

Clinical Decision Support Implementers' Workbook



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About the Book

The Clinical Decision Support Implementers' Workbook is designed to help healthcare organizations use clinical decision support (CDS) to measurably improve outcomes important to the organization. It helps readers guide the selection, customization, and implementation of the most usable and effective CDS interventions to address specific clinical or strategic concerns.

The workbook helps organizations identify stakeholders in their CDS programs, and then guides them through the steps of working with those stakeholders to

- Determine the CDS program's goals and clinical objectives;
- Catalog local information systems' capabilities to help achieve those targets;
- Select the best approach to address the targets with specific CDS interventions;
- Develop the interventions;
- Ensure those interventions are acceptable to stakeholders and put them into use; and
- Monitor the CDS program on an ongoing basis to ensure it achieves organizational objectives.

This valuable resource will be useful for organizations with applications in place that support CDS, but it will also be a guide for organizations that anticipate implementing clinical decision support.



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For over 30 years, Thomson MICROMEDEX's trusted medical information and flexible technology have enabled clinicians to access answers, alerts, and recommendations. From evidence-based references to system-integrated knowledge, clinicians rely on MICROMEDEX to enhance decisions, prevent adverse events, and promote best clinical practices throughout the continuum of care. (www.micromedex.com)

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The University of Pennsylvania Health System is an organization that includes four hospitals, a home care organization, and a large primary care network. The health system is located in Philadelphia and its surrounding suburbs. Its mission is excellence in patient care, research, and education. (www.uphs.upenn.edu)

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Kaiser Permanente is America's largest not-for-profit health care organization, serving 8.1 million members in nine states and the District of Columbia. An integrated health delivery

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Founded in 1902, Cedars-Sinai Medical Center is the largest voluntary hospital in the western United States. Its 1,800 affiliated physicians and 8,000 employees offer inpatient and outpatient services to the greater Los Angeles area and to an international clientele. Cedars-Sinai is also a leader in medical education and research. With a reputation for excellence in medical informatics, Cedars-Sinai was named one of the 100 "most wired" hospitals by *Hospitals and Health Networks*. (www.csmc.edu)

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HEALTHvision is a leading healthcare Internet company focused on helping healthcare organizations address the needs of physicians, patients, consumers, and employees through locally branded, web-based clinical information systems and public consumer web sites. More than 300 organizations use a customized version of the company's portal solution, supporting more than 20,000 clinicians. The company's web-based infrastructure, e-healthSOURCE, is the most widely used in the industry, hosting more than 5 million unique patient records. (www.healthvision.com)

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Introduction

This resource is designed as a practical tool to help healthcare institutions use clinical decision support (CDS) to measurably improve outcomes important to the organization. It does this by guiding the selection, customization and implementation of the most usable and effective CDS interventions to address specific clinical or strategic concerns.

The workbook first helps organizations identify stakeholders in their CDS programs. It then guides them through the steps of working with these stakeholders to:

- Determine the CDS program's goals and clinical objectives;
- Catalogue local information systems capabilities to help achieve those targets;
- Select the best approach to address the targets with specific CDS interventions;
- Develop the interventions;
- Make sure those interventions are acceptable to stakeholders and put them into use; and
- Monitor the CDS program on an ongoing basis to ensure it achieves organizational objectives.

Definitions

- **Clinical Decision Support (CDS)** refers broadly to providing clinicians or patients with clinical knowledge and patient-related information, intelligently filtered or presented at appropriate times, to enhance patient care. Clinical knowledge of interest could range from simple facts and relationships to best practices for managing patients with specific disease states, new medical knowledge from clinical research and other types of information.
- **CDS goals and objectives** are the target healthcare processes and outcomes that CDS efforts are intended to achieve. Goals are high-level or strategic targets such as increasing patient safety; objectives are more specific, tactical targets, such as increasing the use of specific life-saving medications in appropriate circumstances. [Figures 1-1](#) and [1-3](#) provide some examples.
- **A CDS intervention** involves delivering one or more specific pieces of clinical knowledge or data to an individual at a specific time and place to address a CDS objective. CDS interventions include the CDS content and the logistics (such as software applications and workflow processes) by which it is delivered. As illustrated in [Figure 3-3](#), the range of CDS interventions is broad and extends far beyond rule-based approaches. While there are many successful examples of CDS provided via paper-based systems, this workbook focuses on computer-facilitated interventions.
- **A CDS program** consists of the overall set of CDS interventions that an organization uses to achieve its healthcare goals, as well as the processes used to select, prioritize, implement and evaluate these interventions.

Audience

This workbook is designed for healthcare organizations interested in implementing CDS programs. It is intended primarily for organizations with applications in place that

support CDS, such as computerized provider order entry (CPOE) or an electronic medical record system (EMR), but it also will be useful to organizations that are anticipating implementing CDS but are in earlier stages of such projects. Similarly, the workbook can be used to support a comprehensive, full-featured CDS program or a more narrowly focused use of CDS to address a particular, limited need.

Individuals who are responsible for developing and implementing an organization's CDS strategy and those who have a leadership role in improving patient safety and quality are likely to benefit from this workbook. They may have broad leadership roles such as Chief Medical/Nursing/Quality/Safety Officers, may be leaders in key quality-related departments such as Pharmacy and Laboratory, may hold information systems positions such as Chief Information Officer or Medical Director of Information Systems, or may be participating in departmental or organization-wide safety and quality programs. CDS system developers and researchers also may find the framework and material in the workbook useful.

Using this workbook

This workbook's approach to CDS implementation involves a series of processes, outlined above and schematically in [Figure 1](#). Sections devoted to each process include:

- An overview of the key tasks;
- A discussion of pertinent issues;
- Worksheets (with sample data) and recommendations to help gather, organize and process institution-specific information critical to accomplishing the tasks;
- Concluding comments; and
- A bibliography with references and Web links to additional readings and resources.

Throughout this workbook, numbered superscripts refer to references at the end of each section, while lettered superscripts refer to explanatory footnotes at the bottom of that page.

The Workbook Supplement (www.himss.org/CDSworkbook) is a companion resource. It contains templates of the worksheets that you can download and use. More components will be added over time, and might include additional background information; completed worksheets and related documents from institutions that have implemented CDS interventions; sponsored links to vendors' Web sites; and other supporting material.

This workbook is intended to help focus, enhance and organize your approach to CDS implementation. It is not essential to follow it in a strictly linear fashion, to address every step, or to complete each worksheet. For example, you might focus on specific sections that address issues that are important or timely in your organization. Similarly, you can use the ideas reflected in the worksheets and steps as background material to validate or stimulate your own CDS approach.

Feedback and subsequent editions

The authors expect this workbook to be an iterative offering that, over time, will provide increasingly helpful guidance on improving outcomes through CDS. Because of this, users' feedback on enhancements will be very valuable. Important topics not covered in the current version but contemplated for subsequent editions include financial considerations for embarking on CDS programs and more extensive CDS-related

guidance tailored for those planning major IT infrastructure purchases. Readers' input will help determine which areas are addressed next.

Readers from institutions that have successfully accomplished specific CDS implementation tasks can be an important source of guidance to others. They are particularly invited to share their insights, tools and sample documents with others in subsequent editions of this workbook. For example, your insights and completed worksheets may be included in subsequent workbook editions and/or supplementary material on the HIMSS CDS Web site (www.himss.org/CDSworkbook)

Input from users just beginning to develop CDS programs will be valuable because their questions and comments will help ensure that future editions are responsive to users' needs. The workbook team also is exploring the creation of an online forum to enable the exchange of insights, strategies and questions about CDS implementation.

Please send e-mail with any material, questions, or suggestions for improving this workbook to cdsworkbook@himss.org.

Overview

This workbook is organized around the following decision support implementation steps, which are also depicted graphically in [Figure 1](#):

[Section 1](#): Identifying stakeholders and goals

[Section 2](#): Cataloguing available information systems

[Section 3](#): Selecting CDS interventions

[Section 4](#): Validating and finalizing the program

[Section 5](#): Putting interventions into action

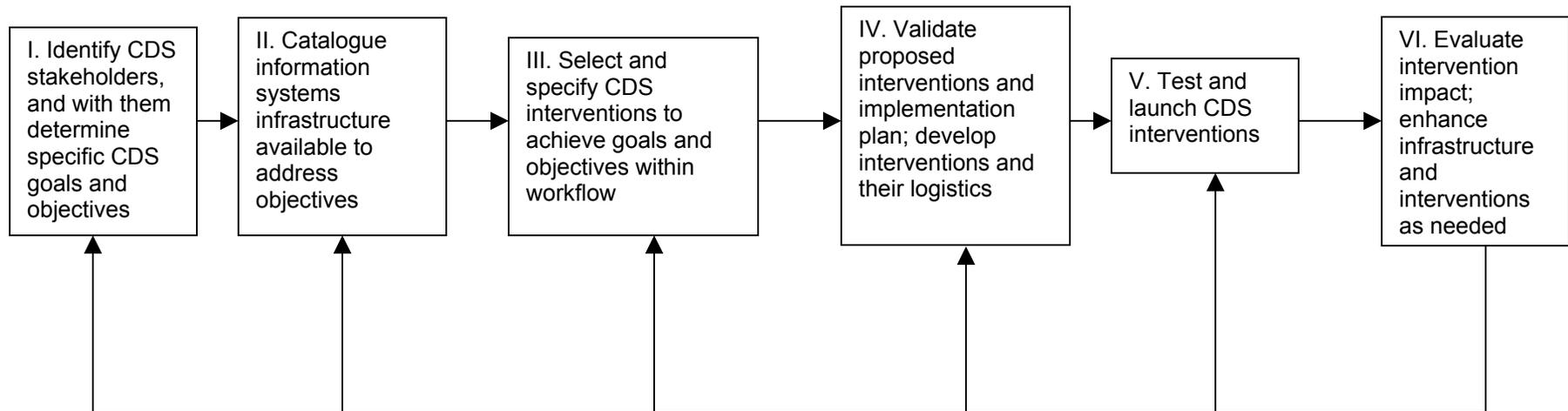
[Section 6](#): Monitoring results and refining the program



A note about Internet resources

All Internet Web links in this workbook were accessible as of December 19, 2003.

Figure 1: Summary for applying clinical decision support to improve outcomes in healthcare organizations



Identifying stakeholders and goals

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To create a solid foundation for the clinical decision support program, those responsible for its development should begin by identifying key stakeholders, and working with them to establish goals and objectives.

Tasks

1. Identify the key local committees, positions and individuals currently in place that will have a stake in the CDS program by proposing, validating, supporting, communicating or using the CDS interventions. Begin considering their current role and activities pertinent to your CDS program, as well as what new positions or teams might be needed to ensure the program's success. ([Worksheet 1-1](#))
2. Document CDS goals and objectives of importance to, or already being addressed at, your organization. ([Worksheet 1-2](#))
3. Synthesize and validate a 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 of these further into more operational objectives, such as clinical actions. ([Worksheet 1-3](#))

Discussion

People: the keys to success

Although information systems process and deliver CDS interventions, people establish the CDS program's goals and objectives, and are the crucial factor in whether or not these are achieved. Individuals must agree on appropriate CDS interventions, support their implementation, incorporate them into their workflow and respond appropriately when they are delivered.

Implementing a CDS program can require significant behavior changes for both individuals and organizations. There is an extensive body of literature on successfully managing organizational change¹ and reviewing these resources may prove useful in building your CDS program.

An essential first step in establishing a CDS program involves identifying the key individuals, committees and positions on which the program's success will depend. Effectively collaborating with these people will be important, and those relationships will be emphasized throughout the steps outlined in this workbook. [Worksheet 1-1](#) helps identify these stakeholders and provides a foundation for establishing such collaborations.

CDS program goals and objectives

It is important to approach CDS program goals from a broad organizational perspective, because this is primarily how the program's success will be judged. The process outlined

in this workbook emphasizes maintaining a tight link between these goals and the CDS program’s interventions and results. Many businesses are using management systems that link high-level goals to specific performance objectives and process outcomes². These approaches also may find wider application in patient care delivery, as health systems are increasingly being held accountable for their clinical performance³.

The CDS stakeholders in your organization may have already identified key healthcare goals, such as improving the safety or cost-effectiveness of patient care, before a formal CDS program is undertaken. There might even be initiatives under way in specific focus areas to address these high-level goals, such as improving performance on individual NCQA HEDIS measures⁴ or addressing specific JCAHO⁵ and NCQA⁶ accreditation requirements.

A key initial task is cataloguing the CDS-related goals and initiatives already in place at your organization. [Worksheet 1-2](#) can be used to document this inventory.

[Figure 1-1](#) lists some high-level goals that a CDS program could support, and illustrates focus areas, clinical goals and clinical objectives that can be used to address each high-level goal. A CDS target, as listed in [Figure 1-3](#) for example, refers to one or more of these items. CDS goals and objectives, as well as targets, may be overlapping and interrelated.

[Figure 1-2](#) outlines some approaches to determining which CDS targets are of greatest importance in your organization.

Figure 1-1: Examples of organizational CDS goals, focus areas, and clinical goals and objectives

High-level CDS goal	Focus area	Clinical goal	Clinical objective
Improve outcomes for a particular class of complaints, diagnoses or procedures, e.g. by facilitating specific disease management initiatives ⁷	Diabetes	Decrease incidence and complications associated with diabetic kidney disease	Increase screening for diabetic kidney disease
Improve overall care safety	<ul style="list-style-type: none"> Medication safety Patient care handoffs 	<ul style="list-style-type: none"> Minimize adverse drug events Optimize critical information transfer between clinicians within hospital, inpatient and outpatient clinicians, generalist and specialist clinicians, clinicians and patients 	<ul style="list-style-type: none"> Decrease occurrence of severe drug interactions Decrease inadequate follow-up of critical test results such as abnormal biopsies and radiological studies
Foster evidence-based practice	Organization’s most common outpatient diagnoses	Increase compliance with “beneficial” interventions in clinical evidence (see Figure 1-3 , row 1)	Increase the percentage of eligible patients with congestive heart failure who are taking beta blockers

High-level CDS goal	Focus area	Clinical goal	Clinical objective
Optimize reimbursement for and cost-effectiveness of care, e.g. pay-for performance initiatives; appropriate use of interventions, referrals and tests; and reducing length of inpatient stay	Acute myocardial infarction	Increase percent of patients with condition who meet all criteria in pay-for-performance pilot	Increase percent of patient prescribed beta blockers on arrival at the hospital
Enhance patient education and empowerment	Preventive care	Optimize patient adherence with indicated screening tests	Increase percentage of women eligible for screening mammography who obtain the test
Foster compliance with clinical guidelines ⁸	Organization's most common discharge diagnoses	Minimize variation from specific quality measures	Administer antibiotics within recommended timeframe for patients admitted with community-acquired pneumonia
Address clinicians' recognized and unrecognized information needs	Disease treatment information	Provide needed information within clinical workflow	Address X% of clinicians' needs within Y minutes
Meet reporting, regulatory and accreditation requirements ⁹	HEDIS measures	Improve performance on specific measures	Offer Chlamydia screening to all eligible women

Figure 1-2: Sources for determining and validating CDS targets

<ul style="list-style-type: none"> Institutional analyses of quality, safety, cost and regulatory problems, e.g. from committees such as pharmacy and therapeutics, quality assurance, patient safety, utilization review or others
<ul style="list-style-type: none"> Technology-supported analyses and mining of local care and outcomes conducted in-house¹⁰ or with support from vendors
<ul style="list-style-type: none"> Interviews with clinicians, medical directors and other stakeholders
<ul style="list-style-type: none"> Surveys assessing stakeholders' CDS-related activities, needs and priorities
<ul style="list-style-type: none"> Direct observation of information needs in clinical settings
<ul style="list-style-type: none"> Community-based priorities and programs

Key organizational factors

The CDS program can leverage organizational buy-in for these goals and objectives, and can help achieve them. For example, if there is organizational commitment and resources for a comprehensive disease management program, CDS interventions focused on improving the management of these conditions can build on this momentum.

Similarly, support from clinicians and management who are concerned about specific CDS targets can help drive the behavior change (such as for modified workflows) and resource allocation (for example, for CDS-related hardware and software purchases) that will be required to achieve the target. In general, understanding and

thoughtfully addressing the organizational strengths and barriers affecting a CDS program will help ensure its success.

The success of both individual CDS interventions and the overall CDS program often is largely dependent on the extent to which the organization and its leadership is involved in the program. Specific success factors include:

- Deep executive support for clinical quality improvement and belief in the value of information technology to achieve it.
- A history of successful clinical information technology projects, fostering a strong belief among clinicians and organizational leaders that clinical information systems are their allies.
- Excellent communication about the clinical and technological nature of the CDS program to all involved stakeholders.
- Involvement of key users and clinical champions well in advance of the implementation of any new CDS program.
- Strong support and problem resolution for the interventions from information systems staff before, and especially during, implementation.

Your CDS program targets likely will consist of issues uncovered in the environmental analysis that are currently being addressed in some way. It is often the case, especially in larger organizations, that there are relatively independent efforts focused on similar objectives. For example, two different clinical departments might be pursuing care improvement efforts (for example, focusing on safer and more effective heparin administration) that could benefit from richer cross-fertilization. Identifying such synergies is an important benefit of a thorough environmental analysis for the CDS program.

You also may uncover potential new goals and objectives. For example, discussions with key stakeholders might reveal that some of the goals listed in [Figure 1-1](#) aren't being addressed but should be. The data-gathering approaches listed in [Figure 1-2](#) can be used to elicit additional CDS opportunities from within your organization.

You should also consider potential targets that have been identified outside your organization and that might be appropriate goals, objectives and focus areas for your CDS program (see [Figure 1-3](#)).

Figure 1-3: Promising decision support targets^a

Target	Examples/references
<ul style="list-style-type: none"> • Clinical interventions for which there is strong evidence that patient benefit outweighs harm 	<ul style="list-style-type: none"> • Interventions identified in evidence-based clinical practice guidelines)¹¹ • Interventions marked as “beneficial” in Clinical Evidence¹² • Findings in AHRQ Evidence Reports¹³
<ul style="list-style-type: none"> • Clinical interventions for which trials have demonstrated that CDS approaches are or might be effective in improving healthcare processes and outcomes¹⁴ 	<ul style="list-style-type: none"> • Practices supported by evidence¹⁵ • Physician performance¹⁶ • Medication safety¹⁷ • Disease management¹⁸ • Chronic care management¹⁹

^a Please send feedback to the workgroup authors on improving this list (see [workbook home page](#) or [introduction](#) for the [e-mail](#) link).

Target	Examples/references
<ul style="list-style-type: none"> Institute of Medicine (IOM) priority areas for transforming healthcare quality 	<ul style="list-style-type: none"> Asthma, diabetes, hypertension, immunizations, patient self-management²⁰
<ul style="list-style-type: none"> National quality measures, especially those being investigated in "pay for performance" pilots (such as those linked to management of acute myocardial infarction, community acquired pneumonia, heart failure, among others) 	<ul style="list-style-type: none"> CMS/Premier quality measures/pay for performance pilot²¹ Leapfrog Group; Rewarding Results²² Bridges to Excellence²³
<ul style="list-style-type: none"> Results of systematic analyses of clinical errors or quality problems 	<ul style="list-style-type: none"> USP MedMarx database²⁴ HHS patient safety reporting systems²⁵ McGlynn et. al. The Quality of Health Care Delivered To Adults in the United States²⁶ NCQA State of Health Care Quality report²⁷ Preventing adverse drug events²⁸ Types of medical errors²⁹
<ul style="list-style-type: none"> Topics addressed by CDS knowledge shared informally among institutions or from commercial CDS content vendors 	<ul style="list-style-type: none"> SAGE project model for knowledge sharing³⁰

Ideal objectives for CDS interventions might be patient management issues that occur frequently; activities that are associated with a significant gap in performance or a missed opportunity to optimize care; care events in which the performance shortfall substantially boosts clinical costs or lowers quality and safety; and activities in which performance can be improved through better distribution of knowledge, improved communication or heightened awareness. Issues that occur less frequently, but which could have catastrophic consequences, are also potentially attractive candidates for decision support interventions.

[Figure 1-4](#) is a rough unvalidated heuristic that illustrates the relationship among these factors affecting the desirability of addressing individual CDS objectives. These variables can be considered as part of the effort to explore CDS objectives later in this section, to help uncover those likely to be of greatest value.

Figure 1-4 Factors affecting the desirability of a CDS objective

CDS Objective Value Score = (P+O+C+N+G)-(D+C), where^b

P= Patient impact (individual/population) (positive, e.g. quality, safe, cost-effective care; improved morbidity and mortality, of interest to patients)

O= Organizational impact (positive, e.g. regulatory or audit compliance, appropriate resource use, liability)

C= Clinician impact (favorable, e.g. enhanced workflow; consistent with consensus, local standards, feasible to address, of interest to clinicians)

N= Number of patients positively affected

G= Gap between ideal and actual behavior pertinent to the intervention

D= Difficulty associated with addressing the objective

C= Cost of addressing the objective

^b The strength of objective, systematic evidence about the magnitude of the variable should be considered when practical.

Unfortunately, a unified comprehensive list of the most promising decision support targets from which to choose is not readily available, but the items in [Figures 1-1](#) and [1-3](#) can provide a solid starting point.

[Worksheet 1-3](#) can help pull together the results of your internal and external analyses into a working list of CDS goals and objectives. It can be used to prioritize and validate these targets with stakeholders, and will serve as the foundation for selecting specific CDS interventions, as discussed in [Section 3](#).

Worksheets

Step 1: Identify and contact the key local committees, positions and individuals currently in place that will have a stake in the CDS program, either by proposing, validating, supporting, communicating or using the CDS interventions. Begin considering their current roles and activities, and how they relate to your CDS program, as well as the new positions and teams that might be needed to ensure the program's success.

You can use [Worksheet 1-1](#) to catalogue key stakeholders in the CDS program and begin assessing their potential role in it. Indicate which elements are currently in place, including specific individuals such as key decision makers and others expected to be influential or vocal about a proposed CDS program. Begin documenting the potential role each might have in the program.

From the earliest stages of CDS program development, it is crucial to obtain significant input and involvement from the communities that will be the targets for the CDS interventions. Pioneers in the field say their experiences show that successes are characterized by such involvement, while prominent failures are characterized by the lack of it.

In working through this workbook, you might find that one or more new teams or positions focused on CDS could help develop, implement and evaluate the CDS program. Whether or not such groups are established, you also should consider making the CDS program an explicit component of other pertinent committees and positions that are already in place. Because this worksheet is used repeatedly throughout this workbook, it will be most beneficial if you synchronize it with pertinent changes in both the CDS program itself and the broader organizational chart.

Worksheet 1-1 example: People and process infrastructure for a CDS program

Stakeholders ^c	Pertinent CDS activities and key names	Notes ^d
Committees		
<input type="checkbox"/> Pharmacy and Therapeutics	[name], Committee Chair	Important
<input type="checkbox"/> Quality Assurance (Organization-wide)	[name] (Chief Quality Officer); Clinical Effectiveness and Quality Improvement committee (CEQI)	Effective set up for CDS, important

^c Place checks in boxes of pertinent elements.

^d For example, relative importance and potential role in CDS program, modifications to position or role needed for the program.

Stakeholders ^c	Pertinent CDS activities and key names	Notes ^d
☐ Quality (Departmental)	Multiple: Ob Gyn, Surgery, Medicine and Neuro important; ICU and ER areas very interested	
☐ Patient Safety	[name] Patient Safety Officer	
☐ Utilization Review (Organization-wide or departmental, such as blood product use)	[name] (Director of UR), Pathology Director: [name]	
☐ Medical Staff		Needs to be kept updated but unlikely to participate in the program
☐ Clinical information systems implementation team(s)		Not involved heavily in goal setting
☐ Guideline/Practice Standards, Clinical Strategy, Disease/Care Management	Disease management-outpatient: [names of program leaders]	Multiple areas and committees focus on guidelines and practice standards-in particular, nursing committees and pharmacy committees
☐ Medical Records	[Name] (Director of Medical Records), Medical Records Committee	Unclear how much interest they will have in decision support
☐ Others	Residency committees and directors	Very important for goal setting and program development
Positions		
☐ Medical Director of Clinical Decision Support	Not yet named	Position is in planning stages
☐ Chief Medical Officer/Medical Director	Multiple in each hospital and one overall for the health system	Very important for overall program validation
☐ Chief Medical Information Officer/Medical Director of Information Systems	[name]	A driver for the CDS program, important for the development of focused goals
☐ Chief Information Officer	[name]	Very supportive of DS, will provide resources as needed and some project management; needs to be kept updated frequently
☐ VP/Director of Nursing	[name]	Favors decision support, has a good set up that will facilitate goal setting
☐ Pharmacy Director		
☐ Quality Officer	[name].	
Patient Safety Officer		Important
☐ Department Chairs		
☐ IPA / Physician Group chairs	[name] (CMO for primary care network)	Key in the outpatient area

Stakeholders ^c	Pertinent CDS activities and key names	Notes ^d
Other CDS stakeholders		
<input type="checkbox"/> Clinicians vocal on clinical computing/CDS issues (positively or negatively)	Important areas include ER, ICU, CCU, infection control.	All have shown interest in computing and decision support
<input type="checkbox"/> Clinical thought leaders	CMO for health system as well as multiple areas throughout the health system	
<input type="checkbox"/> Patients/patient representatives		Difficult to access, need to think of how they might be engaged

Step 2: Document CDS goals and clinical focus areas of importance to, or already being addressed at, your organization.

CDS interventions focused on issues of greatest importance to the organization will have the best opportunity to succeed. [Worksheet 1-2](#) can be used to document the analysis outlined in [Figures 1-1](#) and [1-2](#) and discussed above. Because specific CDS goals and objectives important to your organization will emerge from dialogue with the stakeholders listed in [Worksheet 1-1](#), these proponents for specific targets anchor [Worksheet 1-2](#).

Look carefully at the case management activities in your organization. These initiatives often are quite labor-intensive and could be ripe for CDS interventions. If your organization has or is contemplating a clinical transformation process to improve operations and outcomes, seek ways to ensure the initiatives are mutually supportive.

Similarly, look for pertinent initiatives under the following headings: patient safety, quality improvement, care improvement, clinical pathways, disease management or strategic initiatives.

Because different constituencies (such as management, clinicians and patients) might have different perspectives on the importance of each goal or objective, consider these perspectives individually and collectively. For example, CDS interventions focused on goals that are a high priority for management, clinicians and patients will likely receive the sustained focus and support that are required for successful implementation. Conversely, interventions focused on goals that are of low priority to one or more of these constituents will have less chance of succeeding.

Strong imbalances in the priority given to a goal or objective between different stakeholders can indicate the need for dialogue and education to achieve a shared vision on the issue. Reconciling such differences before specific CDS interventions focused on the goal are developed and implemented could save significant time, aggravation and money.

Worksheet 1-2 example: Current, local CDS goals and clinical focus areas

Proponents ^e	High-level goals ^f	Focus areas	Priority for proponents and the organization overall ^g	Pertinent CDS-related initiatives under way
CEQI, Departmental Directors, Nursing	Medication Safety	Anticoagulants	High	
Oncology area, Departmental directors		Chemotherapy	High	
Infection control, infectious diseases		Antibiotics	High	
Endocrinology, CEQI, Disease Management Leaders: (names, including clinical champions)	Disease Management	Diabetes	Medium	
Same as above with different clinical champions		Asthma	Low	
Residency directors.	Resident Education	Effective clinical teaching	High	

Step 3: Synthesize and validate a 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 into more operational objectives (such as clinical actions).

The analysis of internal CDS goals (from [Worksheet 1-2](#)) and additional CDS opportunities (as outlined above) provides the foundation for a comprehensive listing of the CDS goals and focus areas that your CDS program will address. Separate copies of [Worksheet 1-3](#) can be used to document each of these focus areas, along with its associated clinical goals and objectives. Much of the data needed to complete this worksheet will be derived from interactions with stakeholders and committees as outlined in [Worksheets 1-1](#) and [1-2](#), so you can begin completing it as a derivative of that documentation.

[Worksheet 1-3](#) also enables you to document the rationale for selecting the goal, as well as the local stakeholders and initiatives related to it. This additional information can be used to prioritize the various CDS goals and focus areas, as well as their component clinical goals and objectives. Prioritizing can be important if limited resources or other factors constrain the number of issues that the CDS program can address at one time. It might be useful to first begin developing detailed clinical goals and objectives for the CDS goals and focus areas expected to be of greatest importance to your organization.

^e Committees, positions, individuals concerned about a specific goal or objective.

^f As outlined in [Figure 1-1](#).

^g What is the priority (e.g. high, medium, low) for stakeholders individually and for the organization as a whole?

Clinical objectives should be as discrete and specific as possible to facilitate the selection of interventions to achieve the objective and the measurement of their success. For example, an objective such as “Improve prescribing practices for heparin” will likely be less useful than a more specific one, such as “Decrease incidence of heparin overdose.” To help prepare for measuring progress toward CDS targets, [Worksheet 1-3](#) includes a column in which you can begin documenting indicators that the targets have been reached.

Below is a partially completed CDS program goal worksheet that illustrates the process of articulating clinical goals to accomplish CDS goals, and specific objectives to accomplish these clinical goals. Immediately below this sample is a blank worksheet for your use. You will likely complete the set of worksheets for your CDS program over time, building, refining, prioritizing and validating their contents during multiple meetings with internal stakeholders and based on other research as discussed above.

Worksheet 1-3 example: CDS program goal and focus area, and corresponding clinical goals and objectives

High-level goal: Support disease management programs that measurably improve care processes and outcomes^h

Focus area and context: Diabetes mellitus disease management programⁱ

Clinical goal (to support CDS goal)	Specific objectives (clinical actions)	Success indicators	Notes ^j
A. Prevent diabetic retinopathy	A1. Increase regular ophthalmology follow-up A2. Perform annual funduscopic exam	X% yearly ophthalmology visits	
B. Decrease complications of diabetic neuropathy	B1. Increase regular podiatry follow-up	X% yearly foot exams; reduced hospitalizations for diabetic foot problems	
C. Prevent diabetic nephropathy	C1. Increase regular measurement of microalbumin	X% yearly microalbumin orders	
D. Improve lipid management	D1. Increase regular measurement of LDL, cholesterol D2. Increase use of statins for patients with appropriate levels	X% measured LDL's, cholesterol Y% of patients with LDL < etc.	

^h Consider completing one version of this worksheet for each high-level CDS goal and focus area, such as those outlined in [Figure 1-3](#) and [Worksheet 1-2](#).

ⁱ Includes stakeholders and initiatives pertinent to the overall goal, local data supporting organizational priority for the goal and external evidence supporting importance of goal.

^j Specific stakeholders and local initiatives that are pertinent to the clinical goal or objective; internal or external data that support the importance of goal and objectives.

Clinical goal (to support CDS goal)	Specific objectives (clinical actions)	Success indicators	Notes ^j
E. Improve BP management	E1. Increase regular measurement of BP E2. Increase number of patients with BP in desirable range	X% of patients with BP recorded at recommended intervals Y% of patients with SBP/DPB in desirable range	
F. Improve glycemic control	F1. Increase regular measurement of FBS and HbA1C F2. Optimize medication use based on levels and protocol	X% measured HbA1C Y% of patients with HbA1C < 7	
G. Diagnose DM effectively	G1. Screen appropriate patients for diabetes based on age, family history	X% of appropriate patients screened for diabetes	
H. Prevent unsafe drug use	H1. Check for medication errors or hazards whenever medications are changed H2. Obtain appropriate screening labs based on medication use H3. Adjust medications if necessary based on screening labs	Number of medication errors less than X% Number of adverse drug events and complications less than Y%	

Concluding comments

The importance of the people component to the CDS program's success can't be overstated. Time invested early in the process to fully understand the needs and motivations of all stakeholders in the program will provide a payback in later implementation stages. Likewise, capitalizing on existing organizational momentum toward what will become CDS program goals and objectives can help overcome the obstacles that the program inevitably will encounter and ensure its ultimate success.

After completing this section, you will have a detailed, prioritized working list of your CDS program targets. Although substantial effort is required to get to this point, the list should remain dynamic. Expect that as the CDS implementation process unfolds, the targets and priorities will evolve, perhaps as a result of changes within the local environment and in the external forces in healthcare acting upon it.

The implications of addressing the issues discussed in this section go beyond the CDS program itself. For example, the detailed articulation of goals and objectives for clinical improvement in [Worksheet 1-3](#) could be the most complete synthesis of these issues in your organization. As such, they could be useful for addressing the targets in ways other than the primarily computer-based approaches discussed in this workbook.

For example, they might suggest workflow reorganization and other mechanisms to help achieve the goals.

The next section will help you assess your information systems infrastructure that's available for selecting specific interventions (discussed in [Section 3](#)) that will be used to accomplish the program's goals and objectives.



Additional Web reading and resources

- Metzger J, Stablein D, Turisco F. Clinical Decision Support: Finding the Right Path. First Consulting Group First Reports. September 2002. <https://www.fcg.com/research/serve-research.asp?rid=61> (registration and log-in required).
- Institute of Medicine Reports
 - Patient Safety: Achieving a New Standard For Care (2003: <http://www.iom.edu/report.asp?id=16663>).
 - Key Capabilities of an Electronic Health Record System (2003: <http://www.nap.edu/catalog/10781.html>; see especially Decision Support Core Functionality, described on page 8).
 - Fostering Rapid Advances in Health Care: Learning from System Demonstrations (2002: <http://www.iom.edu/report.asp?id=4294>; e.g. see executive summary and chapter 4 on Information and Communications Technology Infrastructure).
 - Crossing the Quality Chasm: a New Health System for the 21st Century (2001: <http://www.iom.edu/report.asp?id=5432>).
 - To Err is Human: Building a Safer Health System (1999: <http://www.iom.edu/report.asp?id=5575>).
- Bates DW, Gawande AA. Improving Safety with Information Technology. *New England Journal of Medicine*, 384;25:2526-2534. <http://content.nejm.org/cgi/content/extract/348/25/2526>.
- Addressing Medication Errors in Hospitals: A Framework for Developing a Plan <http://www.chcf.org/topics/view.cfm?itemID=12682>.
- Computer Physician Order Entry: Benefits, Costs, Issues. Kuperman G, Gibson R. *Annals of Internal Medicine*. 2003;139:31-39. <http://www.annals.org/issues/v139n1/abs/200307010-00010.html>.

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¹ The Heart of Change: Real-Life Stories of How People Change Their Organizations, by John P. Kotter and Dan S. Cohen.

² R. Kaplan and D. Norton, Using the Balanced Scorecard as a Strategic Management System, *Harvard Business Review*, Vol. 74, No. 1, January-February 1996, pp. 75-85.

³ Hongsermeier T, Schmeling W., Knowledge Management: The Use Of Knowledge Strategies To Transform Health Care. 2002 HIMSS Conference Proceedings. <http://www.himss.org/content/files/proceedings/2002/sessions/ses152.pdf>.

⁴ National Committee for Quality Assurance, What is HEDIS? <http://www.ncqa.org/Programs/HEDIS/>.

⁵ Joint Commission on Accreditation of Healthcare Organizations, position statement on reporting medical errors, <http://www.jcaho.org/accredited+organizations/patient+safety/medical+errors+disclosure/index.htm>.

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- ⁶ National Committee for Quality Assurance, accreditation parameters, <http://www.ncqa.org/Programs/Accreditation/MCO/mcostdsoverview.htm>. Note especially quality improvement processes.
- ⁷ Priority Areas for National Action: Transforming Health Care Quality, Institute of Medicine (IOM): <http://www.ahrq.gov/qual/iompriorities.htm>.
- ⁸ For example, note recent increased emphasis on implementing guidelines in practice (Annals of Internal Medicine, September 16, 2003, 139:6, Pp 493-498, <http://www.annals.org/cgi/content/abstract/139/6/493>). Consider guideline types as outlined in the 1992 IOM report and discussed in the 1998 Journal of the American Medical Informatics Association (<http://www.jamia.org/cgi/content/abstract/5/4/357>); The guideline types, and examples provided by the Institute's report include screening and prevention (vaccination for pregnant women who are planning international travel); diagnosis and pre-diagnosis management of patients (evaluation of chest pain in the emergency department); indications for use of surgical procedures (indications for carotid endarterectomy); appropriate use of specific technologies and tests as part of clinical care (use of autologous or donor blood for transfusions); and guidelines for care of clinical conditions (management of patients following coronary-artery bypass graft).
- ⁹ Such as JCAHO/NCQA accreditation, and quality measures such as NCQA/HEDIS and those in the National Healthcare Quality Report (<http://www.ahcpr.gov/qual/nhqr02/premeasures.htm>), the National Quality Measures Clearinghouse (<http://www.qualitymeasures.ahrq.gov/browse/browsecondition.aspx>) and the National Quality Forum hospital performance measures (<http://www.qualityforum.org/txhospmeasBEACHpublic.pdf>).
- ¹⁰ Evans RS, Gardner RM, Bush AR, et al. Development of a Computerized Infectious Disease Monitor (CIDM). *Comput Biomed Res.* 1985 Apr;18(2):103-13.
- ¹¹ National Guideline Clearinghouse, <http://www.guidelines.gov>.
- ¹² BMJ Publishing Group, Clinical Evidence Web site, <http://www.clinicalevidence.com/>.
- ¹³ Agency for Healthcare Research and Quality, Evidence-based Practice, <http://www.ahrq.gov/clinic/epcix.htm>.
- ¹⁴ Users' Guides to the Medical Literature: XVIII. How to Use an Article Evaluating the Clinical Impact of a Computer-Based Clinical Decision Support System, *Journal of the American Medical Association*, <http://www.ucl.ac.uk/kmc/publications/pdfs/JAMA1999.pdf>.
- ¹⁵ Agency for Healthcare Quality and Research, Making Health Care Safer: a Critical Analysis of Patient Safety Practices, AHRQ, July 2001, <http://www.ahrq.gov/clinic/ptsafety/summrpt.htm>. See especially the 11 practices strongly supported by evidence, and Chapter 53, Clinical decision support systems.
- ¹⁶ Hunt, Haynes, Hanna, Smith; Effects of Computer-Based Clinical Decision Support Systems on Physician Performance and Patient Outcomes: A Systematic Review, *Journal of the American Medical Association*, October 98, <http://jama.ama-assn.org/cgi/content/abstract/280/15/1339>. See tables 1-3 for outcomes measured and effects.
- ¹⁷ Kaushal R., Shojania K, Bates D., Effects of Computerized Physician Order Entry and Clinical Decision Support Systems on Medication Safety: A Systematic Review, *Archives of Internal Medicine*. 2003;163:1409-1416. <http://archinte.ama-assn.org/cgi/content/abstract/163/12/1409>.
- ¹⁸ Weingarten SR et. al, Interventions Used in Disease Management Programmes for Patients with Chronic Illness – Which Ones Work? Meta-Analysis of Published Reports. *BMJ*. 2002;323:925 <http://bmj.bmjournals.com/cgi/content/abstract/325/7370/925>.
- ¹⁹ Rundall TG, et. al. As Good As It Gets? Chronic Care Management in Nine Leading US Physician Organizations *BMJ* 2002;325:958-61. <http://bmj.bmjournals.com/cgi/content/full/325/7370/958>.
- ²⁰ Priority Areas for National Action: Transforming Health Care Quality, 2003, National Academies Press, <http://www.nap.edu/books/0309085438/html/>.
- ²¹ Clinical conditions and measures for reporting and incentives, Premier Inc., www.premierinc.com/all/informatics/qualitydemo/quality-measures/index.html.
- ²² Rewarding results: aligning incentives with high-quality healthcare, <http://www.leapfroggroup.org/RewardingResults/>; See also footnotes to quality measures in footnote to Figure 1-1.
- ²³ National Committee for Quality Assurance, Bridges to Excellence, <http://www.ncqa.org/Programs/bridgestoexcellence/>.

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- ²⁴ U.S. Pharmacopeia, National Database for Medication Errors, <https://www.medmarx.com>. See also America's Riskiest Drugs, *Forbes*, February 24, 2003, http://www.forbes.com/2003/02/24/cx_mh_0224risk.html.
- ²⁵ Agency for Healthcare Research Quality, patient safety reporting systems, <http://www.ahrq.gov/qual/taskforce/hhsrepor.htm>.
- ²⁶ McGlynn et al, The Quality of Healthcare Delivered to Adults in the United States, *New England Journal of Medicine*, June 26, 2003, 348:2635-2645, <http://content.nejm.org/cgi/content/short/348/26/2635>.
- ²⁷ National Committee for Quality Assurance, The State of Healthcare Quality:2003, <http://www.ncqa.org/Communications/State%20Of%20Managed%20Care/SOHCREPORT2003.pdf>.
- ²⁸ Gurwitz et. al Incidence and Preventability of Adverse Drug Events Among Older Persons in the Ambulatory Setting. *Journal of the American Medical Association*, 2003;289:1107-16. <http://jama.ama-assn.org/cgi/content/abstract/289/9/1107>.
- ²⁹ Dovey SM, Phillips RL, Green LA, Fryer GE. Types of Medical Errors Commonly Reported by Family Physicians. *Am Fam Physician*, 2003;67:697 <http://www.aafppolicy.org/x394.xml>.
- ³⁰ The SAGE Project, for Standards-based Sharable Active Guideline Environment, <http://sageproject.net>.

Cataloguing available information systems

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The clinical information systems available within an organization need to be catalogued, along with their CDS-related features, to identify the tools that can be used to process and deliver CDS interventions.

Tasks

1. Inventory the clinical information systems in your organization that could play a role in delivering CDS interventions. ([Worksheet 2-1](#))
2. Begin noting functionality and content in each system that could support CDS interventions.
3. Delineate the types of data each system handles, and how the data is coded, communicated and aggregated across the organization.

Discussion

Healthcare organizations often begin to develop a comprehensive CDS program after the clinical information systems that will deliver these interventions have been purchased or implemented. In this case, opportunities to achieve the goals and objectives developed in [Section 1](#) through CDS interventions may be somewhat constrained by the capabilities of available information systems.

A careful analysis of pertinent system capabilities is important because providing clinical decision support might not have been a primary consideration in selecting these systems. Organizations that will be purchasing or replacing key clinical information systems after CDS targets have been determined can ensure that these new systems are optimally suited to achieving the targets.

Knowledge processing and delivery capabilities

The healthcare information technology industry is at a relatively early stage of delivering clinical knowledge into workflow. For example, there isn't even a widely accepted outline of knowledge delivery modes (one is proposed in the next section – [Figure 3-3](#), Clinical decision support intervention types). Even with clinical alerts and reminders, one of the longer and more widely used CDS interventions, there are many approaches to getting the knowledge into the information system, managing it and presenting it to the recipient.

As the marketplace focuses greater attention on knowledge delivery and demands sophisticated tools for this function, the range of possible CDS delivery and management capabilities will expand. For now, some types of interventions that seem like the best way to achieve a particular objective might not be supported by the available IT infrastructure. Nonetheless, fully exploiting functionality in your systems should provide a solid foundation toward achieving your CDS objectives.

Inter-system communication and vocabularies

A robust CDS program will likely involve a variety of specific interventions delivered via several different information systems or system components. Even a single intervention, such as a clinical alert, might require information from several systems (such as lab, pharmacy or CPOE) and perhaps also from external electronic knowledge sources. Integrating the various components of CDS interventions, such as pertinent patient data and clinical knowledge, often requires a common underlying vocabulary and coding scheme.

Universally accepted schemes for this don't exist yet, but some consensus is beginning to emerge. For example, there are codes for medical and nursing diagnoses and procedures, laboratory and radiology tests, and drugs available in systems such as the Systemized Nomenclature Of Medicine Clinical Terms (SNOMED-CT), International Classification of Diseases (ICD-9), Current Procedural Terminology (CPT-4), Logical Observation Identifiers Names and Codes (LOINC), and National Drug Codes (NDC). Coded data is generally structured; in other words, all allowable entries for the data are drawn from a fixed vocabulary or coding scheme.

Data aggregation

Some healthcare organizations aggregate data from various ancillary systems or applications into databases. The way in which this is done can have implications for what types of CDS interventions may be delivered and how they are created. When data is not aggregated but instead isolated in various software applications, mechanisms for retrieving and combining the data will have to be explicitly developed to achieve the CDS intervention.

In this situation, you must determine whether the applications have modules that enable messaging or some sort of communication capability that provides access to needed data. The ease with which data can be exchanged will be determined in part by whether the access methods are compliant with any standard, such as a specific version of the Health Level 7 messaging standard. In some cases, specific applications may have these modules, but they may not have been installed or activated at a particular location. Doing so may require additional cost or further negotiation with a vendor.

Even in those settings in which data may be aggregated into a central clinical data repository (CDR), the methods through which this is done will have an impact on the design of the CDS intervention. Those implementing the intervention must determine whether data are aggregated using a standard vocabulary (such as SNOMED-CT or LOINC) or whether the original vendor terminology is used.

Also, those implementing the intervention must ascertain how information is organized in the CDR so that needed data may be retrieved for processing. Changes in both vocabulary (for example, through the installation of a new laboratory information system) and the database organization may affect generation of the intervention, and coordination of future information system changes with CDS implementers will be important.

In addition, some organizations maintain a distinct data warehouse into which data are stored periodically, but not necessarily in real time. Data warehouses often are used by administrators for quality assurance and by researchers to perform scientific studies. While the data warehouse may not be as up-to-date as the clinical data repository

at any given moment, the warehouse may be used for CDS when the interventions are not necessarily urgent or time-sensitive, for example, to generate a clinician reminder to order a periodic screening test for a patient. Using a non-real-time system such as a data warehouse for this type of intervention will reduce the processing load on the data repository and help minimize the chance that CDS interventions will adversely affect the performance of other components of the information system architecture.

Data types

Clinicians have traditionally recorded patient observations as uncoded data, commonly called free text, but it's difficult to use such information to automatically drive CDS interventions. In some circumstances, automated coding systems can assign terms from a structured vocabulary to free text to facilitate such processing. In general, however, CDS interventions such as alerts that are triggered by the system, in contrast to those requested by the user, will require coded data.

The types of data each system manipulates also helps determine the role that the system can play in specific CDS interventions. Data types include:

- **Patient-centric**, such as medications; allergies; lab test results; imaging study results; visit history; health maintenance and immunization records; prior orders; problems; diagnoses; interventions and procedures; admission, functional and discharge status; and others.
- **Site-specific**, such as local antibiotic resistance patterns and sensitivities, formularies, and others.

The nature of available local data (for example, data types, structured vs. unstructured) will help define the opportunities and challenges in developing specific CDS interventions.

[Worksheet 2-1](#) can be used to catalogue your information systems and their features on which you will build CDS interventions. In addition to documenting systems already in place, it can be used to record information about specific systems you are considering adding. This can help clarify how new components can enhance (or complicate) your IT infrastructure for CDS.

Worksheets

Step 1: Conduct an inventory of the clinical information systems of your organization that could play a role in delivering CDS interventions.

CDS interventions draw on data from, and deliver material through, a variety of clinical information systems. The specific systems available in your environment can be documented in the second column in [Worksheet 2-1](#). Key executives or staff in your IS department can be a good starting point for gathering this information.

The first column divides clinical information systems into various functional groups, for example whether data flows into or out of the system, and the type of information being manipulated. Clinicians and patients interact directly with some of these systems, making them important conduits through which CDS content can be delivered. Others that might not be within typical clinician or patient workflow, such as scheduling or billing systems, can provide patient-related demographic information that will undergird CDS interventions.

The content grouping in the worksheet is a placeholder under which you can list all the different clinical content and knowledge resources that are available in your organization to support clinical care and decision making. Some of these might be tightly integrated into specific clinical systems (for example, drug interaction detection within CPOE), while others might be stand-alone reference databases. Tightly imbedded sources can be documented with the pertinent system in [step 2](#) below.

Your organization probably already has CDS content that has been developed locally such as clinical protocols and guidelines, or licensed from content vendors, such as clinical reference databases or knowledge components integrated into clinical information systems. This information can provide the seed from which you expand the clinical knowledge for your CDS program.

While in most cases the information will be in electronic format and delivered via electronic clinical information systems, paper-based CDS can be effective¹ and may have a role in your program. Most likely, additional content (developed locally, shared with other institutions or acquired from vendors) will be required to fully meet the needs of your CDS program.

Worksheet 2-1 example: Local clinical information systems and their knowledge-delivery features

Information system type	System name/ vendor	CDS-related capabilities and content ^a	Data types available and coding systems/controlled vocabularies used ^b	Notes ^c
Departmental data management				
Pharmacy information system	[vendor 1]	Alerts and interaction dose checking	Homegrown vocabulary, inpatient MRN	
Laboratory information system / results reporting system	[vendor 1]	Alerts	Homegrown vocabulary, inpatient MRN	
Radiology information / results reporting system	[vendor 2]	None	Homegrown vocabulary, outpatient MRN	
Clinical documentation				
Electronic medical record – Ambulatory	[vendor 3]	Alerts, order sets, documentation tools, data display, reference material	ICD 9, CPT, outpatient MRN.	

^a How is knowledge loaded into the system, managed and presented to the user? What types of knowledge are pre-loaded or easy to integrate? Consider jumping ahead to [Figure 3-3](#) for an overview of different intervention types that you might want to document here.

^b Data types include laboratory and radiology tests, diagnoses, drugs, procedures and others that may be coded by systems such as SNOMED, ICD-9, LOINC, CPT, NDC. Note if the data are uncoded or coded using local schemes (e.g. patient identifier codes).

^c Regarding the extent to which this system is integrated with other systems (shares data, patient identifiers, etc.), and whether message communication standards (e.g. Health Level 7) are used.

Information system type	System name/ vendor	CDS-related capabilities and content ^a	Data types available and coding systems/controlled vocabularies used ^b	Notes ^c
Electronic medical record – inpatient	[vendor 4]	Alerts, order sets, documentation tools, data display, reference material	Homegrown order nomenclature, inpatient MRN, Multum mapping for drugs.	
Emergency medicine – tracking system	Homegrown ER system.	Order sets, documentation tools, order sets	Homegrown, inpatient MRN.	
Financial/administrative				
Charge capture system	[vendor 2]			
Billing system	[vendor 2]	None		
Scheduling/registration system	[vendor 2]			Used for all outpatients making the MRN useful
Ordering				
Order entry – ambulatory	[vendor 3]			
Order entry – inpatient	[vendor 4]			
Order entry – emergency medicine	Homegrown (see above)			
Communication – user devices				
Wireless infrastructure: smart phones, wireless PDA, alphanumeric pager, wireless laptops	Wireless in large areas of the hospital, pagers are centralized			Pagers might be used for output messages
Telemedicine infrastructure (e.g. remote monitoring/data exchange with patients at home)	None			
Data aggregation				
Clinical data repository	Homegrown research database, also the repositories that go along with main inpatient and outpatient systems			
Data warehouse	See above			

Information system type	System name/ vendor	CDS-related capabilities and content ^a	Data types available and coding systems/controlled vocabularies used ^b	Notes ^c
Content				
Reference/knowledge sources for clinicians	various on-line references and textbooks; disease management Web site			
Health information for patients	[Widely acclaimed, home-grown, condition-specific Web site]			
Other knowledge-based tools				
Health risk assessment tools	Some exist in homecare, need to investigate			

Step 2: Begin noting functionality and content in each system that could support CDS interventions.

The specific clinical objectives and success indicators outlined in [Section 1](#) might begin to trigger ideas about promising interventions as you survey your information system infrastructure. Although these details will be examined in much greater detail in the next two sections, you can begin documenting in column 3 of [Worksheet 2-1](#) the pertinent content, such as integrated knowledge bases, and features like alerting capabilities that you uncover during this survey.

Step 3: Delineate the types of data each system handles, and how the data is coded, communicated and aggregated across the organization.

Use the fourth column in [Worksheet 2-1](#) to document the data types available in the system (for example coded vs. uncoded; laboratory results, medication lists, and so on) and any coding systems used. In the fifth column, record notes about the extent to which each system shares data and patient identifiers with other systems. Such interoperability can be essential for interventions that require coordination between several information systems.

Concluding comments

[Worksheet 2-1](#) outlines the information systems and content currently available in your organization that can be called upon to support the CDS interventions needed to meet the goals and objectives outlined in the previous section.

In many cases, your organization won't have all the infrastructure, functionality and interoperability necessary to achieve all your goals and objectives. Although the current inventory might limit the opportunities to select specific CDS interventions, your

analysis in this section will help you make the best use of available infrastructure. In addition, this documentation can help set the stage for business cases that define the need for enhancements to IT infrastructure.

The next section discusses how to select specific CDS interventions that will leverage current information systems to achieve CDS program targets. The assessment of supported data types and vocabularies also foreshadows logistical considerations that might arise from trying to coordinate information flow in potentially disparate systems. [Section 4](#) addresses these issues in greater detail.



Additional Web reading and resources

- Health Level 7 Electronic Health Record Functional Model and Standard <http://www.hl7.org/ehr/>; this model and standard will include descriptions of clinical decision support functions within EHRs. See also the EHR Collaborative Web site: <http://www.ehrcollaborative.org/>.
- Healthcare Informatics Annual Resource Guide (<http://www.healthcare-informatics.com/aresource.htm>) lists many commercial clinical information systems.

References

¹ Montgomery AA, et al, Evaluation of computer based clinical decision support system and risk chart for management of hypertension in primary care: randomised controlled trial, *BMJ*, 2000.March 320;(7236):686-90. <http://bmj.bmjournals.com/cgi/content/full/320/7236/686>.

Selecting CDS interventions

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After cataloguing local clinical information systems and their features, the next step is to select specific CDS interventions to accomplish the CDS program's goals and objectives.

Tasks

1. For each clinical objective identified in [Section 1](#), determine its objective class as outlined in [Figure 3-1](#) and add this information to the goals and objectives data in [Worksheet 1-3](#). ([Worksheet 3-1](#))
2. Use [Figure 3-4](#) to help identify the optimal workflow opportunities and CDS intervention types for that objective class, in light of your available CDS infrastructure outlined in [Worksheet 2-1](#). ([Worksheet 3-2](#))
3. Define the specifics and parameters for each chosen intervention (in other words, the who, what, when, how and where). ([Worksheet 3-3](#))
4. When the interventions and associated details have been determined, summarize each on an intervention summary form. ([Worksheet 3-4](#))

Discussion

The previous two sections established the CDS targets that your organization hopes to achieve and the information system capabilities available to achieve them. This section will help you create a link between these targets and capabilities.

The proper selection of when and how to deliver a CDS intervention is essential to ensure its effectiveness. This section helps you choose the best intervention types and the best opportunities to deliver those interventions to accomplish your objectives.

Clinical objective classes

Most clinical objectives can be grouped into a few specific classes, and these classes lend themselves well to specific types of CDS interventions. For example, the general objective class of promoting health maintenance screening can be effectively addressed by interventions that display recommended tests at the start of each clinical encounter and enable the clinician to order them immediately¹.

Mapping specific clinical objectives to objective classes, mapping those classes to CDS opportunity points in workflow, and then selecting specific CDS interventions pertinent to the CDS opportunity points can help you find the best interventions to achieve those objectives. [Figure 3-1](#) illustrates the first link in this chain by outlining some classes of clinical objectives and associated objective examples.

Figure 3-1 Classes of objectives and specific examples^a

Objective class	Example objective within the class
Increase appropriate gathering of key patient history findings	<ul style="list-style-type: none"> Assess and document patient smoking status at every encounter
Increase indicated clinical follow-up or screening physical examinations	<ul style="list-style-type: none"> Perform annual funduscopy and regular foot exams for diabetics
Increase indicated screening and follow-up testing	<ul style="list-style-type: none"> Obtain annual cholesterol/LDL testing for appropriate persons Patients perform home glucose monitored regularly and communicate results to caregivers
Increase delivery of indicated preventive interventions and counseling	<ul style="list-style-type: none"> Annual flu shot received by appropriate persons Bicycle safety counseling provided for appropriate children
Increase referrals indicated for necessary diagnostic or therapeutic interventions	<ul style="list-style-type: none"> Diabetics receive regular podiatry referrals Women receive regular mammography referrals as appropriate
Institute initial management orders appropriate to clinical situation / chief complaint and care setting	<ul style="list-style-type: none"> Full complement of indicated interventions ordered in patients seen in the emergency department with acute MI Most effective and efficient diagnostic evaluation ordered in ambulatory settings for patients with suspected rheumatologic disease
Check orders immediately for problems ² or needed consequent orders	<p>Orders checked when entered to look for:</p> <ul style="list-style-type: none"> Therapeutic duplication Single or cumulative dose limits exceeded, or drug under dosed Inappropriate drug given allergies and cross allergies Contraindicated route of administration Drug-drug, drug-food interactions (including IV compatibility problems) Drug contraindicated/dose limits exceeded based on patient diagnosis, age and weight, laboratory studies, and/or radiology studies Key consequent orders not implemented Repeat test ordered sooner than appropriate More cost-effective diagnostic or therapeutic alternative Follow-up orders needed for indicated monitoring or associated interventions (e.g. rescue medications for certain drugs)
Optimize treatment regimen over time based on patient's clinical circumstances (e.g. current disease stage, laboratory and examination findings)	<ul style="list-style-type: none"> Patients with specific clinical conditions (e.g. MI, CHF) receive interventions (if indicated) that are clearly shown to improve morbidity, mortality (e.g. aspirin, ACE inhibitors) Patients are on treatment regimens that achieve and maintains target disease parameters, e.g. goal BP in hypertension, HbA1C in diabetes, LDL in hyperlipidemia Hospitalized patients are managed in a manner that safely minimizes length of stay
Empower patients with information needed to participate effectively in maintaining their health and managing illness	<ul style="list-style-type: none"> Patients receive self-care instructions at clinical encounters pertinent to their illness stage and details, as well as their reading level Patients receive focused answers to clinical questions from trusted clinicians, along with supplementary explanatory materials

^a This table will be refined and expanded over time with input from workbook users.

CDS opportunities in workflow

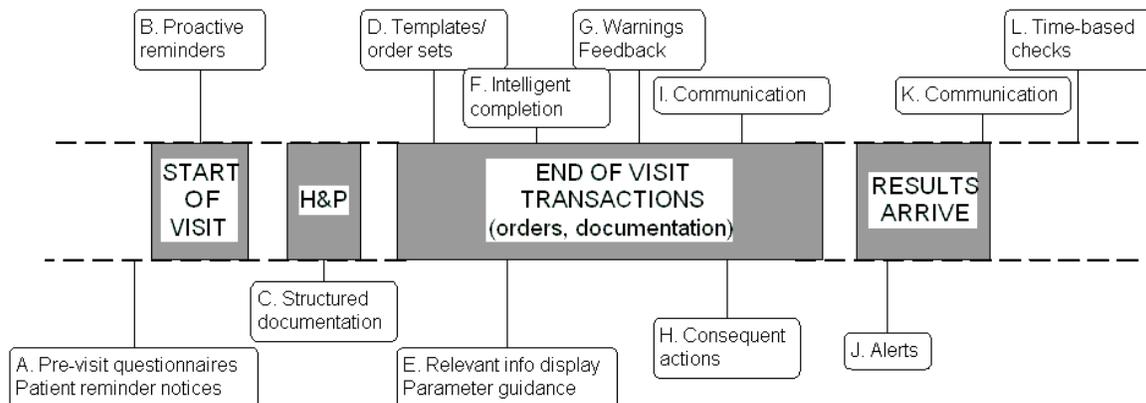
Different objective classes are best handled at different points in the continuum of care. Opportunities to address objectives in each class with CDS interventions occur when patient care is at a critical juncture or decision point, when pertinent clinical data is available, and when pertinent parties can be reached with the intervention.

These opportunities can be spread across healthcare system encounters (such as ambulatory or emergency department visits, home self-care, inpatient care) or outside of such encounters (such as when test results are posted outside of a care episode or clinicians receive a practice audit and feedback). The opportunities can arise at a variety of points within an encounter, for example at pre-visit, patient intake, and clinician documentation, ordering and results review.

It's important to consider that patients' actions are often a critical factor in whether or not CDS targets are reached. Liberal use of interventions that empower patients (for example, reminders to obtain indicated health maintenance care, or tools to help them track and optimize critical disease markers) can help ensure that patients participate fully in achieving clinical objectives. Multi-pronged interventions that help several recipients, such as clinicians, patients and support staff, to work toward the same goal (like ensuring that patients get indicated mammograms or flu shots) might be particularly effective.

[Figure 3-2](#) illustrates some of these opportunities and introduces some CDS intervention types that can be delivered at various points along the care continuum.

Figure 3-2 CDS opportunities in clinical workflow



CDS intervention types

[Figure 3-3](#) presents a categorized overview of clinical decision support intervention types. The specific intervention subtypes listed in the table represent the option palate that you can use to assemble a suite of CDS interventions. Information systems that deliver the various interventions are listed for each type, which will help you determine which specific options are available in your IT environment by referring back to [Worksheet 2-1](#). Note that interventions implemented in practice can be formed by combining these elemental interventions, for example, by linking an alert to supporting reference materials.

Figure 3-3: Clinical decision support intervention types

1. Forms and templates

- **Benefits:** complete documentation for quality/continuity care, reimbursement, legal; complete orders; facilitates other data-driven decision support
- **Subtypes:**
 - 1.1. Prompts for collection of necessary information to make more advanced decision support suggestions for a complex process
 - 1.2. Clinician encounter documentation forms (comprehensive or specialized elements for charting progress of specific conditions and preventive services)
 - 1.3. Patient self-assessment forms completed prior to encounter (e.g. general, problem-oriented, or health-risk assessment)
 - 1.4. Order templates that guide complex ordering, e.g., guided dose algorithms, orders with counter-detailing and so on, as well as data capture (for parameter checking, alternative recommendations)
- **Applications/systems where intervention type is found^b**
 - Clinical documentation (e.g. documentation templates in EMRs or personal health records)
 - Ordering (e.g. order sets in CPOE and electronic prescribing)
 - Communication (e.g. problem-oriented patient self-assessment sent via secure messaging)

2. Relevant data presentation

- **Benefits:** optimize decision making by ensuring all pertinent data are considered
- **Subtypes**
 - 2.1. Patient-specific data display for general data review (e.g. in a problem-specific or preventive care flow sheet)
 - 2.2. Patient-specific data display for context during clinician ordering (e.g. previous test results, probability of obtaining an abnormal result)
 - 2.3. Situation-specific data display that's relevant to a setting (e.g., recent hospital antibiotic sensitivities), or a condition (e.g. practice audit and feedback report indicating all the patients overdue for a key preventive care intervention or with a poor disease control parameter)
 - 2.4. Costs of orders display
 - 2.5. Retrospective reporting (e.g. physician practice audit and feedback, report cards)
- **Applications/systems where intervention type is found**
 - Clinical documentation (e.g. problem-specific EMR/PHR flowsheets)
 - Ordering (e.g. order-relevant data)
 - Communication (e.g. results summaries for patients)
 - Departmental data management (e.g. results reporting, medication summaries)
 - Data aggregation (e.g. physician report cards from data warehouses)

3. Proactive order suggestions and order sets

- **Benefits:** Makes the right thing the easiest to do; ensures that a situation is addressed completely; prevents errors of omission; promotes standardization of orders
- **Subtypes:**
 - 3.1. Prompts for correct and complete orders and related situation-specific documentation
 - 3.2. Condition-specific order sets; fully specified or pick lists, fill-in-the-blank
 - 3.3. Consequent orders, e.g. tests (for follow-up), interventions (e.g. rescue drugs)
 - 3.4. User-requested access to decision logic/critiquing under 6 (below)

^b This heading in this table contains selected examples drawn from the systems listed in column 1 of [Worksheet 2-1](#). Note that the “Content” and “Other knowledge-based tools” headings from that worksheet don't apply here.

- 3.5. Recommendations on preferred diagnostic and treatment intervention(s)
- **Applications/systems where intervention type is found:**
 - Ordering systems
4. **Support for guidelines, complex protocols, algorithms, clinical pathways^c**
- **Benefits:** Makes the right thing the easiest to do and helps avoid omission errors in care processes stretching over time
 - **Subtypes:**
 - 4.1. Stepwise processing of multi-step protocol or guideline
 - 4.2. Checks ensuring that management protocols are followed in a long-term care process
 - 4.3. Time-based reminders, such as health maintenance and preventive services
 - **Applications/systems where intervention type is found:**
 - Clinical documentation (e.g. time-based alerts in EMR/PHR)
 - Ordering (e.g. order sets, active guidelines in CPOE)
5. **Reference information and guidance**
- **Benefits:** address recognized information needs of patients and clinicians
 - **Subtypes:**
 - 5.1. Context-insensitive delivery of reference and guidance materials (e.g. links from EMR to clinical reference table of contents)
 - 5.2. Context-sensitive delivery of reference and guidance materials (e.g. InfoButtons^d, calculators/nomograms); diagnostic decision support; “notify me when...” user-configured alert
 - **Applications/systems where intervention type is found:**
 - Clinical documentation (e.g. reference links from problems, abnormal results in EMR/PHR)
 - Ordering (reference links from orderable items CPOE)
 - Communication (e.g. reference links from items in physician-to -patient correspondence)
 - Departmental data management (e.g. reference links from results or drugs posted in departmental systems)
6. **Reactive alerts (i.e. unsolicited by patient or clinician recipient)^{e f g h}**
- **Benefits:** Prevent errors of omission or commission because of unrecognized knowledge needs of physicians or patients
 - **Subtypes:**
 - 6.1. Alerts to prevent potential errors
 - 6.1.1. Drug contraindication/interaction (drug, food, disease, lifestyle, age, allergy, test administration or result, therapeutic duplication, wrong route)

^c For example: Tang et al, ActiveGuidelines: Integrating Web-based Guidelines with Computer-based Patient Records, <http://www.amia.org/pubs/symposia/D200173.PDF>; The SAGE Project, <http://www.sageproject.net/>; and Maviglia et al, Automating Complex Guidelines for Chronic Disease: Lessons Learned, *Journal of the American Medical Informatics Association*, <http://www.jamia.org/cgi/content/abstract/10/2/154>.

^d For example: Columbia University, The InfoButton Manager, <http://www.dbmi.columbia.edu/~ciminoj/Infobuttons.html>; Del Fiol et al, Digital Library Access (HL7 InfoButton API Proposal, <http://www.hl7.org/library/committees/dss/minutes/rocha-presentation-library-access-0103.pdf>).

^e May occur in order-entry process, in response to event detection, etc.

^f Drawn from sources including, “Description of Order Categories in the Leapfrog CPOE Evaluation” Table 1, page 6: <http://www.leapfroggroup.org/CPOE/CPOE%20Evaluation.pdf>.

^g Knowledge interventions can be directed to physicians and/or patients as appropriate.

^h Can process varying amounts of patient-specific data to provide tailored information.

- 6.1.2. Under/overdose (single/total/frequency, incorporating multiple patient factors)
- 6.1.3. Incorrect test or study for an indication
- 6.1.4. Critical lab test result notification (e.g. via pager)
- 6.2. Alerts to foster preferred or optimal orders and care plans (e.g. reduce service over/underuse). For example, recommendations to optimize:
 - 6.2.1. Clinical problem management
 - 6.2.2. Preventive services delivery (e.g. screening, counseling, chemoprevention)
- 6.3. Alerts to promote more cost-effective orders, e.g. when:
 - 6.3.1. There is a more cost-effective drug, regimen or formulary-compliant option available
 - 6.3.2. Tests are inappropriately duplicated
- **Applications/systems where intervention type is found:**
 - Clinical documentation (e.g. abnormal results warning in EMR with management recommendations)
 - Ordering (e.g. drug interaction warning in CPOE)
 - Departmental data management (e.g. abnormal results or drug interaction flagged in departmental systems)

[Figure 3-4](#) is a detailed framework for interrelating the CDS clinical objectives and CDS intervention types discussed above with clinical workflow³. As such, it is the linchpin for selecting CDS interventions. Key steps, as discussed below, include mapping each clinical objective to an objective class; locating each objective class in the middle column of [Figure 3-4](#); and looking in the corresponding row in the third and first column to identify promising interventions to achieve the objective, and possible points in the workflow to deliver them.

Keep in mind that this mapping is an inexact science at present. For example, the workflow steps in this table are idealized and will vary somewhat depending on care setting, and some interventions and workflow steps will be pertinent to achieving objectives that aren't reflected in the corresponding row's objective classes.

Nonetheless, this table should provide a helpful framework and stimulus for considering and selecting specific CDS interventions. The workbook authors welcome feedback on improving this tool.

Figure 3-4 example: Clinical workflow and corresponding CDS objective classes and intervention opportunities

Clinical workflow ⁱ	Clinical objective classes ^j	CDS interventions ^k
1. Before clinical encounter		
1.1. Clinician reviews patient-specific targeted health summary	Gather findings, increase indicated examinations, increase indicated testing, increase preventive care	Data presentation
1.2. Patient-submits pre-visit questionnaire	Gather findings	Patient self-assessment forms

ⁱ Generic idealized sequence; can be adapted as needed to reflect specific, local circumstances.

^j From [Figure 3-1](#).

^k Mostly intervention types from [Figure 3-3](#), but in some cases subtypes.

Clinical workflowⁱ	Clinical objective classes^j	CDS interventions^k
1.3. Clinician reviews knowledge about problem/issue	Optimize treatment	Reference, protocols
1.4. Alerts/reminders (e.g. health maintenance, on face sheet)	Increase indicated examinations, increase indicated testing, increase preventive care, optimize treatment	Alerts, protocols
1.5. Patient information and patient decision aids	Empower patients, increase preventive care	Alerts, templates, reference
2. During clinical encounter		
2.1. Diagnostic evaluation		
2.1.1. Data gathered from patient record	Gather findings	Data presentation, reference, documentation templates
2.1.2. Data gathered from patient (history and exam)	Increase indicated physical examinations	Documentation templates, reference
2.1.3. Testing	Increase indicated testing, check orders/optimize treatment (to decrease unnecessary testing)	Order sets, protocols, alerts, reference
2.1.4. Diagnostic consultations obtained	Increase indicated referrals, optimize treatment (to decrease unnecessary referrals)	Order sets, protocols, alerts, reference
2.1.5. Diagnoses and differential diagnoses established	Gather findings	Reference, alerts, data presentation, protocols
2.2. Management planned and implemented via orders	Appropriate initial management, check orders, increase preventive care, increase appropriate referrals, optimize treatment regimen	Order sets, protocols, reference, alerts, data presentation
2.2.1. Drugs selected (safe, cost effective, and appropriate for patient circumstances; such as selection and dosing for age, co-morbid illness, other drugs, formulary)		
2.2.2. Non-drug interventions selected (invasive, nursing, etc.)		
2.2.3. Follow-up for intervention efficacy and side effects; further clinical evaluation, testing and modification of plan as needed		
2.2.4. Therapeutic consultations obtained		
2.2.5. Encounter discharge or follow-up planned and arranged		

Clinical workflow ⁱ	Clinical objective classes ^j	CDS interventions ^k
2.3. Patient educated (customizable to patient, clinician)	Empower patients	Reference, order sets, alerts
2.3.1. Information on condition, including risk assessment/prioritization, shared decision making		
2.3.2. Patient self care		
2.3.3. Discharge instructions		
3. After clinical encounter		
3.1. Drugs Dispensed (e.g. appropriate as in 2.2.1)	Check orders, Appropriate initial management, optimize treatment regimen	Alerts, reference
3.2. Drugs administered (e.g. IV compatibility, site restrictions)	Check orders	Alerts, reference
3.3. Test results posted		
3.3.1. Result interpreted in context of previous patient data and addressed accordingly	Optimize treatment regimen	Data presentation, alerts, reference, order sets, protocols
3.3.2. Result, interpretation, plan conveyed to patient	Optimize regimen, empower patients	Reference, order set, alert
3.4. Orders placed outside encounter	check orders, increase appropriate referrals, optimize treatment regimen	Order set, protocol, reference, alert
3.5. New clinical information available (e.g. drug withdrawn)	Optimize treatment regimen, increase appropriate referrals	Order sets, reference, alerts
3.6. Clinician reflects on encounter/condition or multiple encounters (alternative diagnoses or Rx possibilities)	Optimize treatment regimen	Reference, alerts
3.7. Information system sends a population-based clinical data report to clinician (e.g. report card, practice audit; patient-specific information may be formatted for distribution to individual patients)	Increase appropriate examinations, increase appropriate testing, increase preventive care, increase referrals, optimize treatment regimen (including decreasing unnecessary interventions), empower patients	Data presentation, alerts

Armed with the background from the discussion above on the relationship between CDS clinical objectives, objectives classes, clinical workflow and CDS intervention types, and information system functionality, you now can begin identifying specific CDS interventions to help achieve your CDS targets.

Worksheets

Step 1: For each clinical objective identified in [Section 1](#), determine its objective class as outlined in [Figure 3-1](#) and add this information to the goals and objectives data in [Worksheet 1-3](#).

[Worksheet 3-1](#) is a duplicate of [Worksheet 1-3](#) with an additional column to indicate the objective class for each clinical objective listed. Use objective classes in [Figure 3-1](#) to assign an objective class to each clinical objective in [Worksheet 3-1](#) (with the data brought forward from [Worksheet 1-3](#)). Directly below is the example presented earlier in [Section 1](#), but with the “objective class” column completed to illustrate how objective classes can be generated from specific clinical objectives.

Worksheet 3-1 example: CDS program goals and corresponding clinical goals and objectives (and objective classes)

CDS program goal: Support diabetes disease management outcomes that measurably improves care processes and outcomes^l

Focus area and context: Diabetes mellitus disease management program^m

Clinical goal to support CDS goal	Specific objectives (clinical actions)	Class of objective	Success indicators	Notes ⁿ
A. Prevent diabetic retinopathy	A1. Increase regular ophthalmology follow-up A2. Perform annual funduscopy exam	A1. Increase indicated referrals A2. Increase indicated physical examinations	X% yearly ophthalmology visits	
B. Decrease complications of diabetic neuropathy	B1. Increase regular podiatry follow-up	B1. Increase indicated referral	X% yearly foot exams; reduced hospitalizations for diabetic foot problems	
C. Prevent diabetic nephropathy	C1. Increase regular measurement of microalbumin	C1. Increase indicated testing	X% yearly microalbumin orders	
D. Improve lipid management	D1. Increase regular measurement of LDL, cholesterol D2. Increase use of statins for patients with appropriate levels	D1. Increase indicated testing D2. Optimize treatment regimen	X% measured LDLs, cholesterol Y% of patients with LDL < etc.	
E. Improve BP management	E1. Increase regular measurement of	E1. Increase indicated physical examinations	X% of patients with BP recorded at recommended	

^l Consider completing one version of this worksheet for each high-level CDS goal and focus area, such as those outlined in [Figure 1-1](#) and [Worksheet 1-2](#).

^m Includes stakeholders and initiatives pertinent to the overall goal, local data supporting organizational priority for the goal, external evidence supporting importance of goal.

ⁿ Specific stakeholders and local initiatives pertinent to the clinical goal or objective, internal or external data supporting importance of goal and objectives.

Clinical goal to support CDS goal	Specific objectives (clinical actions)	Class of objective	Success indicators	Notes ⁿ
	BP E2. Increase number of patients with BP in desirable range	E2. Optimize treatment regimen	intervals Y% of patients with SBP/DPB in desirable range	
F. Improve glycemic control	F1. Increase regular measurement of FBS and HbA1C F2. Optimize medication use based on levels and protocol	F1. Increase indicated testing F2. Optimize treatment regimen	X% measured HbA1C Y% of patients with HbA1C < 7	
G. Diagnose DM effectively	G1. Screen appropriate patients for diabetes based on age, family history	G1. Increase indicated testing	X% of appropriate patients screened for diabetes	
H. Prevent unsafe drug use	H1. Check for medication errors or hazards whenever medications are changed H2. Obtain appropriate screening labs based on medication use H3. Adjust medications if necessary based on screening labs	H1. Check orders H2. Check orders H3. Optimize treatment regimen	Number of medication errors less than X% Number of adverse drug events and complications fewer than Y%	
I. Engage patients fully in their care	I1. Ensure optimal patient participation in addressing the objectives above	H1. Empower patients	X% of patients achieve each of the targets listed above	

Step 2: Use the objective classes identified above to help identify workflow opportunities and select CDS intervention types to accomplish specific clinical objectives; consider available CDS infrastructure as outlined in [Worksheet 2-1](#).

You can copy the specific clinical objectives and classes from [Worksheet 3-1](#) into [Worksheet 3-2](#) below. Using [Figure 3-4](#) as a guide, identify specific opportunities in clinical workflow and CDS interventions to address the objective class (and corresponding clinical objective).

For example, if your objective is to increase the use of a lifesaving drug to treat a particular condition, you would map that to the objective class “Optimize treatment regimen” (for example, using [Figure 3-1](#) as a guide). You then would find all the rows in the center column of [Figure 3-4](#) where that objective class appears. The clinical workflow stage in the first column of that row will suggest opportunities for addressing the objective, while the third column will contain CDS interventions you can apply at that point in the workflow to achieve the objective.

Note that as in [Figure 3-4](#), one intervention class might be pertinent to several points in the workflow and also be addressed by several CDS interventions. Thus, there might be several entries in each of those [Worksheet 3-2](#) columns for a single objective and objective class pair.

While filling in the interventions column, refer back to [Worksheet 2-1](#), Local clinical information systems and their knowledge-delivery features, to stimulate your thinking about CDS capabilities available in your environment. Use the last column of [Worksheet 3-2](#) (or the “capabilities” column of [Worksheet 2-1](#)) to record notes about this infrastructure, for example, important opportunities or challenges in presenting desirable CDS interventions.

In some cases, limitations of your information systems will reduce the number of choices you consider and direct you toward a single intervention. When possible, having more than one intervention focused on an objective can help ensure it is achieved. However, be careful not to overwhelm recipients with too many interventions on one clinical issue or in the overall CDS program.

Worksheet 3-2 example: Using objective classes to help identify workflow opportunities and select intervention types to accomplish specific clinical objectives

Obj. #	Clinical objective	Objective class	Workflow opportunities	Specific CDS interventions	Pertinent IT infrastructure
D1.	Increase likelihood of ordering yearly LDL on diabetics.	Increase indicated testing	1. Pre-visit: data review, face sheet, patient intervention 2. During visit: planning, ordering 3. After visit: practice audit, patient intervention	1. Flowsheets, reminders, patient education 2. Order sets, protocols, alerts 3. Data display, patient education	Outpatient EMR; needed functions available in order entry, data review and reporting modules

Step 3: Define the parameters for each intervention (for example, who, what, when, how and where) and consider potential interactions among multiple alerts.

[Worksheet 3-2](#) generates a list of CDS interventions that you’ve determined can help achieve individual clinical objectives. In this step, you begin fleshing out details of how each intervention will be implemented and the nature of the entire intervention set.

Parameters that need to be established and documented for each intervention include:

- When and how is the intervention *triggered*? Usually, this occurs at one of the workflow points outlined in [Figures 3-2](#) and [3-4](#). Some interventions are initiated by the information system, while users initiates others. System-initiated interventions include those triggered by new data (a specific type of order is entered, a particular event such as an admission occurs, a lab result becomes available), or by the passage of time (every night at midnight, eight hours after another event occurs). User-initiated interventions include information delivered

in response to a user request, for example, for reference information about a specific drug or clinical problem, or for a particular order set or flowsheet.

- For system-initiated interventions, after the intervention is triggered, what is the **rule** that is evaluated to determine whether specific information is presented to someone? For example, in the case of drug-drug interactions, the interaction-checking intervention is triggered every time a new medication is ordered. The results are delivered to a user only if certain criteria are met, for example the presence of a severe drug interaction. Triggering and notification criteria for system-initiated interventions must be carefully established to avoid excessive alerting.
- Is all the **data available** that the triggered rule needs to process? For example, reminding clinicians when diabetic patients are overdue for a foot examination requires a reliable mechanism for determining when the last examination was performed. This can be difficult if this information isn't stored in coded form.
- What **exact information** will be delivered to cause the desired outcome? Particularly for system-initiated interventions such as alerts, what actions can the clinician take in response to the information delivered? In the case of a drug-drug interaction, the intervention might allow the clinician to cancel the current order or to change one of the medications.
- How is the information **delivered**^{4,5}? Will a system user see a pop-up screen that he or she must address before proceeding? Is an e-mail message or a page sent to someone? Is there a user screen in some application that is updated so the next time the screen is accessed the intervention will be apparent? To what extent is the intervention output customized to the clinical workflow stage, the clinician and the patient?
- **Who will receive** the information generated by the intervention? This might be a person in a role pertinent to the patient or setting, such as a physician, nurse, pharmacist or the patient. Where will the recipient be when they receive the intervention—the bedside or exam room, at the patient's home, or in the pharmacy, nursing station or clinical office? What, if any, HIPAA (Health Insurance Portability and Accountability Act of 1996) data privacy and security implications⁶ must be considered regarding transmission and storage of patient specific data related to the planned CDS interventions?

Think carefully about how the intervention set will affect everyone's workflow, including that of clinicians, support staff, patients and others. Identify ways to ensure that information is delivered in a format and at a time that will be most conducive to its being acted upon appropriately. Consider opportunities to facilitate shared decision making between clinicians and patients.

You can use [Worksheet 3-3](#) to help determine and document these parameters for each CDS intervention from [Worksheet 3-2](#).

Worksheet 3-3 example: Implementation parameters for each intervention

CDS intervention

LDL reminder

Description:	Last LDL cholesterol measurement posted in summary data sheet for diabetic patients; alert generated in electronic record if patient is overdue; patients significantly overdue are noted on clinician audit report for all their diabetic patients
When (workflow step)	Various: during results/summary sheet review before or during visit, outside of visit for audit report
Why (triggered by, rule)	Data automatically added to diabetes summary sheet on result posting; non-intrusive alert (i.e. in “reminder” area of electronic face sheet) is generated when patient’s electronic chart is opened if the test is overdue
What (information presented)	Date and value of last LDL measurements; alert mentions importance of yearly testing, provides supportive reference, and includes option to order the test with a single click.
How (delivered)	As above
Who (recipient)	Nurse or physician working with the electronic chart, or physician reviewing practice audit
Which (actions facilitated)	Ordering of LDL cholesterol level

Step 4: When the interventions and associated details have been determined, summarize each on an intervention specification form.

An intervention specification form outlines the details of an intervention. The completed document can be used to gain buy-in and approval from key stakeholders about the intervention scope and expected effects, and to clarify project specifications for developers and implementers. [Worksheet 3-4](#) contains such a form.

Worksheet 3-4 example: Intervention specification form⁷

TITLE: Flu shot reminder system

1. **Objective:** Increase the number of eligible patients who get flu shots in our outpatient practices
2. **Approach:** Determine eligible patients who have visits today; put reminders to give flu shots on the standard printed schedule sheet
3. **Clinical background:** Flu shots should be offered to eligible patients. In the past, mailings to patients have not been effective at increasing flu shot use. Many patients have not received flu shots even though they had a regular visit with their provider
4. **Selection criteria:** Use CDC guidelines to determine which patients are eligible for flu shots and the duration of season in which to offer them
5. **Exclusion criteria:** Patients whose health grid shows a flu shot for the current flu season, or who have an egg allergy
6. **Target population for intervention:** Primary care physicians and nurses in outpatient practices
7. **User interface:** Printed suggestion to offer flu shot, if appropriate, at bottom of schedule sheet
8. **Monitoring:** Assess whether patients who meet eligibility criteria do get printed reminders; monitor proportion of patients getting flu shots
9. **Evaluation:** Analyze proportion of eligible patients in practice who receive flu shots.
10. **Primary stakeholders:** Directors of ambulatory practices
11. **Clinical champion for this project:** Dr. Phyllis Smith
12. **Urgency / required delivery time:** Before September 1
13. **Whose jobs do you expect to be affected by this project?** Practice managers or secretaries who print schedules; providers; nurses or assistants who administer flu shots
14. **What are possible adverse consequences of implementing this project?** What if the reminder is given on a patient who had a flu shot already (elsewhere, or here but after reminder was queued or printed)—would patients receive extra flu shot?
15. **Specification approval:** [approvers, date]

Your collection of completed intervention specification forms reflects the scope of interventions in your CDS program. You might consider summarizing key elements from these forms into a single CDS program overview that you can use to help communicate the breadth and status of the program to other stakeholders.

Concluding comments

At this point, you have translated your clinical goals and objectives into specific proposed interventions, and have described each intervention (using [Worksheet 3-4](#)) so key stakeholders can carefully review it. That review process, which is important to achieve optimal tuning and acceptance of the intervention, is discussed in the next section.

Picking CDS interventions is often more art than science, and the figures and worksheets in this section are intended as a rough guide rather than a detailed roadmap for this process. The information in the figures (e.g. classes of objectives, CDS intervention types, workflow steps) will very likely be refined and expanded over time based on growing global experience with these concepts. The authors would greatly appreciate having readers share insights that they glean from selecting CDS interventions to accomplish objectives. This input will be very helpful in making this section increasingly helpful.

It is likely that you will identify gaps between the CDS capabilities (both content and IT) in your environment and what you would want to have to optimally achieve your

CDS objectives. Coping strategies include making the best of what you have, and upgrading your CDS-related systems and content.

Because the CDS market is at a relatively early stage of evolution, you may find that the functionality you want is not available from your current vendors, or perhaps it isn't available at all. In these cases, you should work closely with vendors and other customers to articulate your needs and help drive the industry toward meeting them. With subsequent editions of this workbook, we're hoping to develop a forum capability that will facilitate such an exchange.



Additional Web reading and resources

- How to Use an Article Evaluating the Clinical Impact of a Computer-Based Clinical Decision Support System. *Journal of the American Medical Association*; <http://www.ucl.ac.uk/kmc/publications/pdfs/JAMA1999.pdf>.
- Addressing Medication Errors in Hospitals: 10 Tools (Categorization of Medication Errors: Potential Technological Solutions). <http://www.chcf.org/topics/view.cfm?itemID=12682>; see various useful worksheets and tables, such as those under Tool No. 5: A Guide to Potential IT Solutions to Medication Errors).
- Computerized Physician Order Entry: A Look at the Marketplace and Getting Started. FCG, December 2001, <http://www.leapfroggroup.org/CPOE/CPOE%20Guide.pdf>. See chapter 3, "Introduction to CPOE Clinical Decision Support" pages 12-16.
- Overview of the Leapfrog Group evaluation tool for computerized physician order entry, FCG, <http://www.leapfroggroup.org/CPOE/CPOE%20Evaluation.pdf>, December 2001. See Table 1, "Description of Order Categories in the Leapfrog CPOE Evaluation" page 6.

References

¹ Khoury AT, Wan GJ, Niedermaier ON, LeBrun B, Stiebeling B, Roth M, Alexander CM. Improved cholesterol management in coronary heart disease patients enrolled in an HMO. *Journal of Healthcare Quality*. 2001 Mar-Apr;23(2):29-33.

² Examples are based upon and extend Leapfrog CPOE criteria; see Table 1, "Description of order categories in the Leapfrog CPOE evaluation" page 6: <http://www.leapfroggroup.org/CPOE/CPOE%20Evaluation.pdf>.

³ See Table 4: Mapping of order categories in evaluation tool for Leapfrog CPOE standard to clinical decision support, page 16 in <http://www.leapfroggroup.org/CPOE/CPOE%20Guide.pdf>, for an example of how the Leapfrog Group performed a similar mapping in the more limited domain of CPOE.

⁴ Kuperman GJ, Teich JM, Bates DW, Hiltz FL, Hurley JM, Lee RY, Paterno MD. Detecting alerts, Notifying the Physician, and Offering Action Items: a Comprehensive Alerting System. *Journal of the American Medical Informatics Association*, 1996, 3(suppl):704-708.

⁶ Kuperman GJ, Teich JM, Tanasijevic MJ, Ma'Luf N, Rittenberg E, Jha A, Fiskio J, Winkelman J, Bates DW. Improving Response To Critical Laboratory Results With Automation: Results Of A Randomized Controlled Trial, *Journal of the American Medical Informatics Association*, 1999 Nov-Dec; 6(6):512-22.

⁶ Centers for Medicare and Medicaid Services, HIPAA-Administrative Simplification, <http://www.cms.hhs.gov/hipaa/hipaa2/default.asp>.

⁷ From Abookire SA, Teich JM, Bates DW. An Institution-Based Process To Ensure Clinical Software Quality. Proceedings, AMIA Symposium 1999; (1-2):461-5.
<http://www.amia.org/pubs/symposia/D005594.PDF>; reprinted with permission from AMIA.

Validating and finalizing the program

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Once the set of desirable interventions are determined, the next steps are to ensure that key stakeholders accept or formally approve the plan, and then to fully define and develop the interventions.

Tasks

1. Validate the CDS intervention plan developed at the end of [Section 3 \(Worksheet 3-4\)](#), the intervention specification form) with appropriate stakeholders.
 - 1.1. Identify one or more groups to review and approve the implementation plan, if you haven't already done so. Use this group to ensure that the planned CDS interventions (individually and collectively) are acceptable to key stakeholders and recipients, fit into workflow, are likely to achieve their desired outcome and will not adversely affect other healthcare processes. ([Worksheet 4-1](#))
 - 1.2. Finalize all logistical details necessary to successfully launch the CDS intervention set. Prioritize the interventions according to value and impact, if necessary.
2. Develop the planned CDS interventions to optimize stakeholder acceptance, ease and cost of implementation, effect on workflow, and magnitude of benefit. Build in technological and people-based mechanisms for gathering and processing feedback from intervention recipients.

Discussion

Having mapped out the CDS program in detail, you now must obtain buy-in for the plan from all appropriate stakeholders. This validation process will provide further information to assist intervention design and will draw additional people more deeply into the CDS program activities. Still others will become involved during development phases. The individuals and process infrastructure you identified in [Worksheet 1-1](#) provide the pool from which these people will come.

Although [Worksheets 3-3](#) and [3-4](#) outline the basic logistics of individual interventions, there are finer details that must be designed and developed. Different types of interventions (alerts compared with templates or reference information) will each have different logistical issues. The remainder of this discussion is a laundry list of considerations and recommendations to keep in mind as you complete specifications and begin designing your CDS interventions.

General logistical recommendations include:

- Link advice to **action opportunities** as much as possible; this will optimize translation of the information into the desired action.
- Provide appropriate **customization** and tailoring of the intervention when possible, related to the setting, specialty, workflow context, practice case-mix, provider,

patient-specific factors, and so on. This extent to which individual users should be able to configure some specific interventions is controversial. For example, while users generally prefer maximal flexibility, many organizations do not permit individuals to customize order sets (which would reduce the ability of this intervention to minimize practice variations).

- Develop a **fail-safe** plan in case the clinical information systems underlying the CDS interventions become temporarily unavailable (for reasons such as scheduled maintenance or malfunction). Anticipate and mitigate any implications for patient safety from such events.
- Consider the **side effects** that successful change in targeted behavior may have on your organization. For example, when an intervention is designed to increase use of underutilized screening tests, such as mammograms, or interventions like flu shots, the volume of tests or interventions may rise significantly. Preparing affected units for intervention success with adequate capacity and supplies will help ensure that the CDS intervention achieves its overall intended result.
- Remember that there are **special considerations** for patient-directed interventions. These factors can include the patient's native language, level of formal education, culture and ways of receiving information, such as the presence of a telephone or Internet access in the home, and personal beliefs about health and illness.
- Provide **incentives** wherever possible for effective use of CDS interventions. Because the interventions often may interrupt normal workflow, it will be helpful to consider approaches to minimize their disruptive effect and optimize value. For example, providing continuing medical education credits when possible for using CDS content can provide additional incentives for clinicians to take time to review it. The AMA has been conducting pilot programs to provide Category 1 CME credit for self-directed, self-initiated, Internet-based CME¹. Presumably this would cover researching answers to clinical questions via reference-type CDS interventions.

For alerts, consider the following:

- **When** exactly within workflow will the alert be delivered? Don't underestimate the annoyance caused when a clinician's thought process or interaction with the patient is interrupted by an out-of-context alert. In practice, alerts are often ignored². While some of this is a result of improper thresholds for delivering an alert, experience suggests that intrusive alerts—even important ones—may be ignored if delivered at an inopportune moment.
- **Who** will get the message (including when and how) if an unsolicited alert is delivered during a time when the intended target isn't available to receive it, for example, accessing the system area where it is delivered? How will this escalation protocol be established and maintained?
- If an intervention is stored in a patient's electronic record, **how long** will that intervention be available to the recipient? Will it be presented to only a specific named recipient, only one member of a class of recipients or to every member of the class? For example, when issuing an alert regarding a patient's potentially life-threatening hypokalemia, you may want to notify everyone that accesses the patient's electronic record. Less urgent interventions may be presented only to the patient's primary care clinician.

- How **urgent** is the intervention, considering the rapidity of deleterious effects on the patient if an action recommended in an intervention doesn't occur? In light of the urgency, is it necessary for the recipient to acknowledge that the communication has been received? If so, what is the maximum delay before a lack of acknowledgement prompts escalation of the intervention? Does the alert stop workflow until it is addressed? Can it be overridden, and, if so, is a reason required?
- Which **medium** will be used to convey the message, (e-mail inbox, wireless and/or handheld device, pager, EMR/CPOE screen, printed encounter sheet or turn-around document)? For example, an intervention that is being offered to improve patient compliance with screening tests (such as a reminder issued to a woman to schedule an appointment for a screening pelvic examination) may be delivered by a less urgent mechanism (e.g., postal letter) than one that involves potential harm to patients (warning about laboratory test results that may indicate life-threatening conditions) that might be delivered in real time via pager to a clinician.
- What is the expected average and maximum **number** of alerts per patient and clinician? Excessive alerting is an important factor in negative perceptions of individual alerts and to the alerting component of the CDS program.
- Might **unwanted interactions** among alerts occur, because of their number and nature?
- What is the proper **notification threshold** to maintain adequate sensitivity yet minimize negative workflow effects (such as causing nuisance alerts or requiring more time or effort to accomplish a clinical task)?³
- Is it appropriate and technically feasible to allow recipients to **opt out** of specific alerts in general or for a specific patient (for example, to indicate to the system, "don't show me this again...")? Should recipients be allowed to alter the notification parameters? Under what circumstances, if any, should patients be able to modify alerts or opt out of receiving them?
- What is the **evidence** supporting the alert or recommendation? Presenting this explicitly to the recipient (in other words, as a rationale accompanying an intervention) may support their responding appropriately.
- When and how can previously issued alerts be retracted? In some instances, the data used to generate it may be discovered to be incorrect after the intervention has been received. In these situations, you must devise a mechanism for issuing a correction or retraction of the intervention.

Each point above touches on some aspect of the workflow for those affected by CDS interventions. To a great extent, the core task of this section is to successfully redesign this workflow to achieve the benefits planned for the CDS intervention.

Worksheets

Step 1: Validate the CDS intervention plan developed at the end of [Section 3](#) with appropriate stakeholders.

Step 1a: Identify one or more groups to review and approve the implementation plan. With this group, ensure that the planned CDS interventions, both individually and collectively, are acceptable to key stakeholders and recipients, fit into workflow, are likely to achieve their desired outcome, and will not adversely affect other healthcare processes.

Begin by revisiting and updating your people and process infrastructure catalogue that you collected on [Worksheet 1-1](#). Make sure any new teams or positions you created for the CDS program are reflected on it.

Identify stakeholder individuals, positions and committees who must review and approve the implementation plan. Include not only representatives who must officially sanction the plan for the organization, but also those who will be affected by the interventions and will have to develop and implement them. Whether or not you create a formal team of such individuals, you should carefully review the plan with each, and obtain their constructive advice and support.

You can use [Worksheet 4-1](#) to document this review and approval process for the overall CDS intervention plan. You also can update [Worksheets 3-3](#) and [3-4](#) with any major new logistics established for specific intervention during the review, and note on [Worksheet 3-4](#) the approval of individual interventions. Alternatively, you can adapt [Worksheet 4-1](#) so it reflects the review and approval of each individual intervention on this single worksheet.

Worksheet 4-1 example: CDS interventions for diabetes disease management program, review and approval

Reviewer/approver name	Position/role ^a	Date CDS plan presented	Date CDS plan approved ^b	Reviewer comments
[name]	Diabetes clinical champion			
[name]	Endocrinology chief			
[name]	Disease management project lead			
	CEQI committee			

Step 1b: Complete all logistical details necessary to successfully launch the CDS intervention set. Prioritize the alerts according to value and impact, if necessary to help prune down the total set.

The fine logistical details of your CDS interventions will likely emerge as you complete the vetting process in Step 1a and consider the logistical issues outlined in the discussion above. If you have been keeping [Worksheets 3-3](#) and [3-4](#) updated during this process, they will represent your final approved intervention specifications when the vetting is complete.

The points in the discussion about alerts emphasize the complex nature of these interventions. For a variety of reasons, including the complexity of developing and implementing them and potential workflow burden on clinicians, you might want to initially limit the number of alerts you provide to a core that you determine to be the most

^a Both in organization and as representative of a pertinent committee.

^b Indicate whether “approval” signifies authoritative organizational sanctioning of the intervention or just buy in from some other stakeholder type.

essential. As a backdrop for prioritizing alerts, you can look again at the equation in [Figure 1-4](#) to identify which objectives are of greatest value to your organization.

Step 2: Develop the planned CDS interventions to optimize stakeholder acceptance, ease and cost of implementation, effect on workflow, and magnitude of benefit. Build in technological and people-based mechanisms for gathering and processing feedback from intervention recipients.

Careful attention to specifying and validating the CDS intervention plan should pay off when it comes time to create the CDS interventions. For example, developers should benefit from the clear and detailed direction on exactly what is to be implemented and why. Similarly, the investment in cataloguing the available clinical information system infrastructure and selecting and designing interventions with those capabilities in mind should help minimize any surprises for developers.

Likewise, carefully considering throughout the earlier stages the workflow of those who will be affected by the CDS interventions will pay dividends during intervention development. The interventions almost inevitably will require alterations in typical routines, and the goal is to have targeted individuals perceive the changes as positive, to the greatest extent possible. Approaching the intervention development task, at least in part, as a workflow redesign process can help achieve this outcome.

You will likely draw on a broad range of the people and groups in [Worksheet 1-1](#) to oversee and support actual development. If you create a new formal team for this, or assign the responsibility to an existing team, you should document this in [Worksheet 1-1](#).

The oversight group will help resolve inevitable issues that arise during development, ensuring that the intentions and objectives previously defined for the CDS program are factored into the compromises and modifications that creep in. When this happens, [Worksheets 3-3](#) and [3-4](#) should be updated so that they continue to accurately reflect the CDS program status.

In addition to developing systems that deliver the interventions to recipients, it is important to build feedback channels for assessing the use and response to the interventions, particularly unsolicited ones such as alerts. This includes mechanisms that enable recipients to provide feedback about specific interventions, ideally in a convenient manner soon after their interaction with the intervention.

For example, if a recipient believes that a particular alert is inappropriate or some other piece of delivered information is inadequate in content or presentation, there should be a channel associated with the intervention (or perhaps the underlying information system) to communicate any concerns to an appropriate person. Similarly, there should be mechanisms to gather implicit feedback about interventions, for example, that an intended recipient is failing to respond to an alert.

Ideally, both manual and technological approaches to gathering feedback will be developed; this is considered further in [Section 6](#), which discusses evaluation. The more that individuals targeted to receive CDS interventions believe that those responsible for the interventions are responsive to their needs and concerns, the better partners they will be in achieving the desired program outcomes.

Concluding comments

The tasks outlined in this workbook section depend heavily on the work accomplished in all of the preceding sections. Ideally, clear articulation of CDS program goals, objectives and interventions, derived from broad-based and iterative input, will simplify intervention development. Similarly, this shared vision will support the workflow redesign that will accompany these interventions, and that will help determine the success or failure of the CDS interventions. Continuing this people-oriented project approach with the tasks here should similarly set the stage for a successful program launch in the next section.

Remember that your organization does not have an unlimited capacity to absorb the changes required to develop and implement CDS interventions. As a result, you should carefully consider the timeframe and order in which interventions are implemented.

By this stage in the process, you will have a clear picture of the interventions under consideration, including their anticipated costs and benefits. Although the next section discusses rollout planning in detail, it's worth reassessing now whether all of your planned interventions can be successfully handled by your organization in the next implementation round. If resources are tightly constrained, consider starting small with interventions that have a high benefit-to-cost ratio, documenting effects and building on early successes.



Additional Web reading and resources

- CDS implementation recommendations distilled from one institutions extensive experience:
 - Bates, DW, Kuperman, GJ, Wang, S et. al. Ten Commandments for Effective Clinical Decision Support: Making the Practice of Evidence-Based Medicine a Reality. *Journal of the American Informatics Association*. 2003;10:523-530 <http://www.jamia.org/cgi/content/abstract/10/6/523>.
- Research documenting usability and usefulness requirements for computer-based clinical alerts and reminders:
 - Krall MA and Sittig DF. Clinicians' Assessments of Outpatient Electronic Medical Record Alert and Reminder Usability and Usefulness Requirements AMIA Proceedings 2002, 400-405: http://www.imki.org/includes/pdf/Krall_Clinicians_Assessment.pdf.
 - Krall MA and Sittig DF. Subjective Assessment of Usefulness and Appropriate Presentation Mode of Alerts and Reminders in the Outpatient Setting. AMIA Proceedings 2001, 334-338. http://adams.mgh.harvard.edu/PDF_Repository/D010000982.pdf.
- Work regarding system architecture required to implement decision support interventions:
 - Jenders RA, Hripcsak G, Sideli RV, DuMouchel W, Zhang H, Cimino JJ, Johnson SB, Sherman EH, Clayton PD. Medical Decision Support: Experience with Implementing the Arden Syntax at the Columbia-Presbyterian Medical Center. Proc AMIA Symposium 1995; 169-173.

- Hripesak G, Clayton PD, Jenders RA, Cimino JJ, Johnson SB. Design of a Clinical Event Monitor. *Computers and Biomedical Research*, 1996; 29(3):194-221.

References

¹ <http://www.ama-assn.org/ama/upload/mm/44/winter2001.pdf>, page 4.

² Weingart SN, et. al. Physicians' Decisions to Override Computerized Drug Alerts in Primary Care Arch Intern Med. 2003;163:2625-2631. <http://archinte.ama-assn.org/cgi/content/abstract/163/21/2625>.

³ See Krall/Sittig references in additional Web readings and resources section for systematic analysis of usability and usefulness requirements for alerts and reminders.

Putting interventions into action

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After specific CDS interventions are developed, the next step is to ensure that they perform as expected and to carefully introduce them into the clinical environment.

Tasks

1. Test and validate the content, mechanics and logistics of the intervention program with appropriate stakeholders before it's launched.
 - 1.1. Evaluate intervention impact on end-user workflow and modify the intervention/program before launch to address any critical concerns.
 - 1.2. Verify that any processing done to incorporate clinical knowledge into the CDS intervention has not changed its clinical meaning or effect. ([Worksheet 5-1](#))
 - 1.3. Test and finalize support and feedback channels. ([Worksheet 5-2](#))
2. Finalize parameters and targets that will be used to assess intervention effectiveness
3. Develop rollout plan and schedule.
 - 3.1. Determine rollout sequence and communication to users; conduct a limited pilot phase to test highly invasive interventions. ([Worksheet 5-3](#))
 - 3.2. Establish ongoing routines for content/mechanics monitoring/support.
 - 3.3. Leverage and expand the involvement of any champions engaged earlier in the process. ([Worksheet 5-4](#))

Discussion

The goal of this stage is to ensure that the intervention program will be disseminated successfully to intended recipients and smoothly and efficiently achieve the desired results. As noted previously, successful interventions will have a significant effect on clinical decision making and workflow.

Clearly, the processes and workflow routines that the CDS interventions will alter are complex. They may involve many different individuals and roles, be stressful, have high stakes, and be multifaceted. Understanding the current processes in detail, as well as the effects that the new interventions will have, is essential. Careful planning, testing and rollout are required to ensure that intended recipients embrace the decision support and use it effectively.

An appropriate group drawn from the people infrastructure in [Worksheet 1-1](#) will be responsible for and oversee the program launch. Be sure to document this group explicitly on that worksheet. It also can help identify productive individuals and units with whom to pilot test the CDS interventions.

Worksheets

Step 1: Before the launch, test and validate the intervention program content, mechanics and logistics with appropriate stakeholders.

Step 1a: Evaluate intervention impact on end-user workflow and modify the intervention or program before launch to address any critical concerns.

End-user testing occurs during this step. Test cases and use scenarios can be helpful in ensuring that individual interventions and the intervention set actually function as designed. Develop scenarios that reflect plausible circumstances in which the intervention will be pertinent, and ensure that the intervention performs as expected. Have representative end-users verify that the scenarios are appropriate, and provide feedback on how the interventions alter workflow and on how to minimize any negative effects.

This stage of user testing will help assess widespread clinician readiness for the interventions and identify the need for additional education, support or incentives to ensure successful adoption. Engaging users in the development process should help minimize workflow disruption, or at least help recipients anticipate it. During the pre-launch phase, gaining widespread CDS recipient buy-in on the interventions (particularly unsolicited ones such as alerts) and their delivery details, can help ensure that these individuals will handle delivered materials appropriately after launch.

Testing also can uncover difficulties, such as unexpected or counterproductive side effects, workflow implications or costs associated with the intervention, and, in the process, suggest potential remedies before launch. The careful analysis and validation steps already accomplished should help reduce surprises at this late stage, but there probably will be some anyway. Be sure to consider how support staff will be affected by the interventions, and how best to educate and engage them in the process.

Step 1b: Verify that any processing done to incorporate clinical knowledge into the CDS intervention has not changed its clinical meaning or effect.

In addition to user-interaction testing, the content itself must be validated to ensure it's appropriate for its intended use. You also must ensure that it is triggered and delivered as intended. These tasks amount to technical quality assurance. This validation will take different forms for different intervention types, for reference information compared with order sets and alerts.

[Worksheet 5-1](#) can be used to validate that different combinations of alert inputs will produce appropriate and expected outputs. The technical team, with input from the clinical team, often performs this test of system responses to scenarios or use cases.

Attempt to create a broad, if not exhaustive, collection of different scenarios to fully test the system under different possible combinations of input variables. Likewise, include a range of scenarios that trigger each of the possible outputs of the system. Also, include scenarios for which the rule should not trigger to ensure that it doesn't. Incorrect or unexpected responses should be addressed accordingly. Note that the scenarios can be reused for ongoing testing after launch, as discussed in [Section 6](#).

Worksheet 5-1 example: Alert/recommendation appropriateness test

Test Scenario: A diabetic patient without an LDL result in the last 12 months should trigger an alert to clinicians reminding them to order an LDL test.

System logic: *IF* diabetic patient [identified by 1) member of diabetic registry; 2) ICD-9 code for Diabetes Mellitus as outpatient visit diagnosis or hospital discharge diagnosis; or 3) recent prescription for Insulin or Glucagon, etc.] **AND** No LDL result available in last 12 months

THEN: Generate alert that will be available for review prior to the patient’s visit OR will pop-up if no order has been generated and the user attempts to “close” the outpatient visit encounter.

Patient/ scenario ID	Value of alert triggering variable 1:	Value of alert triggering variable 2:	Alert/ recommen- dation text	Alert/recom- mendation Appropriate? (y/n)
	Diabetic?	LDL result in last 12 months?		
Test 1	Yes	yes	No alert	Y
Test 2	Yes	no	Alert	Y
Test 3	No	yes	No alert	Y
Test 4	No	no	No alert	Y

Step 1c: Test and finalize support and feedback channels.

This step helps ensure that both IT staff and clinical champions will be efficiently notified and prepared to address user concerns after launch. The foundation for these channels was established in [Step 2 in Section 4](#).

[Worksheet 5-2](#) can be used to document the testing and validation addressed in [Step 1](#), along with needed follow-up.

Worksheet 5-2 example: CDS validation and testing – summary issues^a

Interven- tion	Test Case/ scenario (description)	Issues raised by end user (details)	Content and mechanics validated (group/individual and date)	Feedback/ support channel validated (date)	Corrective actions needed (details)
Yearly LDL reminder	Diabetic tested 11 months 23 days ago	Can we notify patient by email or postcard that test is almost due and has been ordered by clinician?	Yes	Yes	Add new rule: Diabetic and tested >11, but less than 12 months ago...send reminder to patient by email or postcard
Diabetic foot exam	Exam done, but documented	Can we develop a natural	No. We do not currently have this capability	Yes. CMIO will call	None for now. Watch for NLP

^a Exclude concerns from [Worksheet 5-1](#) (i.e. inappropriate alerts), unless these aren’t already being addressed.

Intervention	Test Case/ scenario (description)	Issues raised by end user (details)	Content and mechanics validated (group/individual and date)	Feedback/ support channel validated (date)	Corrective actions needed (details)
	in progress note in free text rather than using coded field	language parser to recognize completed tests documented in progress note?		clinician and explain problem	solutions at HIMSS

Step 2: Finalize parameters and targets that will be used to assess intervention effectiveness.

This task uses the CDS intervention “success indicators” and “anticipated benefits” documented earlier in [Worksheets 1-3](#), [3-1](#) and [3-4](#). Where possible, the targets should include magnitude of the expected benefit.

Articulating measurable objectives for interventions clarifies for everyone (implementers and users) why the intervention is being implemented and a key criteria by which its success or failure will be determined. Making the targets explicit can help all participants focus on achieving the objectives. Alternatively, it can help identify at an early stage when there is disagreement about the objective’s desirability. Reconciling any differences earlier is much better for resource utilization and morale than doing so later.

For this step, revalidate with pertinent stakeholders the targets in [Worksheets 3-1](#) and [3-4](#) based on actual pre-launch intervention characteristics, and modify the targets as needed. If you haven’t done so already, consider collecting “pre-intervention” data to use as a baseline for determining the CDS intervention effects. This can be useful not only for internal purposes, but also if you decide to publish information about your program and its effects.

Consider the types of data that will be needed to assess intervention impact, and where and how that data can be obtained. For example, assessing outcome measures—such as patients achieving target laboratory parameters, obtaining indicated referrals and receiving appropriate medications—may require data from disparate systems, such as departmental, clinical data repository, and others). Gathering, validating and processing this information can require as much care and effort as developing the intervention itself.

Step 3: Develop rollout plan and schedule.

Step 3a: Determine rollout sequence and communication to users; conduct a limited pilot phase to test highly invasive interventions.

Even if the CDS program has been developed with significant input from all stakeholders, great care still must be exercised in establishing the rollout plan. As noted in [Section 1](#), the program is fundamentally an exercise in organizational change management, and the rollout is how that change is formally introduced to the environment.

The nature of both the CDS program and the environment should be considered in determining the speed, scope (which clinical units), and order (which interventions first) of an intervention launch. For example, issues such as the urgency in addressing the

underlying CDS objective, the magnitude of the CDS program (whether it's limited in scope or a comprehensive suite of interventions), and the capacity of the implementation team and intervention recipients each will affect these rollout variables.

How the intervention is communicated to the recipient community is as important as the rollout details themselves because that communication can help set the tone for acceptance by users. Once again, this communication should build on the support and buy-in established in earlier implementation stages. For example, it should convey that the interventions were developed with broad input from stakeholders, and outline expected changes to workflow and benefits to key healthcare outcomes, as well as to the recipients themselves.

Keep in mind that, in some cases, CDS interventions might be more strictly reinforcing specific clinical policies that are already in effect. For example, an intervention might make it impossible to order a restricted medication in a CPOE system without required approval. In instances where the policy might be somewhat unpopular, consider decoupling its enforcement with the CDS intervention launch. For example, one approach might be to more strictly enforce the policy by other methods beginning several months before the CDS intervention launch. This can reduce negative reactions to the policy itself, which would complicate the launch of the CDS intervention. Conversely, CDS interventions that reinforce policies beneficial or desirable to recipients can be launched at a time and manner that leverages this anticipated support.

For interventions such as alerts that are potentially disruptive to workflow and counterproductive if not implemented properly, it will be helpful to launch them initially with a small number of users or in selected locations. Such limited live testing can uncover problems not previously identified from development testing. This phased release for a potentially problematic intervention provides an opportunity to work out problems that might occur with its routine use, before exposing large numbers of recipients to it.

Step 3b: Establish ongoing routines for content/mechanics monitoring/support

Both the clinical knowledge base from which CDS interventions are derived and the technology infrastructure through which they are delivered are in a constant state of flux. As such, it is essential to monitor both the CDS content and delivery mechanisms on an ongoing basis to ensure that they are performing as expected.

Maintenance issues will inevitably arise because important new knowledge is available and must be incorporated, or because adding new clinical content to information systems changed behavior in undesirable ways. Even before the launch, it's essential to anticipate these monitoring and maintenance needs and develop routines for addressing them.

[Worksheet 5-3](#) can be used to document these rollout and monitoring/support plans. If needed, you can separate documentation for these functions into two separate worksheets.

Worksheet 5-3 example: Decision support rollout plan^b

Phase: Initial rollout

Intervention	Launch Date	Applications involved	Intervention type	Settings Involved	Communication plan (to end-users)	Content/delivery validation date	Content Delivery monitoring /maintenance plan	Responsible individuals, committees (content/IT)
Facilitating yearly LDL measurement for diabetics	March 1, 2004	Ambulatory EMR and CPOE, Clinical data repository (for audit)	Data display (summary sheet, audit), reminder, alert	All primary care and endocrinology outpatient	Monthly staff meetings with pizza; e-mail reminder week of go-live, posters in clinics; e-mail	Jan 15, 2004	Feb 15, 2004 – Add reminder to CDS monitoring DB	Diabetes disease management steering committee
Warfarin/Sulfa interaction	April 15, 2004	CPOE	Alert	ALL	Reminder week of go live	Jan 15, 2004, for all interactions	Feb 15, 2004 – Add all interactions to CDS monitoring DB	Pharmacy and Therapeutics P&T committee

Step 3c: Leverage and expand the involvement of any champions who were involved earlier in the process.

Healthcare organizations generally find that clinician champions are crucial to successful decision support implementation.¹ These individuals can include early technology adopters, clinical thought leaders, clinicians closely connected with management, “super users” who quickly learn new systems and are happy to share their knowledge with others, and some who have combinations of these characteristics. Ideally, those chosen for the CDS program will understand the value and importance of clinical decision support, convey this message to their colleagues, and model successful system use.

Conversely, from the early days of clinical decision support to the present, healthcare organizations have encountered individuals who oppose CDS interventions and work to subvert them. To the extent appropriate, the concerns of these individuals should be heard and addressed as early as possible in development process, and unresolved concerns managed proactively during the rollout phase.

Hopefully, several champions already have been identified in [Worksheet 1-1](#) and utilized during earlier CDS implementation stages. Nonetheless, fully engaging them to support the rollout of CDS interventions, and expanding their ranks, can help foster launch success. For example, they can share examples with colleagues of how the suite of interventions can be helpful and effective. Both informal exchanges and more formal presentations in staff meetings and conferences can be useful in spreading this message.

[Worksheet 5-4](#) is an extension of the stakeholder catalogue from [Worksheet 1-1](#). It can help track these champions and engage them in the CDS program’s success.

^b Complete for each phase. For example, initial rollout, major extension or enhancement to CDS program.

Worksheet 5-4 example: Catalogue of CDS champions

Name	Clinical role (e.g. pharmacist, nurse, physician, patient [for pertinent interventions], etc.)	Department/ facility	CDS interests/ objectives	Opportunities to enhance CDS success (e.g. speaking at staff meetings)
[name]	Chair Diabetes Steering Committee	Endocrinology	Improve outcomes for diabetic patients	Tell story of need for and details of CDS interventions when interacting with RN's and physicians
[name]	Diabetes case manager	Quality Improvement	Improve adherence to diabetes management guidelines	Help prepare nursing and physician for diabetes CDS intervention, and follow-up on their implementation
[name]	Primary care clinician with active diabetes practice and interest in CDS	Internal Medicine	Improve quality and efficiency of diabetic patients care	Give grand rounds about diabetes CDS interventions to medical staff

Concluding comments

This launch phase marks both an ending and a beginning. The complex planning and development stages culminate in the actual delivery of knowledge interventions to clinicians and patients, with the goal of modifying their behavior and improving outcomes.

Once again, this is more of a change management challenge than a technological one. Success will depend on the extent to which barriers have been anticipated and addressed. Creating short-term wins in areas that are important to key stakeholders will help demonstrate the value of the CDS program, diffuse skepticism and build momentum.

Even before the first piece of knowledge is delivered, however, it is likely that your organization has reaped significant benefits from its emerging CDS program. For example, the focus on identifying and prioritizing CDS goals and considering strategies for addressing them will likely have beneficial effects on related process- and outcome-improvement activities outside the CDS program. Hopefully, the CDS interventions themselves also will generate substantial returns, but it's worth considering these related side-effects so you can cultivate these additional benefits.

The CDS program launch is a beginning because much hard but important work remains to be done to ensure that the interventions that are delivered function as intended and achieve their desired results. The last section explores this challenge in detail.



Additional Web reading and resources

- Metzger J, Fortin J. Computerized Physician Order Entry in Community Hospitals; Lessons from the Field. 2003. California HealthCare Foundation and First Consulting Group. <http://www.leapfroggroup.org/CPOE/CPOECommHosp.pdf>.

- Bodenheimer T, Grumbach K. Electronic Technology: A Spark to Revitalize Primary Care? *Journal of the American Medical Association*. 2003;290:259-264. <http://jama.ama-assn.org/cgi/content/abstract/290/2/259>.
- Doolan DF, Bates DW, James BC. The Use of Computers for Clinical Care: A Case Series of Advanced U.S. Sites. *Journal of the American Medical Informatics Association*. 2003;10:94-107, <http://www.jamia.org/cgi/content/abstract/10/1/94>. Especially see the discussion of use of decision support and implementation success factors.

References

¹ Krall MA. Clinician Champions and Leaders for Electronic Medical Record Innovations. *The Permanente Journal*, 5:40-45,2001..

Monitoring results and refining the program

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After CDS interventions are launched, they must be continuously monitored to ensure that they are achieving their intended results. The CDS program should be modified as needed so that the organization's goals and objectives are optimally met in an ongoing manner.

Tasks

1. Evaluate the impact of each CDS intervention and the overall program on an ongoing basis; efficiently gather, process, and prioritize user feedback.
 - 1.1. Assess intervention use and usability. ([Worksheets 6-1, 6-2](#))
 - 1.2. Evaluate intervention impact on target objectives. ([Worksheet 6-3](#))
2. Continually enhance the CDS intervention program's value. ([Worksheet 6-4](#))
 - 2.1. Identify and address major concerns with appropriate timeliness, (such as excessive or inappropriate invasive alerting, unacceptably slow system response times).
 - 2.2. Maintain content currency and appropriateness.
 - 2.3. Continually enhance intervention usability, value to users and impact on the CDS program's goals and objectives.

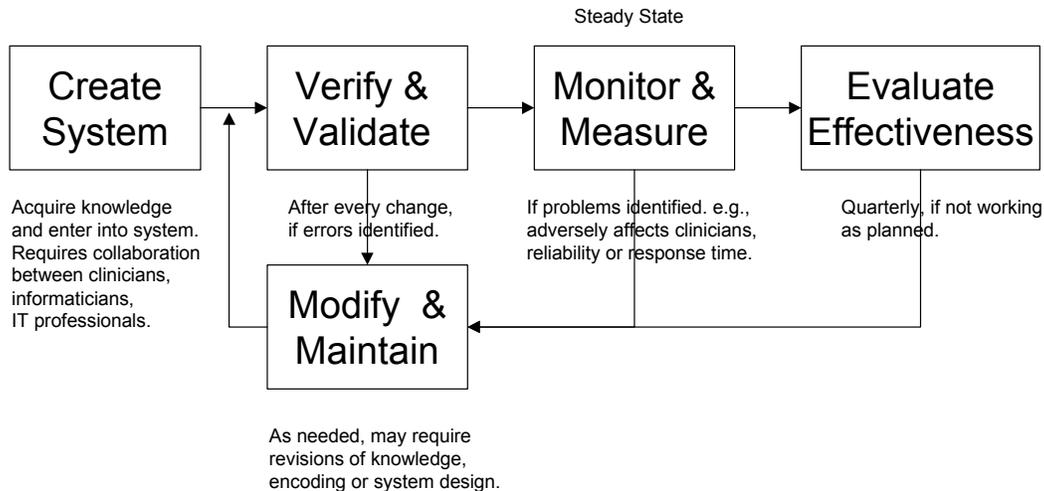
Discussion

The effects of CDS interventions must be analyzed carefully to ensure that the considerable resources required for their implementation yield the intended results. This analysis will demonstrate whether the intervention is being used as expected (and as appropriate), and can help quantify return on investment, both financially and clinically. In some cases, this will require comparing post-intervention data about clinical processes/workflow, satisfaction, specific healthcare outcomes, or other measures to pre-intervention baselines.

Evaluation permeates the entire CDS implementation process, reflected by the multiple vetting and evaluation steps in the preceding sections. Because the clinical environment and clinical knowledge base are so dynamic, this analysis must be ongoing, as noted previously. [Figure 6-1](#) demonstrates this graphically and illustrates that subsequent rounds of system enhancement will involve revisiting many of the previous steps in the workbook. Hopefully, this first attempt created a solid foundation and useful tools to facilitate future cycles.

Figure 6-1: Diagram of the CDS evaluation cycle

An Iterative Multi-dimensional Model for Evaluation of Clinical Decision Support Systems



Worksheets

Step 1: Evaluate the impact of each CDS intervention and the overall program on an ongoing basis; efficiently gather, process and prioritize user feedback.

Step 1a: Assess intervention use and usability.

Multiple channels can be used to assess how the constituents targeted by CDS interventions are making use of them. Hopefully, the interventions were validated to function as intended during the pre-launch phase, but this must be continually reassessed. Mechanisms for gathering feedback about intervention function and use include:

- Direct observations of users (clinicians/patients) interacting with the system in live or test environments.¹
- Subjective user feedback (both spontaneously submitted and periodically solicited).
- Input from clinical champions (and patient champions for interventions in this group).
- Objective measurements of intervention usage.

Processes should be put in place to periodically and systematically gather and evaluate feedback from these channels. Key issues to consider in the evaluation include:

- How often is each intervention used (reference material accessed, specific order sets and templates completed and so on)?
- How often are alerts presented? Heeded? Overridden?
- What do users perceive as the intervention's effects on workflow? Their perceptions can include whether interventions are delivered at an appropriate point,

content/message are considered appropriate and useful, response time is acceptable and performance and access is reliable.

When a question arises about the appropriateness of an alert, revisit [Worksheet 5-1](#) (alert appropriateness) to determine the factors that led to the alert and assess the need for changes. In some cases, it might be desirable to defer for a period of time or turn off an alert for a given patient or clinician, but this might be technically difficult, depending on the underlying clinical information system.

Some quantitative feedback about alerts can be gathered automatically (depending on clinical information system and CDS system functionality). For example, an electronic file can be used to record logistical details about the firing of an unsolicited alert or recommendation and a user's response to it. The worksheet below is an example of a report that can be generated from the log.

Worksheet 6-1 example: System-generated log file for alerts fired and clinician response

Alert or recommendation code	Provider ID	Patient ID	Physical location of terminal	Date/time	Alert accepted (e.g. an offered intervention was selected), rejected (e.g. alert overridden), or simply closed
Periodic LDL	893283	4329023	Briarwood exam 3	09:45 07/04/03	Escape out
Warfarin / Sulfa	003343	0048973	3-south	10:34 11/09/03	Accepted
Warfarin / Sulfa	739202	8973234	OR	07:30 04/04/03	Rejected

Alerts can be a powerful tool for preventing errors and improving care, but they also can be a significant annoyance and can strongly reinforce inappropriate actions if there are problems with their logic or delivery. If a log file is available, such as the one in [Worksheet 6-1](#), then checks can be performed to screen for such potential problems. Below are examples of such screens that can be generated from the log file, along with information about interpreting and using the results.

Total number of alerts of all types generated per patient per visit for outpatients or day during the inpatient stay.

More than 10 alerts per day indicates that patient is very ill, has not been seen for a long time, or that there are too many alerts in the system. Too many alerts also might suggest that there is an underlying clinical problem with the quality of care being delivered. That problem should be addressed using an alternative method that does not interfere with clinical activities. Remember, alerts and reminders are not an effective method to educate clinicians². Nonetheless, other CDS-related interventions might be of use here, for example enabling users to track their clinical information needs³ or providing electronic links to pertinent knowledge resources for outside review.

Acceptance rate for each alert.

Alerts or recommendations with low acceptance rates (for example, less than 50 percent) are candidates for further investigation. Keep in mind that an acceptance rate might vary depending on the nature of the alert. High rejection rates could signify false positives, or errors in alert generation, general clinician disagreement with the recommendation or insufficient appreciation of the evidence or the rationale behind it, data errors and so on. Depending on the cause, the appropriate response could be reassessing alert triggers, providing additional education to clinicians about the importance of the alert, fixing data problems, or reconsidering the appropriateness of the alert and its recommendations.⁴

Number of times each specific alert fires for each clinician over various timeframes.

An excessive number of alerts for any single event to a single clinician could be cause for investigation. For example, greater than five per day, 10 per week, or 20 per month of the same type of alert to the same clinician with less than 50 percent acceptance might indicate an opportunity to refine alert firing parameters, perhaps because there are legitimate reasons why the clinician's actions appear to contradict recommended practice. For example, an oncologist may routinely prescribe a medication in doses not routinely used by other clinicians and that would otherwise be excessive. If this is the case, it might make sense to turn off the alert for the individual clinician, an entire specialty, or perhaps add additional data elements to the alert-triggering criteria to prevent such false positive firings. Also circumstances might have changed and, as a result, the alert might no longer be appropriate in general, in which case its value as a CDS intervention should be reassessed. Alternatively, it could indicate a need for further clinician education.

Acceptance rate for each alert type by physical location of the terminal at which the alert or recommendation was received.

Elevated rejection rates at a location could indicate that the particular alert/recommendation may not be appropriate for patients or clinicians at that location. For example, a system should not send alert pages to surgeons when they are in the operating room.

**Number times each specific alert is generated each day, week and month.
Sort by the most frequently occurring alerts and recommendations.**

Look carefully at the most frequently and least frequently appearing alerts and recommendations. Make sure all of the most frequently occurring alerts are correct and appropriate. Make sure all the least frequently appearing are correct and worth keeping in the system. Be sensitive to patterns showing large changes in alert firings, which could indicate the need for further evaluation. For example, analysis could find a need to reassess alert appropriateness; identify shifts in practice patterns; or determine if software or content changes have inappropriately affected alert firing.

[Worksheet 5-2](#), CDS validation and testing, documents some of these issues that arise during pre-launch review, and a modified version can be used to document these issues during ongoing evaluation.

Worksheet 6-2 example: CDS intervention use and usability issues

Intervention	Use/usability Issue	How issue was identified	Date first noted	Priority for addressing	Responsible individual/committee	Remediation plan
Yearly LDL	Alert text hard to read	[name]; feedback submitted on routine user survey	05/12/03	Medium	IT	Increase font size of all alerts from 12 to 14 point. Put key info in bold
Diabetic foot exam reminder	Pops up in operating room	[name]; irate call from OR assistant to IT help line	12/04/03	High	Clinical Decision Support oversight committee	Turn off all health maintenance reminders to terminals in the OR
Diabetic foot exam	Pops up when entering diabetes on problem list for first time	[name]; issue submitted to IT via email suggestion link	03/04/03	Medium	Diabetic steering committee	Check date of diabetes problem list entry. If less than 12 months before now, do not generate reminder

Step 1b: Evaluate intervention impact on target objectives.

Revisit the success indicators from [Worksheet 3-1](#) in [Worksheet 6-3](#). Quantitatively assess the extent to which the target has been reached, and include comments about any variations and ideas for enhancing intervention's value. [Figure 6-2](#) gives examples of outcomes and process measures associated with different intervention types. This type of data can be included in the fourth column of [Worksheet 6-3](#) as a way to augment the target-oriented impact assessment.

Worksheet 6-3 example: CDS intervention effects

Intervention	Target objective	Performance against target	Other effects (+ and -), e.g. clinical, \$, process	Plans to modify/enhance intervention value	Notes/comments
Yearly LDL	85% of Diabetics with yearly LDL documented	73%	- slows down clinicians	Send postcards / email to patients one month before test is due	Need to begin collecting email addresses from patients
Diabetic foot exams at least every 6 months on appropriate patients	90% of eligible diabetics	40% (by automated analysis)	- clinicians documenting exam results in free text rather than using coded data entry field	Develop natural language processor to scan progress notes for evidence of foot exams on diabetics	Need to collaborate with University Informatics department

Figure 6-2: Examples of potential use and clinical outcome measures associated with various CDS intervention types

Intervention type	Outcome/process measure
Health maintenance reminders ^{5, 6}	Accesses/overrides (if applicable); percentage of patients in compliance with recommendation
In-patient clinical laboratory alerts ⁷	Override frequency; average time patients spend in abnormal physiological state
Outpatient laboratory alerts (e.g. excessive hemoglobin A1C levels)	Override frequency; average HbA1C levels for all diabetic patients; percentage of patients with HbA1c levels above recommendation
Clinical charting templates	Percent of applicable patients for which it was used; percentage of patients with a particular critical data item from the template (e.g. smoking status) for whom the data was acted upon (e.g. with educational intervention)
Order sets	Percent of patients with the condition covered by the order set and for whom it was used

Step 2: Continually enhance the CDS intervention program’s value.

Step 2a: Identify and address major concerns, such as excessive or inappropriate invasive alerting, unacceptably slow system response times, and so on, with appropriate timeliness.

[Worksheet 6-2](#) (Intervention use and usability) helps prioritize major implementation concerns and record ideas about addressing them. For this step, those solutions can be further developed and implemented. Because this is a continuous improvement process in a dynamic environment, new items will be added to the issues list regularly as the top priorities are addressed and removed.

Feedback from intervention recipients via channels outlined under [Step 1a](#) above and other dialogue can be used to help prioritize action items and ensure that modifications will close identified gaps. For example, if there is significant controversy about new alerts or high recipient rejection of them, user champions can serve as an important bridge between other users and the implementation team in reaching a widely acceptable resolution.

Step 2b. Maintain content currency and appropriateness.

All CDS interventions need to be re-evaluated regularly to ensure that clinical knowledge is accurate and up to date, and so it’s delivered in such a way that it achieves the desired outcome. Because the technical and content components are complex and interrelated, changes to any element may require revalidating to ensure that other parts of the system continue to behave as expected after the change.

Similarly, the evidence base and expert opinion on which best practices rest are continually shifting, so it is essential to ensure that the content underlying the CDS interventions remains synchronized with this knowledge. Some organizations assign responsibility for the different content areas to respected individuals with domain expertise in each area. These experts review and periodically update content for which they are responsible, and help address concerns that arise about this content.

In addition, consider assigning an “expiration date” to all CDS interventions. Such time limits should match the anticipated “shelf-life” of the knowledge and trigger review of the content by an appropriate authority.

To ensure that alerts remain appropriate, you can revisit the assessment in [Worksheet 5-1](#) (alert appropriateness) periodically, especially after changes to the hardware or software, or to any related content base. Because rules can be inter-related in complex ways, especially as their number increase, maintaining proper performance of the entire set as it evolves is challenging but critical.

Just as the knowledge base evolves, so do the vocabularies and coding schemes that are used to trigger and process the CDS interventions. As a result, it's important to ensure that changes to these schemas don't have any adverse effects on the behavior of CDS interventions.

Step 2c: Continually enhance intervention usability, value to users, and progress toward achieving CDS goals.

Much of the ongoing enhancement around specific interventions will arise from the preceding steps. In addition, a key element of the continuous improvement process is reassessing the CDS program in light of the organizational goals and objectives it was designed to address. Considering the specific strengths and limitations of the current approach can help with efforts to meet organizational needs. [Worksheet 6-4](#) can be used to document these plans with both current and enhanced CDS infrastructure.

Worksheet 6-4 example: CDS program enhancement plans

Decision support goals and objectives ^a	Current decision support interventions aimed at meeting goals and objectives	Opportunities to better achieve objectives w/current infrastructure ^b	Opportunities to better achieve objectives with enhanced infrastructure
Improve diabetic care	<ul style="list-style-type: none"> Yearly LDL reminder Diabetic foot exams reminder HbA1c < 7 reports 	<ul style="list-style-type: none"> Implement aspirin reminders Send postcards to patients before exams are due 	<ul style="list-style-type: none"> Send reminders to patients via email Develop NLP solutions to facilitate capture of data
Improve medication safety	<ul style="list-style-type: none"> Drug/drug interaction checker 	<ul style="list-style-type: none"> Implement drug/lab checker Implement drug/allergy checker 	<ul style="list-style-type: none"> Develop renal dose adjustment system – need to work with lab to get creatinine clearance; nursing to get them to enter patient height

Concluding comments

As with the last section, this final workbook section is both an ending and a beginning. The continuous improvement approach on which it is based suggests that the sequential process outlined across the six sections should be repeated to move your organization toward increasingly higher performance.

^a Revisit analyses from [Sections 1](#) and [3](#) (e.g. [Worksheets 3-1](#) and [3-4](#)) to validate and refine initial goals for CDS interventions.

^b In this context, infrastructure includes information systems, specific CDS content and delivery mechanisms, workflow processes, etc.

Because there are relatively few examples of robust CDS programs, the content, technology and processes on which such programs depend are at a relatively early stage of development. As the field matures and these components become more widespread, successive CDS implementations will build on richer foundations. For example, more sophisticated content and intervention delivery technology will enable more effective interventions to help your organization achieve its goals.

The workbook authors view this material as a continually evolving resource that will hopefully better meet the needs of healthcare organizations over time. We welcome your participation in the effort, and hope you will consider sending us feedback on this workbook and sharing your experiences and insights with your colleagues and us.



Additional Web reading and resources

- Teich JM, Pankaj R, Merchia BS, et. al. Effects of Computerized Physician Order Entry on Prescribing Practices. *Archives of Internal Medicine*, 2000;160:2741-2747. <http://archinte.ama-assn.org/cgi/content/abstract/160/18/2741>.
- Rosenstein AH. Measuring the benefit of performance improvement and decision support, *American Journal of Medical Quality*, 1999 Nov-Dec:14(6):262-9.
- Shiffman RN. Guideline Maintenance and Revision. 50 Years of the Jones Criteria for Diagnosis of Rheumatic Fever. *Archives of Pediatric Adolescent Medicine*, 1995 Jul;149(7):727-32. The article provides an excellent example of the types of revisions and expected reasons for revising clinical guidelines. The article brings up the point that changes in clinical knowledge are not the No. 1 reason for changes; rather, most changes are required to fix ambiguously defined concepts or outright errors in original encoding.
- Jenders RA, Huang H, Hripcsak G, Clayton PD. Evolution of a Knowledge Base for a Clinical Decision Support System Encoded in the Arden Syntax. Proceedings AMIA Symposium. 1998:558-62. This article illustrates the substantial work required to maintain clinical knowledge bases. For example, in their 156 Medical Logic Modules developed over 78 months, they noted 2,020 distinct versions that included 5,528 changed statements over time.

References

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³ Ely JW, Osheroff JA, Ferguson KJ, Chambliss ML, Vinson DC, Moore JL. Lifelong Self-Directed Learning Using a Computer Database of Clinical Questions. *Journal of Family Practitioners*. 1997;45(5):383-388.

⁴ Doherty JA, Reichley RM, Noiro LA, et al. Monitoring Pharmacy Expert System Performance Using Statistical Process Control Methodology. Proceedings AMIA Symposium. 2003:205-9.

⁵ Dexter PR, Perkins S, Overhage JM, Maharry K, Kohler RB, McDonald CJ. A Computerized Reminder System to Increase the Use of Preventive Care for Hospitalized Patients. *New England Journal of Medicine*. 2001 Sep 27;345(13):965-70.

⁶ Overhage JM, Tierney WM, McDonald CJ. Computer Reminders to Implement Preventive Care Guidelines for Hospitalized Patients. *Archives of Internal Medicine*. 1996 Jul 22;156(14):1551-6.

⁷ Kuperman GJ, Teich JM, Tanasijevic MJ, Ma'Luf N, Rittenberg E, Jha A, Fiskio J, Winkelman J, Bates DW. Improving Response to Critical Laboratory Results with Automation: Results of a Randomized Controlled Trial. *Journal of the American Medical Informatics Association*. 1999 Nov-Dec;6(6):512-22.

Appendix: Rationale and history of the Workbook project

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This workbook grew from informal discussions among the workgroup participants around their shared interest in enhancing healthcare processes and outcomes through clinical decision support (CDS). Initial discussions between Dean Sittig and Jerome Osheroff were triggered by considerations of how best to fill the clinical decision support needs of a healthcare delivery organization ([Kaiser Permanente](#)) with the current and future offerings of a CDS content vendor ([Thomson MICROMEDEX](#)).

When Robert Jenders, Jonathan Teich and Eric Pifer joined the workgroup, the mixture of theoretical and practical explorations expanded to include the perspectives of other stakeholders with whom the workgroup participants associate. These include a standards development organization ([Health Level 7](#)), an e-health solutions company ([HEALTHvision](#)), and other healthcare delivery organizations (the [University of Pennsylvania Health System](#), [Cedars-Sinai Medical Center](#)). Obvious synergies between the goals of this informal workgroup and the HIMSS Patient Safety Task Force, which Jonathan Teich chairs, led to the workgroup becoming a formal component of the task force in Spring 2003. This workbook will be a component of the HIMSS Patient Safety Toolkit that the task force is developing.

Although the Institute of Medicine, Leapfrog Group and others have indicated that decision support technologies are key to addressing many inadequacies in healthcare, relatively little published guidance is available to health systems that want to implement these technologies to achieve desired improvements. The CDS workgroup hopes that this workbook will not only help fill this gap, but that it will also foster and accelerate collaborations among all the various stakeholders—healthcare delivery organizations, CDS infrastructure and content providers, standards organizations, clinical transformation consultants, patients and others—required to deliver on the promise of CDS.