rapid intuitive decision-making. This is the standard operating mode for people most of the time as long as everything fits within the boundaries of "safe and as expected." The slower thought process, which Kahneman calls System 2, must be activated in response to a challenge or a surprise (i.e., when something unexpected, difficult or potentially threatening appears). Using System 2 involves effort and is perceived as work, which means that the person must take discordant information seriously enough to shift gears from System 1 into System 2 in order to analyze it.

The Kahneman model is compelling as it explains modes of thinking across all individuals. The fact that clinicians are no different than anyone else in how they process information means that the dynamic interplay between Systems 1 and 2 (fast and slower thinking) must be taken into consideration when designing tools that present information to clinicians during the course of patient care. Many CDS tools are well designed to support the fast System 1 thinking by providing structure to routine workflows and making organized information readily understandable at a glance. Other CDS tools are better suited to alert clinicians to a surprise or threat and to lower the barriers of activating the slower System 2. Still other CDS tools make it easier to find and organize information that System 2 will need to complete its analytical work.

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Available Clinical Decision Support Tools

In its 2012 landmark *Improving Outcomes with Clinical Decision Support: An Implementer's Guide,* a Healthcare Information and Management Systems Society (HIMSS) work group categorized existing CDS tools into six categories (8):
1) Documentation forms and templates,
2) Relevant data presentation,
3) Order and prescription facilitators,
4) Protocol pathway support,
5) Reference information and guidance,
6) Alerts and reminders

Building on Kahneman's cognitive model of thinking fast and slower, the first three of these tools can be set up to passively guide the user in fast-thinking mode through a routine workflow where the outcome is predictable. The challenge is to avoid omission errors that can occur for many reasons including fatigue and interruptions from competing demands among others.

Protocol pathway support and reference information are often most useful for complex problem solving and along with relevant data presentation they are the mainstay of slow analytical thinking. These tools can save clinicians time and effort if they are engineered to be easily available upon demand. While any information at any time may trigger the activation required for clinicians to shift from fast to slow thinking, alerts and reminders are specifically designed to do so, which is one of the reasons they are so counterproductive when they represent a "false alarm."

1. Documentation Forms and Templates:

Managing the tension between the need for structured data and the fluid nature of the conversations between clinicians and patients that result in narrative chart entries can present a challenge when designing chart note templates (9). Efforts to reduce a patient's history to a series of data entry field inputs that the EHR uses to produce a narrative text may work for simple conditions, such as uncomplicated upper respiratory infections or highly choreographed procedures, but they tend to be inadequate for many clinical situations.

At the same time, some parts of a clinical encounter, including the review of systems and even physical exam findings, are highly structured and have findings that are either normal, or even if not normal, can be easily categorized to simplify data entry. Documentation forms can also be set up for patients and care team members to enter portions of the past medical and social history as structured data. A well-designed visit template allows a clinician to dictate or type a narrative note into the subjective portion of the template while using structured data entry appropriately for portions of the note. The template represents a series of soft prompts to assure essential information is not overlooked.
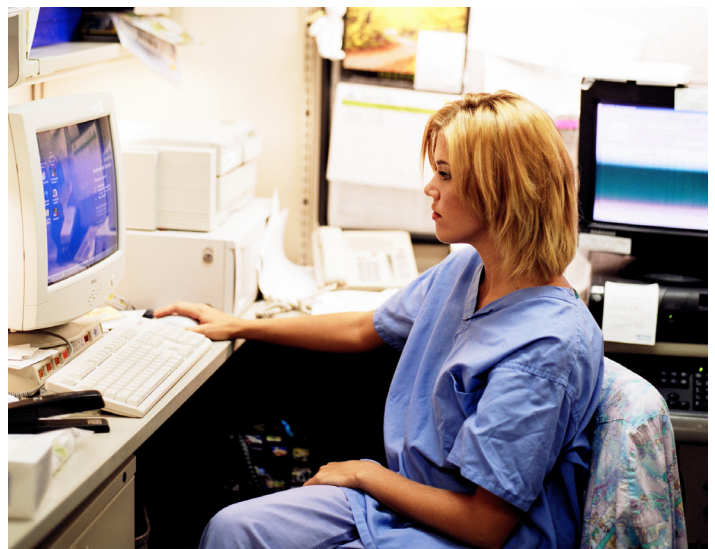
Figure 1. Charting Template

```
Date: {.date}
Time: {.time}

The patient is a {.age} year-old {.sex} presents with the following issues on which {.he} wishes to focus attention:
***
***

SUBJECTIVE:
1) ***
2) ***

REVIEW OF SYSTEMS:                                    Negative
Constitutional: {ros_constitutional:: "negative"}     Negative for: ***
Eyes: {ros_eyes::"negative"}                          Negative for:
ENT: {ros_ears/nose/throat::"negative"}               {ros_cardiosxs}
Cardiovascular: {ros_cardiovascular::"negative"}      As noted in HPI above
Respiratory: {ros_respiratory::"negative"}            Positive for: ***
GI: {ros_gastrointestinal::"negative"}                Positive for: {ros_cardiosxs}
Genitourinary: {ros_genitorurinary::"negative"}       Deferred
Musculoskeletal: {ros_musculoskeletal::"negative"}
Skin: {ros_dermatological::"negative"}
Neuro: {ros_neurological::"negative"}
Endocrine: {ros_endocrine::"negative"}
Psych: {ros_behavioralhealth::"negative"}
Heme/Lymphatic: {ros_hematology/lymphatics::"negative"}
Allergy/Immun: {ros_allergies/Immunology::"negative"}
```

Figure 1 shows an example of a portion of a charting template in which the *** symbol is a cursor-stop, allowing the user to quickly move to the next item with a single keystroke. In this case, the template prompts the clinician to start each visit by setting an agenda with the patient by identifying and prioritizing all the issues the patient wishes to discuss with an agreement that lower priority issues may need to be addressed at a future visit. This establishes shared expectations for what can be accomplished during the visit and reduces end-of-visit surprises (10). The clinical history for each item in the "subjective" section on the agenda can be either typed as text or dictated depending on clinician preference.

The Review of Systems section is set up to prompt the provider to ask and quickly document an important part of the visit that is often overlooked. If a response is negative the clinician can simply hit the return key to move to the next item because "negative" is programmed as the default, whereas if he or she wishes to document in more detail a positive or negative response can be quickly entered either as text or chosen from a dropdown list.

Once a clinician has mastered the hand-eye coordination for this type of template it can be used to finish charting in the exam room and provide structure to the encounter without disrupting the conversation or the rapid intuitive thought process in which many routine encounters are conducted. Of course, any item elicited during the history or the review of systems may activate the clinician to switch to the slow analytical thought process, but the template itself does not interfere.

This particular template format is general enough to cover most adult primary care encounters. Other templates can be designed for specific situations such as preventive exams or procedures. As multidisciplinary teams become more sophisticated in sharing the care charting templates can be designed to support all care team members.
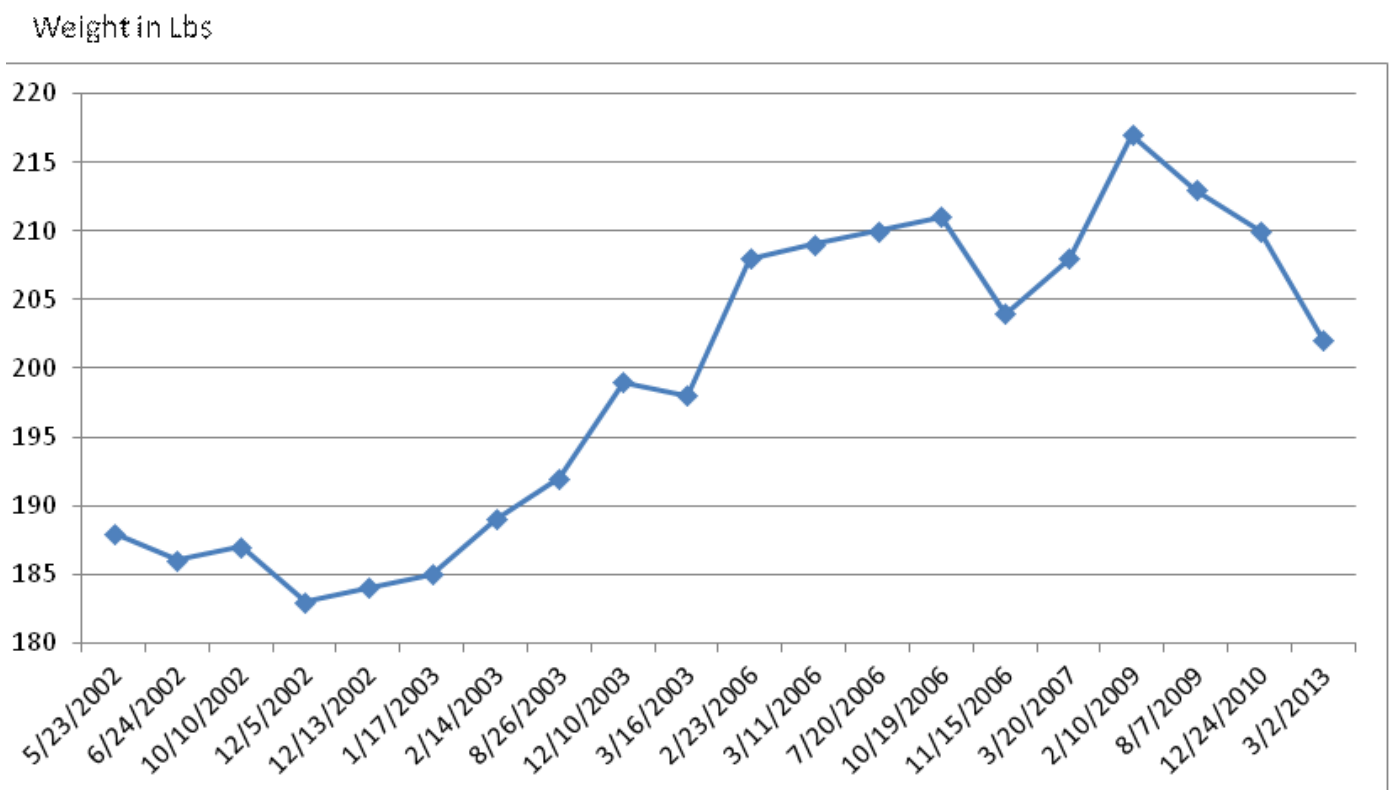
2. Relevant Data Presentation:

There is no doubt that there are yet-to-be-discovered ways of presenting information to clinicians. However, most current EHR data display tools can be characterized as either graphs, dashboards or flow sheets. These tools serve to group and display complex information visually so it makes sense at a glance, highlights issues requiring attention, or reveals important patterns over time. These EHR tools support the busy clinician in both fast and slow types of thinking. They can improve the accuracy and effectiveness of rapid intuitive thinking so that the user can quickly determine that everything is in order. At the same time, well-designed data presentation makes problems both easier to spot and less work to solve.

Graphs: The graphic display of information over time helps the viewer's eye quickly recognize patterns that may otherwise be hard to see. Figure 2 shows a graph of a patient's weight in a way that the numbers "speak

Figure 2. Graphs

Weight in Lbs

for themselves." Viewing this graph with a patient, the clinician is less likely to focus on the fact that the patient is overweight and more likely to start by acknowledging that the patient is now successfully losing weight thereby leading to a discussion on how to sustain this positive outcome. Graphs make also it easier to see worrisome trends in laboratory values, such as a rising creatinine or dropping hemoglobin, when the values themselves are still in the normal range.

Dashboards: Dashboards assemble and organize relevant information on a particular topic. This is work that the clinician or care team would otherwise have to do. A glance at a dashboard showing an overview of a chronic illness or preventive care can help the care team quickly decide where to focus their attention, and it can make it easier to safely delegate simple decisions to non-clinician team members. Dashboards are often of greatest value in fast thinking if they are simple and present the minimum information required to make a decision.

Figure 3 demonstrates how dashboards can facilitate decision making at a glance about which orders to place for monitoring diabetes. The user can quickly respond by ordering a test without changing screens. If the most recent value requires further analysis, another button will take the user to a second screen that helps analyze that specific parameter. Designers of CDS should consider whether the purpose of a dashboard is to support fast thinking (for example in Figure 2), or slower analytic thinking. Dashboards with too much information for fast thinking require extra work to analyze, thereby increasing the probability that the dashboard may be ignored. Other dashboards specifically designed for analytic thinking need to have as much relevant data for a topic as possible on a single screen.

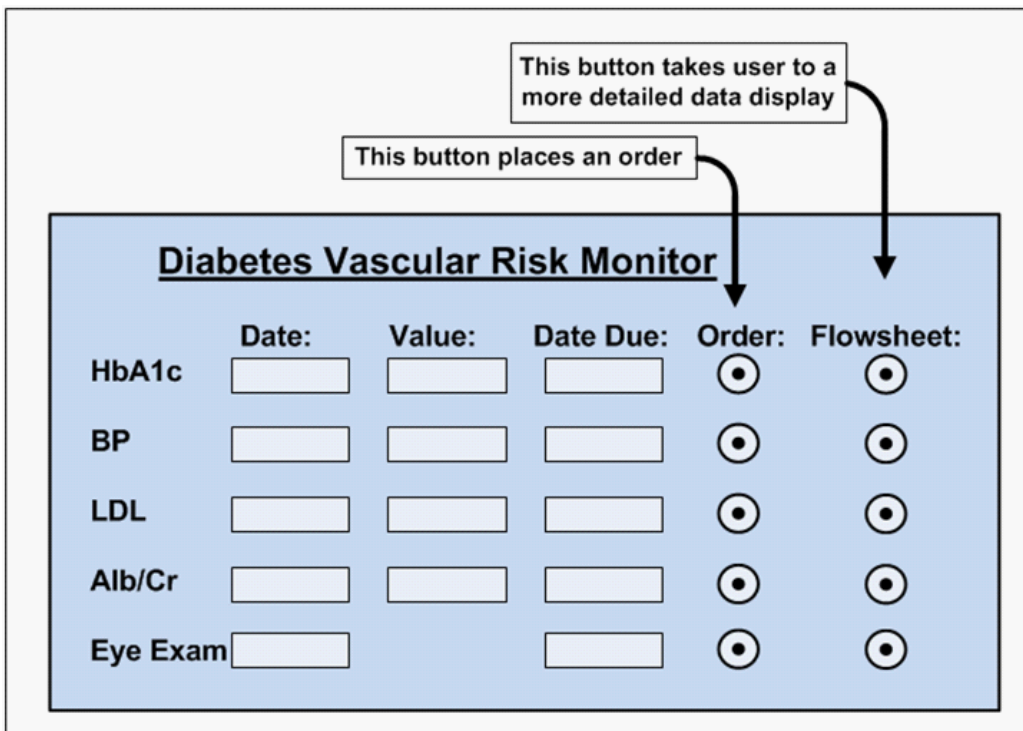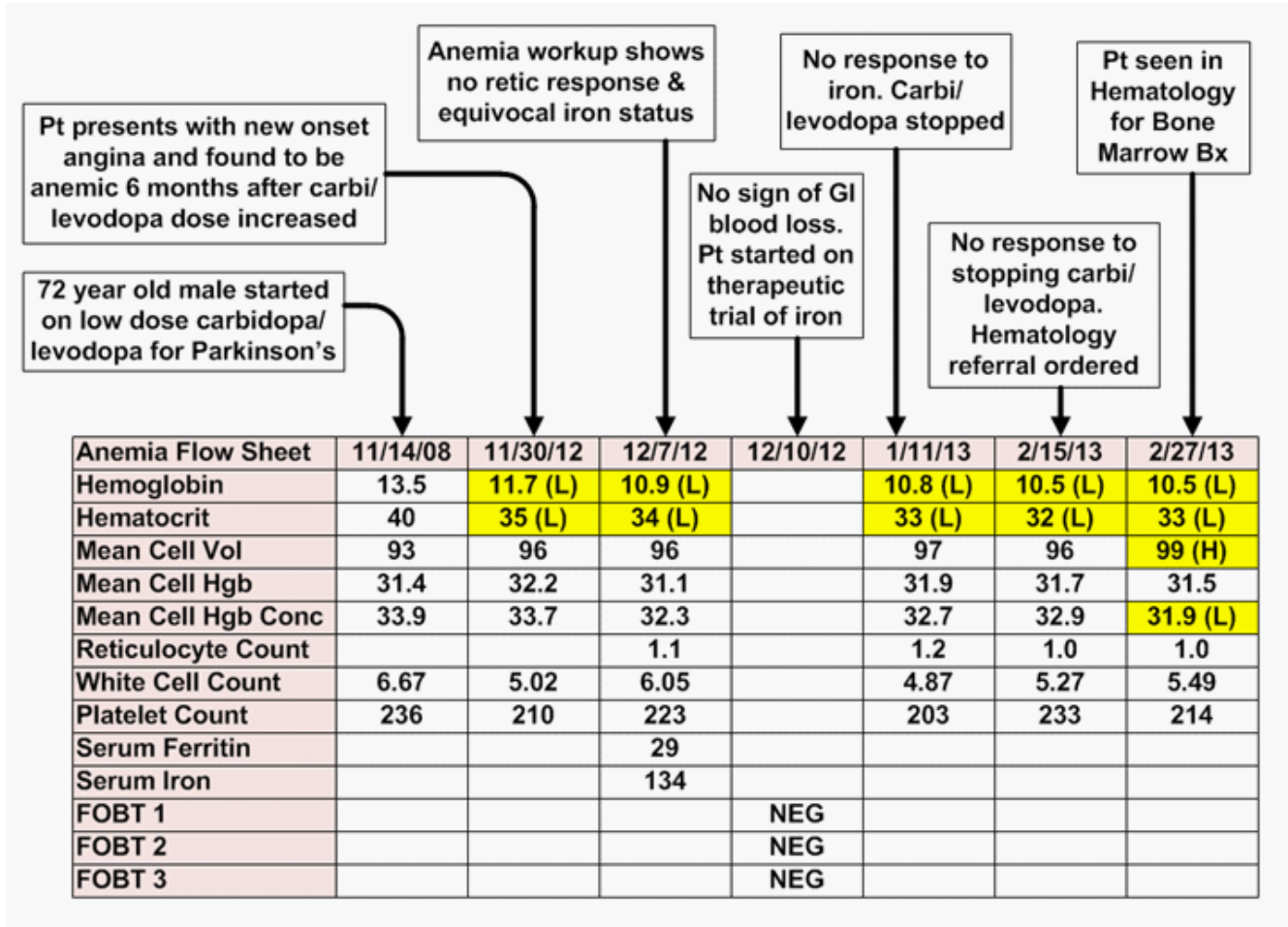Figure 3. A Simple Diabetes Dashboard

Figure 4. Flow Sheets

Pt presents with new onset angina and found to be anemic 6 months after carbi/levodopa dose increased

72 year old male started on low dose carbidopa/levodopa for Parkinson's

Anemia workup shows no retic response & equivocal iron status

No response to iron. Carbi/levodopa stopped

Pt seen in Hematology for Bone Marrow Bx

No sign of GI blood loss. Pt started on therapeutic trial of iron

No response to stopping carbi/levodopa. Hematology referral ordered

Anemia Flow Sheet	11/14/08	11/30/12	12/7/12	12/10/12	1/11/13	2/15/13	2/27/13
Hemoglobin	13.5	11.7 (L)	10.9 (L)		10.8 (L)	10.5 (L)	10.5 (L)
Hematocrit	40	35 (L)	34 (L)		33 (L)	32 (L)	33 (L)
Mean Cell Vol	93	96	96		97	96	99 (H)
Mean Cell Hgb	31.4	32.2	31.1		31.9	31.7	31.5
Mean Cell Hgb Conc	33.9	33.7	32.3		32.7	32.9	31.9 (L)
Reticulocyte Count			1.1		1.2	1.0	1.0
White Cell Count	6.67	5.02	6.05		4.87	5.27	5.49
Platelet Count	236	210	223		203	233	214
Serum Ferritin			29				
Serum Iron			134				
FOBT 1				NEG			
FOBT 2				NEG			
FOBT 3				NEG			

Flow sheets: Flow sheets, like graphs, show data over time, but they do so with numbers making them better suited for slow analytic thinking than fast thinking. They often contain a story that makes sense in the context of the course of a disease, dose of a medication a patient is taking, or illustrating where the patient fits in a diagnostic algorithm. Figure 4 shows a flow sheet designed to help a clinician navigate the complexities of an anemia work up. By assembling important information over time, the flow sheet helps the clinician organize and track the course of a work up.

Figure 4 portrays the workup of an elderly patient with Parkinson's disease who presented with new onset angina and was discovered to be anemic six months after increasing the dose of an anti-Parkinson's medication known to cause bone marrow suppression. One of the questions the clinician needed to answer was whether the anemia was related to iron deficiency from an undiagnosed intestinal lesion, from the medication or caused by some other unrelated process. As it turned out, the patient had a low-grade myelodysplasia unrelated to the medication. By displaying the information from the workup in a flow sheet the clinician (or a covering clinician) can quickly reorient upon reviewing the chart after an interval of several weeks and pick up the work up where it left off.

3. Order/Prescription Creation Facilitators:

Clinical decisions usually result in orders for tests, medications or referrals. Although some orders are simple, many clinical decisions require multiple orders to be correctly carried out. Medications may require dose adjustments based on the patient's weight or renal function, and orders for referrals require coordination between primary care providers and specialists to assure that key information is available when the consultant first sees the patient. CDS can be used to embed prompts into the orders that help the referring clinician ensure that important details are not overlooked.

Order sets: Many orders contain multiple facets, including documenting the decision, preparing a place in the chart for the results to be entered, and linking the decision to a diagnosis and a billing code. The complexity of these details makes them prone to errors that can be reduced by order sets that "pre-package" these different parts of the decision so they require as little extra work as possible.

Figure 5. Order set for a simple procedure

An example of a very simple order set is shown in Figure 5, where the most common components of a punch biopsy are presented together in an order set that the clinician must only accept once to activate all of the related parts. The "details" buttons in the orders will take the clinician to a screen to enter the location of the lesion and details of the biopsy if necessary. Likewise the "edit" section of the progress note contains a template to document details of the procedure. Order sets reduce the risk of omission errors requiring later rework. More complicated order sets are used for complex tasks such as hospital admissions or transfers in and out of an intensive care unit.

Figure 6. Order Facilitators

MRI Chest with or without contrast	
Status	NORMAL
Class	Visible Radiology Associates
Priority	Today

Reason for exam	72 y.o. male smoker new coin lesion LUL plain film
Relevant medical conditions	•••
Internal metal or medical devices	•••
Was Creatinine oredered today?	No ⊙ Yes ⊙
Date Last Creatinine:	12/15/2013
Order today if more than 4 weeks since last creatinine	⊙
Comments:	

No Relevant Conditions
Anticoag Tx
Asthma
Claustrophobia
IV Access Issues
Multiple Myeloma
Chronic Renal Failure
(Accept) (Cancel)

No metal or devices
Brain aneurism clip
Nerve stimulator
Pacemaker
Other: Please note in comments
(Accept) (Cancel)

Structured orders: Orders frequently require consideration of specific contingencies that can be built into the order using CDS to reduce the risk of errors that often result in waste and patient-safety issues.

In Figure 6, an order for a magnetic resonance imaging (MRI) of the chest prompts the ordering clinician to alert the imaging center to co-morbidities and internal metal that may increase the risk of the procedure to the patient. It also prompts the clinician to make sure that a current renal function test is in the chart should the imaging center need to use intravenous contrast material to evaluate a lesion.

Prescription facilitators: The use of medications has increased dramatically over the past several decades creating a major challenge for clinicians and patients (11). Not only must clinicians avoid prescribing medications that potentially interact with something the patient is already taking; clinicians also must frequently look up starting doses, maximum safe doses, and locate dose calculators based on weight, body surface area, or renal function. Many symptoms and abnormal findings may be caused by medications a patient is taking requiring the clinician to research uncommon side effects. All of these medication-related challenges force the busy clinician to stop and look up information, much of which could be engineered as CDS into the EHR so as to be available on demand by, for example, right clicking or holding the cursor over an entry on the medication list or preference list.

4. Alerts and Reminders:

There are an almost infinite number of cues that can cause the clinician to slow down and analyze a situation in response to new or unexpected information. Unlike the other CDS tools, which are most effective when tailored to either fast or slow thinking, the purpose of alerts is to disrupt fast thinking and force clinicians to exert additional effort in response to information that is likely to have been overlooked. Figure 7 shows an example of such an alert, which serves as a sort of "guard rail" to prevent prescribing a medication to which a patient is documented to have a serious allergy. Alerts need to be used sparingly and reserved for situations in which there is an imminent risk to the patient because "false alarms" quickly desensitize users who then are apt to "click them aside" without reading them. Alerts should be designed to minimize unnecessary disruption by including ways to respond without backing out and having to navigate to some other screen.

Figure 7. An alert triggered by a drug allergy interaction
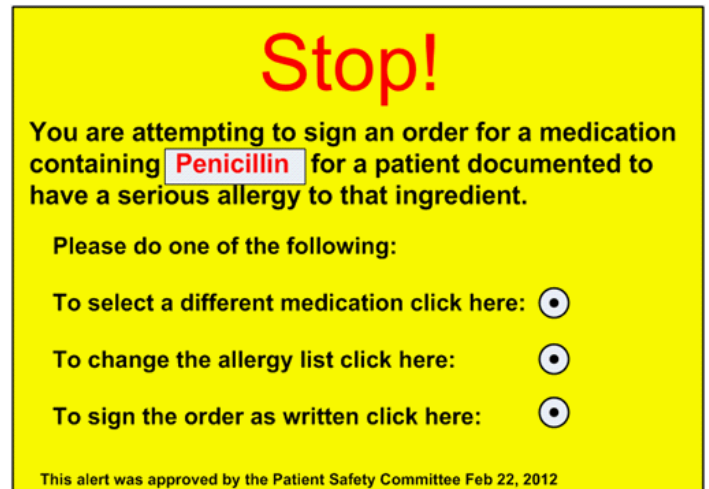
Reminders can be set up to be less disruptive than alerts. The goal of reminders is to make information available to the clinician without requiring that the issue be addressed immediately. Figure 8 shows a reminder that could easily display in a corner of a computer screen. In this case the reminder orients the user to a list of issues that pose the greatest risks to the patient's health regardless of the reason for visit. Reminders can also be built into order sets and referrals to prompt the ordering clinician to obtain specific tests in advance of a referral for a particular condition.

Figure 8. Reminders
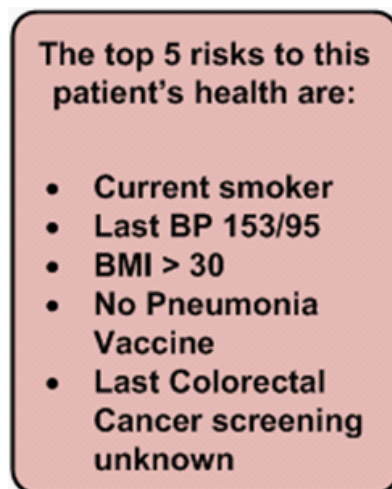
5. Protocol Pathway Support:

Each diagnostic problem requires a clinician to narrow down the patient's symptoms, physical findings, and test results to identify important patterns among a background of extraneous information. Many diagnoses and treatment strategies have a "pathway" outlining a best practice, or at least a logical current standard based on scientific evidence. Some of these protocols are quite simple, and clinicians can often keep many of them in their heads, but for the remainder a clinician must choose between spending the effort to locate a protocol or pathway and simply proceeding on memory alone. The more CDS can reduce the effort required for clinicians to use readily available evidence-based protocols, guidelines and pathways, the more likely it is that major gaps in clinical quality and patient safety can be closed. Figure 9 shows one of several guidelines available for managing a patient with a cervical cancer screening result showing atypical squamous cells of unknown significance (ASCUS). Making such protocols rapidly available to clinicians, care team members, and patients can reduce much of the anxiety and uncertainty about diagnoses like "abnormal pap smear." It is important that users be able to easily identify the source of the decision protocols they are using and that there be a mechanism for keeping them properly cataloged and current.

Figure 9. Protocol Pathway for Cervical Cancer Screening ASCUS Result

Based on recommendations by the American Society of Colposcopy and Cervical Pathology 2007
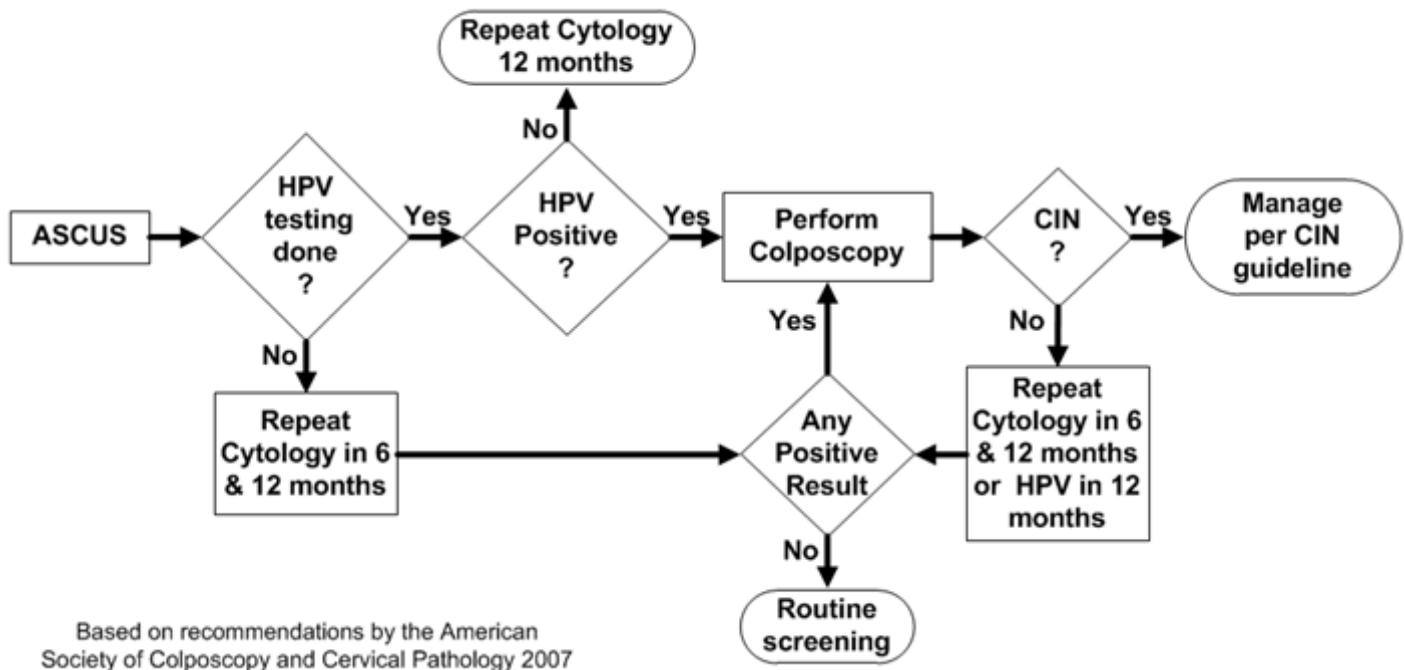
6. Reference Information and Guidance:

Many diagnostic and treatment challenges are too complex for protocol decision-tree graphics. Clinicians frequently encounter situations in which they need to quickly review the approach to a symptom or abnormal finding, or look at an overview of a specific clinical illness or syndrome. These represent the modern equivalent of classic medical textbooks providing support for clinicians when dealing with a diagnostic challenge or managing a complex medical condition. This type of CDS usually connects the user to a web-based information service kept current by an external vendor.

Clinical Decision Support and the Five Rights

In addition to consideration of whether CDS tools support fast or slow thinking, the timing and availability of the appropriate tools is critical. The HIMSS *Improving Outcomes with Clinical Decision Support: An Implementer's Guide* (8) defined five things that CDS must to do right in order to be effective:

It must get the right information to the right person at the right time, using the right channel or medium, and with the information in the right format.

The Right Information: Information in CDS must be what the user wants and/or needs. It should be evidence-based, and it should be actionable in a way that requires as little additional effort by the user as possible.

The Right Person: The person to whom the "filtered and organized" information should be presented can be a clinician, but it might also be another care team member or the patient. The right person is the one able to use it to make a decision that will impact clinical care.

The Right Time: The right time means when the user wants it and is ready to use it; in other words, at the point in time it can be acted on to make a decision.

The Right Channel: This is usually through some feature of the EHR, although it might be a report based on EHR data, a printed piece of paper with information given to patients, or information visible to patients through a portal.

The Right Format: As demonstrated above, there are numerous formats for presenting organized information in the EHR and the patient portal that can be matched appropriately to the context in which it will be used. The Five Rights are intended to serve as a checklist for CDS designers and quality improvement experts to use for assuring that their interventions are properly integrated into workflows. They also provide a useful framework for clinicians to evaluate CDS interventions during development and testing so they can provide clear feedback to the informatics leadership about ways the tools can be optimized for use as intended.

Implementing Clinical Decision Support on a Workflow Level

The "Five Rights" underscore the importance of integrating CDS into the workflows used by clinicians and their care teams to treat patients, manage populations, and coordinate care. CDS is not an end in itself; rather it is a toolset for improving decisions that clinicians and their care team make throughout the cycle of care, including the office visit, depicted at a high level in Figure 10. Each of the segments of the high-level workflow contains within them multiple detailed workflows into which CDS must be integrated, guided by the Five Rights.

Figure 10. High-level View of the Ambulatory Care Workflow Cycle
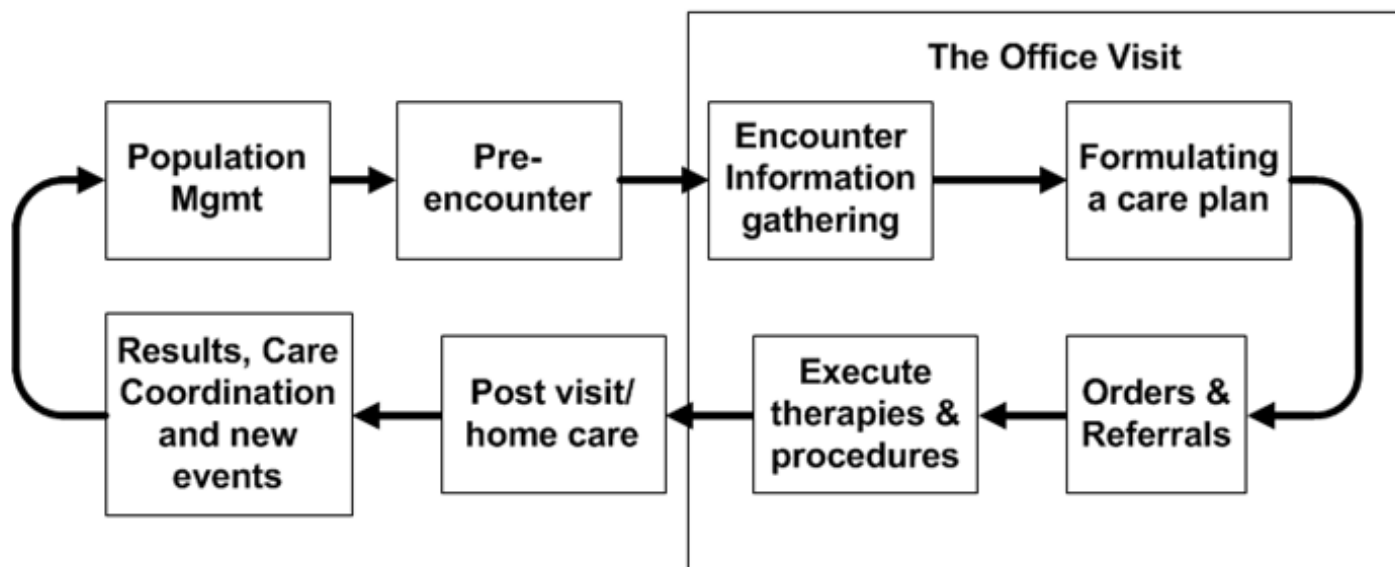
To be effective, CDS should be deployed as part of a quality improvement strategy. This strategy has a number of steps.

Step 1: Identify and quantify a high-priority gap in clinical quality between current outcomes and a stated goal. High priority means that the quality metric is closely aligned with a strategic goal. For example, a clinic might aim to improve the percent of patients with known vascular disease or hypertension whose blood pressure is less than 130/80 from 40% to 80%. This requires having a validated clinical report that can accurately measure the quality gap over time and track improvement.

Step 2: Map in detail the workflow by which the clinical care pertaining to the target issue is delivered. Since every process is perfectly designed to give you the outcome you get, it is essential to understand the process that is producing the quality gap.

Step 3: Design a future state workflow that includes the best ideas for closing the gap and eliminates as much waste as possible. If the goal is to increase the percent of patients with hypertension whose blood pressure is less than 130/80, there are modifications to the workflow that can be made at every part of the ambulatory workflow cycle that may help meet that goal.

Step 4: Identify the information necessary to support the future state workflow. Then, design, test, and perfect CDS interventions using the Five Rights with careful attention to whether the person receiving the information will be using it predominantly for fast thinking, for slow thinking, or as a signal to switch from fast to slow thinking.

Figure 11 shows a template designed to help think through the Five Rights for each CDS tool used to support such a workflow. In this case the template has been filled out to demonstrate specific CDS tools a care team might use to support an initiative to improve hypertension outcomes. The two left hand columns identify the portion of the workflow each CDS intervention will be deployed and the actual decision the CDS is intended to support

Figure 11. Five Rights template for designing CDS to support workflows optimized to improve hypertension management outcomes.**

Workflow step	Pupose/ Decision	Right Info	Right Person	Right Time	Right Medium	Right Format
Before the Visit	Assure Pt brings home BP readings & med list	Reminder to bring home BP readings and medication list	Patient	2 days before the visit	Portal message	Visit reminder note
In the Huddle	Identify Pts with poor control	Recent BP control	Team	When chart reviewed	EHR snap shop view	Graph
Pt Check-in	Assure accurate Med List	EHR Med & Probem List	Patient	At end of check-in process	Paper pre-visit summary given by receptionist	List - data presentation
Pt in Waiting Rm	Assure accurate Med List	Correct Med & Problem List	Patient	While waiting	Paper & pencil	"Corrected" list - data presentation
Rooming the Pt	Assemble information clinician will need for decision-making	Review home BP values, diet, exercise, corrected Med & Prob List	Clinical Assistant	While waiting for Pt to relax before getting BP	EHR progress note template that provider will use	Charting template & Relevant data presentation
Prov in Exam Rm	Determine treatment plan options	Med List with max dose of each med	Clinician	When looking at the med list	Hold cursor over med list and max dose appears	Reference
After the Exam Rm	Pt understands care plan	Care Plan	Clinician	At the end of the visit	Visit Summary	Text - data presentation
After the Visit	Review care plan given new information	Laboratory test and imaging results	Team member	As soon as available	Results in-basket	Data presentation flow sheet, graph
Outside the Visit	Monitor population to identify Pts needing additional treatment	List of Pts with HTN with most recent BP date & value (including home values)	Population Manager RN	weekly	Report	Sorted so that Pts with BP date > 6 months shown first, then Pts with highest BP
	Identify Pts with HTN not included in the population being monitored	List of BPs with elevated BP at last visit who don't have HTN on prob list	Population Manager RN	weekly	Report	List of patients suspected of needing HTN added to problem list

** This material draws on slides and work from the ONC-funded CDS4MU project, which is, in turn based on material from the CHCF-funded CDS/PI Collaborative and the HIMSS CDS Guidebook Series, on which it builds.

The Five Rights are presented in columns to the right. There is no requirement that more than one of the CDS interventions listed in the template be implemented simultaneously. In fact, it may make most sense to implement these CDS tools one at a time, testing each one on a small scale and modifying it based both on the feedback from the people using it and the effect it has on the quality outcome being monitored. Once a CDS tool has been fine-tuned to perform its intended purpose and spread to the entire organization, the next CDS tool can begin the same rapid-cycle of testing, measuring and modification before it is spread. In this way, designing, testing and optimizing CDS becomes part of the ongoing work of quality improvement along with the continuous effort to optimize workflows by identifying and reducing unnecessary wasted activity.

Implementing Clinical Decision Support on an Organizational Level

Quality improvement efforts, including CDS interventions, have a greater likelihood of success if they are piloted at a local level and then spread to the organization as a whole. No matter how well conceived, innovative ideas must be tested against reality and corrected for factors that are impossible to predict before they can be expected to work as intended. Just as CDS operates by integrating information into workflows on a micro-level, there is also an equally important set of requirements for successfully implementing CDS at a macro-level. A team at the Oregon Health Sciences University examined the principles and best practices used by healthcare organizations that had successfully implemented CDS (5). They describe four different system components, or knowledge domains, that must work together for CDS to function as intended. The four system components are:

1) Technology
2) Clinical content
3) Users
4) Governance

Without an organization-wide plan to integrate these system components, individuals working in different parts of an organization risk working at cross-purposes to each other in their efforts to develop and use CDS because they tend to view it from very different perspectives (12). The most important themes for each of the system components are as follows:

1. Technology: The technology component centers on data as the foundation for CDS including how information is entered, stored, organized and presented to the user. The key finding was that there must be sufficient high-quality data for CDS to work. This requires an organization to prioritize a set of specific competencies.

- Participate in robust health information exchange.
- Develop interfaces to gather data from external sources.
- Educate clinicians about the importance of high-quality data and their responsibility in assuring its accuracy .
- Enforce strict internal standards and make an organization-wide commitment to assure the integrity of entered data.
- Test new CDS on users to be sure it is useful.
- Solicit user feedback and customize to meet their needs.
- Identify and prioritize reporting needs.
- Design measures to monitor CDS use and refine CDS based on measures.

2. **The User:** Predictors of success were all closely related to workflow, with particular attention to the roles of individual care team members and specific information needs of each type of user.
   - All CDS projects must start by assessing workflow.
   - CDS interventions must be compatible with optimal workflow.
   - Plan to customize the CDS must fit workflow (and vice versa).

3. **Clinical Content:** The content component of CDS is about knowledge creation and knowledge management. An organization must be able to manage, catalog, and assess the medical evidence on which the rules governing decision support are based in order to assure the appropriateness of the information presented to the user.
   - Plan early and allocate sufficient resources for managing clinical content.
   - Catalog and monitor all CDS interventions from the beginning.

4. **Governance:** The governance component requires articulating a vision to the organization that includes all perspectives on CDS. This requires maintaining an organizational structure to support each of the system components.
   - Commit adequate resources and remove barriers to assure success.
   - Create policies and procedures to ensure standard workflows.
   - Use existing structures when possible and repurpose them as needed.
   - Establish a decision-making structure to assure that CDS remains aligned with organizational strategic goals.
   - Involve clinicians continually at all levels of governance in CDS.

Several translational themes also emerged spanning the four system components that were associated with success in CDS.
- It is essential to create a culture of collaboration not only between the IT experts and the users, but also with software vendors and with other healthcare organizations to share experiences and best practices.
- Everyone in the organization must understand the user's perspective.
- There are essential roles for individuals who can serve as content experts in multiple system components and bridge the boundaries between knowledge domains— for example, a clinician with informatics skills who understands the principles of quality improvement.
- It is essential that everyone in the workforce understands how CDS works, how the information on which it depends is entered, and how its accuracy is maintained.
- Communication, training, and support are at the center of CDS implementation and maintenance.

Conclusion

Although CDS may appear at first glance to be simply one more EHR feature, it is both one of the most important components of health IT and one of the most challenging. CDS is important because it represents the mechanism through which health IT can improve the quality of care by improving the quality of clinical decisions made by clinicians, care teams, and patients. It is the most difficult because it requires a complete set of accurate information about patients to be processed, consistent with evidence-based guidelines and then inserted at exactly the right moment into workflows and human interactions that are, by their very nature, variable, dynamic, and subject to the full spectrum of human psychology.

Every part of the information cycle and the quality improvement process has to work properly if the information that CDS presents to the user is to be trustworthy and useful:

- Health information exchange and data interfaces must successfully fill the gaps in information that exist in the clinician's EHR.
- Every clinician, every care team member, and every patient must understand that the value of their work depends on their ability to protect the quality of their data.
- Decision support must be based on evolving evidence-based guidelines, and the choice of clinical topics CDS will be used to manage must be tightly aligned with strategic priorities and the interests of patients.
- The technology that operates CDS must be capable of presenting information so that complex relationships can be quickly recognized while avoiding information overload.
- The designers of CDS interventions must master the art of using rapid process improvement cycles and work with the intended users of the information to assure that the right information really gets to the right person at the right time in a form the user can easily find, and quickly make sense of so it acts as a blessing and not as a curse.

Additionally, everyone involved in designing, implementing, maintaining, and using CDS must understand and respect the strengths and weaknesses of the human mind as it rapidly processes information, seeking out meaningful patterns amidst the background noise.

The potential for CDS, properly integrated into clinical workflows to improve the abilities of clinicians to make better decisions, is very real. However, the greatest promise for CDS may be its potential to help patients see important patterns in their own health information that previously were only visible only to highly-trained professionals. As patients increasingly become involved in and manage their own health information, the way that the information is organized and presented will, in large part determine their ability to make healthy lifestyle choices, adhere to preventive guidelines, self-manage chronic conditions, and oversee the safety of their medical care.

About WIREC

Led by Qualis Health, WIREC provides vendor-neutral health IT consulting services related to the successful adoption, implementation, and utilization of EHRs for the purposes of improving care. We guide eligible healthcare professionals to achieve meaningful use of EHRs and qualify for Centers for Medicare & Medicaid Services (CMS) incentive payments. WIREC was selected through an objective review process by the U.S. Department of Health and Human Services' Office of the National Coordinator for Health IT (ONC). WIREC serves as a direct pipeline to the national Regional Extension Center program, leveraging our connection to a national collaborative of RECs while bringing local expertise to support providers across the region with technical assistance for successful EHR adoption. For more information, visit www.wirecQH.org.

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Qualis Health is a national leader in improving care delivery and patient outcomes, working with clients throughout the public and private sector to advance the quality, efficiency and value of healthcare for millions of Americans every day. We deliver solutions to ensure that our partners transform the care they provide, with a focus on process improvement, care management and effective use of health information technology. For more information, visit www.qualishealth.org.

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