CHAPTER

Managing the Investment in Clinical Decision Support

24

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24.1 Introduction

In recent years, value-based healthcare purchasing has become an increasingly dominant force in reimbursement, and healthcare providers are looking to invest in systems that help them deliver tangibly cost-effective care. Investment in clinical decision support systems (CDSs) is influenced by the complex technical, workflow, cultural and maintenance challenges associated with their implementation. Meaningful Use regulations require implementation of electronic health records enriched with clinical decision support and capable of quality measure reporting. These business drivers have refocused healthcare delivery organizations on building patient-centered, collaborative approaches to care. Developing an effective, pragmatic clinical decision support investment strategy is now a competitive imperative (Sittig et al., 2008; Davenport and Glaser, 2002).

Health care provider organizations today recognize that investing in the knowledge-enrichment of their clinical information systems is essential to drive IT-enabled quality improvement. Computerized Provider Order entry (CPOE), with drug-drug interaction or expert dosing logic, may be seen as central to efforts to improve patient safety. An Electronic Health Record (EHR) system, with health maintenance reminders, can be an important approach to disease management efforts. Clinical documentation systems designed with quality measure reporting in mind can assist caregivers in meeting pay-for-performance targets. Population management systems with risk-assessment and disease management logic can assist physician-extenders and case-managers with identifying gaps and activating care management between visits.

Given the continuous advances in information systems, innovation, and the ever-changing business climate for providers, there is no such thing as a post-EHR implementation steady state. This conclusion will require that provider organizations establish management structures and processes that enable them to continuously prioritize decision support investment, develop and/or acquire the required clinical decision support solutions, orchestrate and manage the knowledge expressed through clinical information systems and evaluate the impact of their strategies.

Clinical Decision Support.

The organization will need to become agile at designing well-orchestrated team workflows and aligning the key enabling clinical decision support solutions.

This chapter covers four areas of clinical knowledge management, including management of clinical decision support knowledge as a component of clinical knowledge management, the boundaries of clinical knowledge management, key functions of clinical knowledge management, and the evolving "business case" for investing in clinical knowledge management.

The organization of clinical knowledge management with regard to business alignment is reviewed including strategic objectives, governance, CDS impact on quality measurement and reporting, and approaches to insourcing and outsourcing of clinical decision support investment. Key IT strategies and considerations are examined including legacy systems, knowledge management tools and application foundations.

The evaluation of the impact and value of clinical knowledge management is also discussed.

24.2 Clinical knowledge management

Investment in any set of organizational structures that surround a significant information technology can benefit from a discussion of the concepts that will guide and frame that investment. For example, a discussion of the integration of an organization's applications should begin with attempts to answer the question, "What does integration mean to us?" The organization can develop very different strategies, e.g. single vendor or interface engine, based on very different answers.

This section provides some concepts and context that should guide the organization's discussion of clinical decision support.

24.2.1 Management of clinical decision support as a component of clinical knowledge management

Clinical Knowledge Management is essentially a framework for a "Learning Health Care Provider Organization" (see Figure 24.1) (Lewis, et al., 2012). Clinical decision support is a tactic that seeks to ensure that the caregiver (clinician or patient) has the right information necessary to document and deliver superior care. In Figure 24.1, the "Care Framework" on the left illustrates a variety of care tasks that can be impacted by clinical decision support guidance. The "Learning Framework" on the right illustrates how data derived as a by-product of care delivery can be analyzed to develop new insights for how to improve care delivery with clinical decision support guidance as well as develop quality measurement reporting. As data are harvested from the Care Framework, they are then analyzed for insights that factor into governance decisions surrounding ongoing CDS curation. The CDS curation process is informed by a combination of governance prioritization, end-user feedback, and the maintenance demands of ensuring that the content is current with the latest evidence and reference data sets such as drug information, SNOMED, and the like.

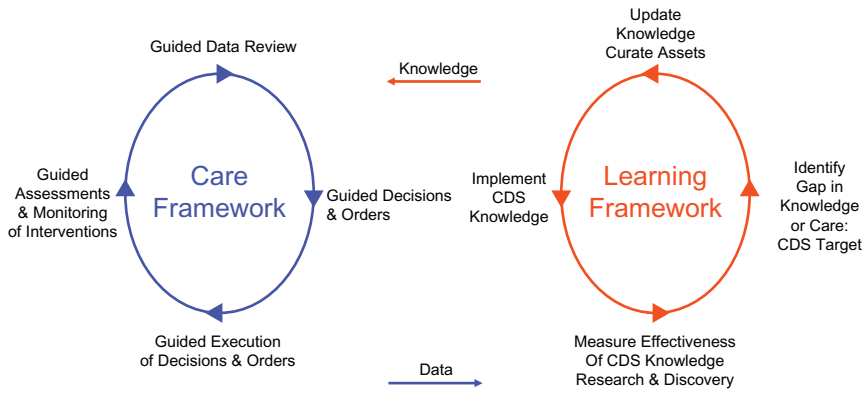

FIGURE 24.1

Interdependence of the Care Framework and the Learning Framework.

A narrow organizational focus on the application of CDS knowledge in workflow may fail to consider equally important aspects of investment in knowledge discovery and knowledge asset management that help organizations become effective at learning and self-improvement. This narrow focus may also fail to consider other IT-based tactics for knowledge application. These tactics may include social media solutions, such as collaboration tools and wikis for knowledge sharing and expertise location or end-user intelligence systems to optimize context-aware knowledge linking.

The organization would be well served to step back and engage in an overall discussion of clinical knowledge management. Such a discussion would force consideration and creation of processes designed to identify the "best" CDS solutions, ensure CDS knowledge is maintained, align CDS with organizational business drivers, and broaden the focus to include a full range of IT-based and non-IT-based tactics.

While a more holistic view of clinical knowledge management is important, it can fall prey to various "traps," e.g. fuzzy boundaries, incomplete understanding of the scope of knowledge management processes and a complex business case. These issues are discussed in the following sections.

24.2.2 The boundaries of clinical knowledge management

Clinical knowledge management can have diffuse boundaries that encompass the entire organization. Translational research is a form of clinical knowledge management. Quality improvement is knowledge management. Training residents and allied health professionals is knowledge management. Training for managers on human resource issues is knowledge management.

If knowledge management is defined too broadly, it will be perceived (rightfully so) as too broad to be tractable and defying the ability to be managed by a

common set of structures and processes. An organizational phenomenon that is too broad risks being seen as unmanageable and is hence dismissed from the management discussion. For example, no one in an organization proposes to be in charge of "decision making."

Boundaries can be defined in several ways, with each way being based on a different core concept, for example:

- **Clinical goals.** Knowledge management can focus on specific goals to improve clinical performance, e.g. reduce medication errors or optimize management of congestive heart failure. IT-based and non-IT-based knowledge can be applied to prevention of errors or treatment of specific diseases for which there is a specific set of financial incentives, a high prevalence, or organizational focus on developing clinical excellence.
- **Application.** Knowledge management can address the broad array of knowledge that is contained in or expressed through specific applications, e.g. CPOE or clinical documentation.
- **Knowledge implementation tactic.** Knowledge management can focus on a specific implementation tactic, e.g. health maintenance reminders or clinical pathways, which might cut across applications and diseases.

An organization may pursue more than one concept. All of the concepts reflect "understandable" boundaries, i.e. you can explain them to a room full of practicing clinicians and they will "get it."

These concepts also supply a context. Knowledge management or decision support that has no context has no value. Achieving a clinical goal or improving the care of the chronically ill provides a reason for pursuing knowledge management.

24.2.3 The key functions of clinical knowledge management

Knowledge management, however an organization defines its boundaries, is essentially comprised of three key functions: knowledge application, knowledge asset management, and knowledge discovery. They are organized in a circle (Figure 24.2) to emphasize that the knowledge management process is one of continuous learning and knowledge dissemination.

Knowledge application is the art of leveraging knowledge at the right places in workflow to achieve a strategic objective. **Knowledge discovery** is the process of analyzing data for the purpose of understanding performance, reporting, predicting, and/or harvesting new knowledge. **Knowledge asset management** is a set of processes for the stewardship, curation, and deployment of knowledge.

Commercial EHR systems are typically designed to support knowledge application much more effectively than either discovery or asset management. For example, the tools for updating knowledge are often function-centric such that an editor for order sets is likely to be decoupled from an editor for alerts and reminders. Thus, when an organization is attempting to build a diabetes management program, it must grapple with multiple disconnected editors to manage all the clinically

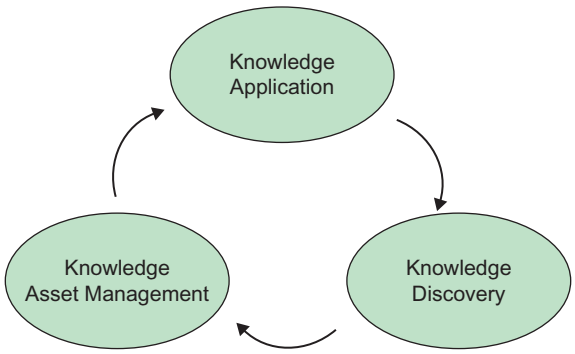

FIGURE 24.2

Knowledge management core processes.

relevant knowledge. This nonintegration of the knowledge curation tools can result in disconnects among the teams responsible for updating the content and/or measuring performance.

Clinical decision support programs must encompass these three aspects of clinical knowledge management and focus on building governance structures that effectively align and integrate the various teams that have a role in this learning framework.

24.2.4 The business case for clinical knowledge management investment

As an example of how business drivers arise, with the passage of the HITECH act in 2009 and Meaningful Use regulations in the US, which emphasize IT functionality that improves information exchange, enables quality measurement and reporting, and requires progress in CDS adoption, among other things (see Chapter 1), the business case has evolved from answering the question of "Why invest?" to the question of "How do we allocate resource investment in clinical knowledge management (CKM) such that it correlates with a tangible impact on business performance?"

Provider organizations are invariably confronted with tight budgets; capital budgets are constrained, and proposals to add expenses to operating budgets are subject to tough scrutiny. CKM requires a budget, and obtaining this budget requires that it compete effectively with other budget priorities.

The CKM business case faces several challenges:

- The term "knowledge management" is often too abstract and intangible for concrete, action-oriented provider organization managers. They may not fund it because the term "knowledge management" gets in the way; it doesn't mean anything to them.

- The knowledge management proponents may defend their case using terms such as "ontologies" or "semantics." These terms are incomprehensible to most managers, and generally managers will not support the funding of something that they don't understand.
- The organization may have no working experience with knowledge management; hence it is not sure how to organize the function or what clinical value will be realized. Managers are often quite conservative and hesitant to launch undertakings which they are unsure of their ability to manage.

A successful business case has several attributes:

- It links a proposal to an accepted organizational strategy or goal. For example, external business drivers such as Meaningful Use and Accountable Care require knowledge-enriched clinical information systems.
- The creation or augmentation of knowledge management capabilities is often tightly linked to an overall investment in clinical information systems or medical care improvement. For example, CDS is an aspect of an overall acquisition of a hospital information system, and the CDS costs are not presented separately. In this case, the knowledge management resources piggyback on the overall resource request, with the overall request being considered in light of organizational goals.
- Table 24.1 provides several examples of how knowledge management infrastructure can be explicitly aligned with business objectives to demonstrate a tangible gain. The current value-based purchasing climate means that a well crafted clinical knowledge management proposal will tightly connect programs for CDS to both quality improvement and quality reporting programs. It is also just as important to describe the potential cost or risk to a provider organization of either not having the CDS knowledge or failing to adequately maintain it. Another CKM business driver on the horizon is the emergence of individualized medicine. Today,

Table 24.1 Linkage of organizational goals to knowledge needs

Organizational Goal	Example Knowledge Need	Benefit
Medication Safety	Drug-drug interaction checking in CPOE	Meaningful Use compliance and incentives, reduced length of stay
Cost management	Radiology and medication order guidance in outpatient CPOE	Accountable Care risk management
Patient Wellness	Health maintenance reminders	Increased reimbursement
Perioperative Safety	Venous thromboembolism prevention protocols	Hospital accreditation, increased reimbursement
Disease management	Diabetes management protocols	Payor contract incentives, increased reimbursement

this exponential growth in the knowledge required to practice medicine is primarily impacting cancer care. However, in the coming years, molecular medicine will impact an ever-increasing percentage of clinical decisions, thus making it wholly unfeasible for clinicians to practice unless partnered with robust CDS solutions.

- The level of resources, such as staff, licensed content, and information systems, needed is deemed to be reasonable. Reasonableness is hard to empirically derive. Often organizations start with small numbers of staff and gradually increase effort, as they understand the nature of the challenge. Other times, benchmark data from other organizations provides guidance on needed resources. Regardless, the expense is deemed to be worth it.
- The business case describes the management structures, tools and processes needed to manage this knowledge. For example, who should make sure that our health maintenance reminders are kept current? How do we determine if our guidance on radiology procedure ordering is leading to reduced radiology costs? Providing thoughtful answers to these questions helps to assure managers that the invested resources are likely to result in the desired gains.
- Lastly, the information technology infrastructure and content needed are defined. This infrastructure can include knowledge libraries, editors, content-lifecycle management systems, and collaboration tools. The tools proposed offer an evolutionary technology path that is robust and enduring.

24.3 Organization of the effort

Organization refers to structures and processes needed to manage the lifecycle of knowledge application, discovery and asset management.

This section will discuss objectives of organization, provide examples of organization structure and processes, and review implications for organizational design strategy.

24.3.1 Objectives of organization

CKM programs require governance structures, stewardship resources, and processes. The CKM team comprises the resources that continuously steward and update the CDS knowledge, support the governance activities, and direct the technical resources that manage the CDS content management systems. These structures and processes are intended to accomplish several objectives:

- Identify new types of knowledge that need to be incorporated into the organization's clinical information systems, e.g. the addition of a new Deep Vein Thrombosis Prevention intervention to the order entry, clinical documentation, and CDS system to reduce the incidence of this event and report on the relevant quality measure
- Ensure that CDS interventions are useful, impactful, and evidence-based through review of the literature and/or consensus-based decisions by appropriate clinical staff

- Ensure that existing knowledge is reviewed at an appropriate frequency to determine if "old" knowledge needs to be revised
- Ensure that CDS stewardship resources and tools are adequate to facilitate ongoing management engagement in CDS decision making, update existing CDS knowledge, and build new CDS interventions
- Recognizing the finiteness of information technology and clinical resources, provide direction on priorities for incorporating or modifying knowledge
- Educate the clinical staff on the rationale for introducing new CDS interventions
- Assess the impact of existing knowledge application tactics on provider decisions and practices to determine if the desired outcomes are being achieved
- Review strategies to improve the effectiveness of existing knowledge application tactics, e.g. does a computer-based intervention impede workflow, is it ignored, or does the application interface confuse rather than inform the user?
- Guide the efforts of information technology staff and/or the application vendor to ensure that appropriate specifications have been developed and testing performed.

Invariably, an organization will have several forums that pursue these objectives. The Pharmacy and Therapeutics Committee can be charged with managing all medication-centric knowledge for an inpatient clinical system. A Diabetes Advisory Council may be convened to develop decision support content to improve the health maintenance processes for a diabetic population. A committee formed to reduce the costs of care operations may decide to examine ways of reducing inappropriate radiology procedure utilization through CPOE. A committee that manages the evolution of an organization's clinical information systems may examine the systems to determine if there are "CDS knowledge gaps" that merit rectifying to meet pay-for-performance goals, e.g. inadequate CDS for antidepressant compliance monitoring.

The result of assigning knowledge management tasks to a range of forums can lead to a complex maze of decision making. While each individual assignment may be the right assignment, the maze needs to be coordinated, conflicts may require resolution, and the resulting demands on the information technology staff will require prioritization.

24.3.2 Examples of approaches

Several examples of approaches to organization are presented in the following sections. These examples are adapted from AMIA, 2005 (American Medical Informatics Association, 2005).

24.3.2.1 Example 1

A Medical Information Systems Committee (MISC) is charged with overseeing the design and implementation of clinical information systems for the organization. The MISC is also responsible for ensuring that the clinical information systems conform to all regulations, JCAHO requirements and the organization's policies.

The MISC has multi-stakeholder representation and reports to an Executive Medical Committee.

The MISC has a subcommittee that oversees the development of CDS. This subcommittee receives requests from various task forces, committees and user groups. The subcommittee requests IT assessment of the costs and time required to fulfill the request. The subcommittee recommends priorities and forwards its recommendations to the MISC for approval.

24.3.2.2 Example 2

The Information Technology Strategy and Policy Committee (ITSPC) is responsible for strategic, policy and tactical decisions for all of the organization's information systems and information management. The Committee is composed of senior clinical, administrative, and IT leadership.

A Clinical Information Systems Committee reports to the ITSPC and is responsible for all patient care systems including CDS. The Clinical Information Systems Committee is responsible for reviewing all requests for decision support, identifying required resources, prioritizing requests and monitoring the effectiveness of existing decision support.

24.3.2.3 Example 3

The Clinical Systems Advisory Committee (CSAC) is responsible for providing direction and monitoring progress on the acquisition and implementation of clinical information systems. The CSAC members are senior leaders from across the organization.

Requests for decision support are sent to the CSAC for review, and analysis of costs and effort and prioritization. Decision support requests that are approved are sent to a Clinical Data and Documentation Committee, a committee of the Medical Staff organization, to ensure that the requests conform to organizational policy and are supportive of organizational efforts to improve patient safety and medical care.

24.3.3 Clinical knowledge management organizations at Partners Healthcare and Intermountain Healthcare

The previous examples center on the management of clinical decision support priorities and are aimed at ensuring that CDS activity is linked into, and fits with, other supporting activities such as the implementation of a clinical information system or medical policies.

At Partners Healthcare System, a Clinical Knowledge Management Group was established in 2003 under the direction of Dr. Tonya Hongsermeier. This group has grown and evolved over the years to serve enterprise-wide and site-specific CKM needs. For example, a Clinical Content Committee (CCC) was created to direct and prioritize investment in the CDS components of an internally developed ambulatory EHR system. This committee's activities are supported by a dedicated ambulatory EHR CKM team that receives proposals from clinical leaders and end users, analyzes these proposals, and facilitates the CCC's evaluation of such proposals for

new CDS or changes to existing CDS. This CKM team also edits and updates the content in the Ambulatory EHR with the support of solicited input from a variety of clinical discipline-centric expert panels focused on Primary Care, Pediatrics, Geriatrics, and the like. These expert panels have been chartered and sponsored by the CCC. The ambulatory CKM team also directs technical resources that ensure that the tools they use to manage the content meet their needs. See Chapter 28 for detailed examination of this activity at Partners, since it is one of the prime examples of how a major health care delivery organization has found it necessary to manage their knowledge resources in order to deliver CDS effectively.

At Intermountain Healthcare, there is a clinical leadership-driven governance model for CDS that explicitly links a focus on clinical performance targets to CDS initiatives (Institute for Health Care Delivery Research, 2013; James, 2008). There are multiple domain specific "Clinical Programs" that provide direction to the appropriate multidisciplinary workgroups and clinical information systems resources to develop CDS artifacts that help them meet their objectives. The Clinical Programs are headed by clinical staff who set goals, facilitate progress, and align resources. Within each Clinical Program, there are numerous multi-disciplinary, multi-stakeholder "Clinical Development Teams" that focus on specific clinical goals such as management of asthma, community-acquired pneumonia, congestive heart failure, diabetes and depression. These teams are tasked with developing a "Care Process Model" and providing direction to CDS implementer resources to integrate knowledge where appropriate into the clinical workflow systems. Once the Care Process Model is up and running, the Clinical Development Teams monitor progress and iteratively make improvements and updates where appropriate to achieve performance targets.

24.3.4 Observations on organization

As can be seen in the preceding examples, which represent a wide range of provider organizations, there is no single best way to organize. However, there are several commonalities and guidelines that can guide the organizing of knowledge management:

- *Understand the roles of oversight, stewardship, and stakeholder engagement.* In Figure 24.3, the typical organizational components of a CKM governance model are outlined. These components include a steering committee that performs prioritization and resourcing decisions, a knowledge stewardship or CKM team the builds and maintains the CDS knowledge, expert panels representing the stakeholders who provide input on CDS design, and technical resources who manage the tools utilized by the knowledge stewardship team. This knowledge stewardship team, in some organizations, is referred to as a knowledge engineering team or CDS team. Regardless of the label or size of this resource pool, they typically combine clinical and technical expertise and sit at the center of the CDS maintenance process.
- *Leverage and evolve existing committees for prioritization and subject matter expert panel expertise.* For a hospital, an existing Pharmacy and Therapeutics (P&T) Committee could be asked to support CKM resources responsible

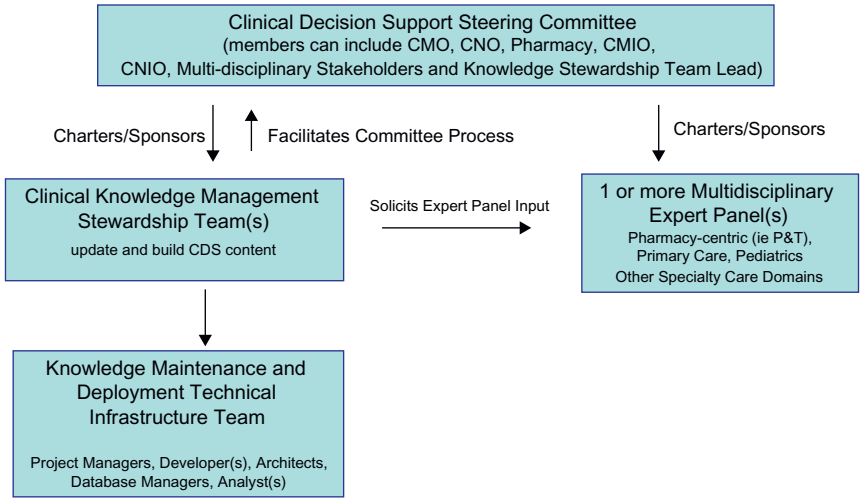

FIGURE 24.3

Typical clinical knowledge management organization components.

for updating medication-centric knowledge. An existing committee devoted to improving cardiac care should be asked to oversee knowledge related to hypertension and congestive heart failure guidelines.

- *Computer-based decision support is viewed as simply another tool available to the committee*. This tool may be new to them, and they may need time and education to become comfortable with understanding its strengths and weaknesses. Nonetheless, one should try to direct CKM oversight to existing forums where the necessary domain expertise exists.
- *The use of existing care-oriented committees helps to address several critical aspects of knowledge management and medical decision support*. First, the committees invariably possess the expertise necessary to determine the clinical utility of a specific decision support recommendation. While "anyone" can propose a specific set of decision support, the experts must review and approve it. The use of an existing, appropriate committee can help silence squabbles about who is "the expert" on specific decision support content. Second, decision support must be maintained. Content will need to be continuously updated by the CKM team and regularly reviewed by the appropriate expert panels. Oversight of this maintenance should be a formal responsibility of the committee. Third, education of clinicians must often occur to explain why the decision support was implemented. The committee can be given this responsibility. Fourth, the committee is in the best position to prioritize requests. For example, a patient safety committee will have the best organizational perspective on the major patient safety issues. Fifth, these committees are usually in the best position to "discover" new knowledge. This discovery can be based on the experiences of the organization or the review of the discoveries of others.

- *Examine committee composition*. Knowledge often spans domains. For example, there are obviously medication-centric rules that are of great interest to a committee focusing on cardiac care. To the degree that there is likely to be a significant set of knowledge that spans several committees, there should be cross-committee representation, e.g. a member of the P&T Committee on the Cardiac Care Committee. Often, this cross-committee representation is already in place; the boundary-spanning issues were present before the introduction of clinical information systems. Nonetheless, it can be useful to review committee composition and ensure that appropriate cross-representation is in place.
- *Cross-representation should not only account for clinical discipline, but overall perspective*. For example, it is important that clinicians representing the strategic concerns of the health system be balanced by those representing usability and efficiency concerns. Respected clinical champions can be those in management positions as well as the clinicians in a community practice who are greatly respected by their peers.
- *The addition of CKM team members from the IT department to these committees as either a member or liaison is highly desirable*. These personnel can update the committee on the status of relevant CDS systems, educate on the CDS capabilities of the system, and assist with the vetting of proposed changes or additions. Regardless of organizational approach, these individuals can help the committee members focus on the most feasible and effective informatics strategies to address a particular challenge, e.g. alerts at the time of ordering and the use of defaults and options for incorporating the knowledge into the workflow. Furthermore, they can direct analysts, as they transform the clinical guidelines into proper CDS design specifications.
- *Ensure IT review and assessment.* CDS proposals must be examined for their impact on system performance, workflow, and productivity. The decision support technology will have limitations, some of which mean that some proposals cannot be practically implemented. The CKM and IT resource effort required to implement a new proposal must be understood. The staff that must "codify" and test the decision support will have a backlog that needs to be prioritized. Decision support can be a significant consumer of processing power; hence the machine performance of a specific decision support rule and the rules in aggregate must be monitored.
- *Define oversight group*. The actions of individual committees will often conflict. The conflict can center on:
  - The definition of appropriate knowledge, e.g. different opinions on best practices such as between orthopedic surgeons and neurosurgeons on back pain management
  - Trade-offs between practicing best care and operational realities, e.g. the primary care physicians are so harried that additional health maintenance reminders will fall on deaf ears, and
  - Prioritization of scarce organizational resources, e.g. budget limitations mean that some ideas can be implemented but not all ideas.

In addition to resolving conflicts, these individual committees must be coordinated. Coordination can be necessary for many reasons. For example, it may be the case that different committees independently embark on duplicative knowledge strategies (e.g. an inpatient Smoking Cessation team and an enterprise Chronic Obstructive Pulmonary Disease team both developing Smoking Cessation CDS). Different groups may be considering investments in redundant tools (e.g. different teams independently investing in analytic infrastructure).

Decision support must conform to the organization's medical policy and hence policy assurance must be determined. At times, the decision support idea may lead to a need to alter policy such as reporting test results to patients. Decision support may also indicate the need to examine organizational roles, e.g. who should respond to an asynchronous panic lab value alert? This oversight committee must have members who can bridge into other important organizational groups, e.g. compliance, and have processes that enable it to turf some issues to those other forums.

An existing committee can be assigned the responsibility for overseeing knowledge management discussions and decisions. Many organizations have committees that have broad responsibility for care improvement, e.g. an integrated delivery system may have a Chief Medical Officer's forum.

In several of the examples cited earlier, this oversight group is one that has been formed to provide overall direction for the implementation and management of the organization's clinical information systems. The placing of decision support oversight responsibility with such a committee is common. This orientation is usually a reflection of the need for such committees during the implementation of major clinical information systems. These implementations are massive and complex undertakings, and a committee of senior leaders is necessary to ensure that progress is made. During implementation, CDS efforts will begin, and it is natural that decision support efforts become the purview of the committee.

However, CDS is a tool, and a natural evolution of tool oversight involves the transition from a tool-centric committee to a care-centric committee that has tools at its disposal, e.g. an Intermountain Clinical Program team.

As an example of this transition, many organizations had Internet Strategy Committees at the turn of the millennium. As understanding of the Internet increased, virtually all of these committees were disbanded, with responsibility for determining the best approaches to tool (the Internet) use being turned over to groups responsible for business performance.

24.4 Key IT strategies and considerations

Several chapters in this book have addressed specific aspects of the information technology and logic and data design of clinical decision support.

This section addresses three overall IT strategy considerations: legacy systems, tools and applications, and foundations. These considerations examine three critical

aspects of defining and implementing the information technology infrastructure necessary for effective decision support.

24.4.1 Legacy systems

How can an organization address the challenge of implementing robust, content-enriched computer-based decision support while working within the constraints of legacy information systems investments? As an example, although the US HITECH act and Meaningful Use incentives have spurred provider organizations to modernize their clinical information system infrastructure, there will still be constraints to contend with.

In pursuing the application of information technology to effect CDS, the organization will confront the reality of its clinical information system investments. In a large integrated delivery system, there may be several clinical information systems from multiple vendors. Each of these systems may have their own decision support technologies, and these technologies are likely to be of variable sophistication and utility. One need not be a large delivery system to face this challenge. A community hospital might find differing decision support capabilities in its laboratory, pharmacy and hospital information systems.

Replacing these investments may not be practical. The organization may not have enough capital, or the replacement would consume an unacceptable amount of the capital budget. Replacement can take years to implement, but the organization needs care improvements in the near term. Moreover, some clinical information systems work well in large hospitals but not in the small physician's practice; hence in a large health system there may be little prospect of finding one system that effectively addresses the needs of all constituents.

There is no easy answer to this challenge. It is possible that advances in service oriented architectures and substitutable applications can enable an organization to access CDS knowledge services outside their core clinical information system infrastructure, e.g. a cloud-based medication reconciliation service or a substitutable application for antibiotic selection, that effectively interoperate with heterogeneous applications. However, such approaches are in their early phases of market penetration.

Faced with this problem, the organization can take several steps to make the most of its legacy investments.

a. *Define the content areas that are important to drive the business*. There are several content areas that can have a tangible effect on an organization's performance. For example, Meaningful Use regulations identify several quality measures for eligible providers. In the hospital setting, critical quality performance topics include stroke management, hospital acquired infection prevention, and venous thromboembolism prophylaxis. In the outpatient setting, value-based reimbursement is aligned with quality performance measures for asthma, obesity prevention, smoking cessation, diabetes, cardiovascular disease and women's health management.

b. *Define the systems that will be the focus of applying decision support.* These systems are likely to include physician order entry, clinical documentation, health maintenance/patient summary systems, case management and the like.

c. *Evaluate the decision support capabilities of these applications.* It is important to evaluate, for example, what kind of medication decision support, order sets, templates, reminders, and reporting these applications support. This evaluation will lead to the development of the "lowest common denominator" of tools, in effect, establishing the limit to which decision support can be implemented across the enterprise. If it appears that the limitations of the legacy infrastructure are woefully inadequate for meeting the strategic goals, decision support component suppliers are emerging on the market in the form of specialized CDS application providers and cloud-based service providers that can significantly augment the native capabilities of the legacy environment at much less than the cost of an new infrastructure purchase.

d. *Define CDS knowledge acquisition strategy.* In most health care delivery organizations, formal structures and resources are often lacking to undertake the process of transforming guidelines into the relevant CDS components and maintaining these artifacts. Most provider organizations are accustomed to licensing drug information as well as terminologies for problem list documentation and billing. The large content vendors offer a menu of prespecified content such as order sets, documentation templates and CDS rules. Some also offer tools for collaborative localization, update, and import into the EHR system, largely because very little of the licensed, importable content can be regarded as "plug-and-play." There are too many local considerations to account for that determine CDS configuration, particularly in the hospital setting. Further, some offer CDS content embedded in an application system or cloud-based CDS service that can integrate with the EHR system. Typically, the cloud-based CDS services approach allows for less customization, but also outsources the content maintenance. The advent of personalized medicine and its dependence on complex genomic decision support content will make cloud-based CDS an imperative. The volume and complexity of such content will exceed the knowledge curation capacity of even the large provider organizations, not to mention the technical capabilities of most EHR vendor systems. Some EHR vendors, particularly for the ambulatory setting, are offering EHR and content-enriched CDS services as a complete package on a cloud-based platform. When licensing content for import and build into the native EHR system, the provider organization must bear the cost of localization and maintenance. With these considerations in mind, an organization must reconcile the cost of localization and maintenance with the value such investments create in clinical performance and usability. There is no easy answer, and as the CDS market evolves, most provider organizations will invest in an ever-evolving hybrid of home-grown, content license with localization, and CDS services strategies.

e. *Define strategies and resources needed to manage consistent knowledge across a heterogeneous set of applications and cultures*, e.g. applications across large academic health centers and small community hospitals. For example, if we have to implement a new health maintenance reminder across six different applications in four different organizations within a single enterprise, how will we do that? How do we ensure that the logic is consistent across the organizations? Ensuring consistency and currency might require that a person at each organization, or for each relevant application, be tasked with implementing content. These individuals can be managed by a corporate person who ensures coordination.

f. *Develop/acquire an infrastructure for knowledge asset management*. The organization must be able to have a repository or library of the content that it has implemented across the enterprise (Wright et al., (2009). This library may be constrained to that content that has been determined to have significant value and/or must be consistent across all care settings. The asset management tools should enable the searching of the library, support audit trails, and assist the organization in ongoing content management, by, for example, identifying content that is due for a regular review. Some of the commercial content suppliers offer enabling tools to support update by that content supplier, inventory, and subject matter review of content.

In the course of determining how to invest in knowledge management infrastructure, an organization must fully understand the comparative strengths and weaknesses of their legacy environment with respect to key functional capabilities. This assessment will lead to some form of the steps outlined above.

24.4.2 Knowledge management tools

Vendors systems are often designed with proprietary database design tools typically called "knowledge editors" which are used to build different content types such as rules, order sets, and documentation templates. Few vendor solutions offer functional support of other critical aspects of knowledge management such as governance, knowledge inventory, knowledge vetting and design of complex cross-functional content such as disease management protocols. As highlighted earlier, the silo-ization of the different CDS content editors creates silo-ization of the content and presents a barrier to building integrated clinical program solutions. Hence, many clinical information systems are undernourished from a knowledge perspective.

An inventory and library of decision support design specifications is a critical component of any knowledge asset management strategy. At Partners, the knowledge management team performed an inventory and cataloguing of all decision support knowledge in production across the enterprise. A taxonomy was designed that enabled the CKM team to tag all the content specifications and publish them to a searchable portal. This portal has enabled clinical leadership to aggregate, compare, and analyze the robustness of content around strategic areas such as diabetes, cardiovascular disease, and adverse drug event surveillance.

Collaboration tools are useful to support subject matter expert review and validation of content. Some of the commercial CDS content suppliers offer collaboration tools. Collaboration platforms have advanced significantly in recent years with advances in Web 2.0 standards (Wright et al., 2009). They typically enable a combination of social interaction management, content life cycle management, and process management. Such tools can facilitate virtual, asynchronous vetting of decision support design specifications among clinicians that are often too busy to attend meetings. Further, they enable capture of an audit trail for decisions made. Collaboration workspaces require dedicated resources to ensure they are deployed in a manner aligned with the strategic initiatives, support cross-disciplinary interaction, and are organized to facilitate stakeholder engagement. For example, a medication cost reduction panel and a geriatric panel may collaborate on cost-effective pain management in the elderly.

Content management systems are useful to support the scheduled maintenance, versioning, and overall life cycle management of content. Typical clinical system vendor knowledge editors do not support easy capture of critical metadata for CDS content such as author, business owner, purpose, subject matter expert validation, date of last update, schedule of next review, and the like. Further, innovative content management systems now support greater reuse and propagation of knowledge. For example, if an organization designs a set of rules and order sets for the use of beta-blockers in patients with coronary artery disease, it saves time and reduces errors if the addition of new beta-blockers to the formulary is automatically propagated to these rules and order sets.

24.4.3 Foundations

The pursuit and progressive experience with knowledge-rich clinical information systems can lead the organization to begin to think of itself as implementing application foundations rather than strictly a set of clinical information system applications (Davenport and Glaser, 2002). A foundation provides the broad ability to perform a never-ending series of application-leveraged small, medium, and occasionally large advances and improvements in organizational performance.

For example, a computerized provider order entry system can be viewed as a foundation to improve physician decision making. Once the system is implemented, the organization can introduce an unending series of decision-support rules and guides. These rules can address medication safety, ensure disease management referrals, critique the appropriateness of test and procedure orders, and facilitate the display to physicians of data relevant to a given order.

In effect applications become the foundation necessary to achieve the core goals of enabling ongoing delivery of new CDS and improving workflow. This view of applications as foundations has several ramifications.

Clearly, there will be a flurry of intense effort as the foundation is laid. Introduction of provider order entry and electronic medical records is difficult work that requires great skill and significant resources. But once the foundation is in place,

there is an ongoing implementation of decision support. In fact, implementation of a clinical information system never stops. Provider organizations are faced with continuously changing reference content, clinical, reimbursement rules, and regulations. Hence, organizational information system processes and management mechanisms must become agile to continuously innovate and iterate their implementations. This can imply that implementation teams do not disband and/or that there is a formal handoff of responsibility from the team that installed hardware and trained staff to the team that carries on ongoing optimization of decision support and workflow improvement.

The foundation must be able to evolve gracefully and support ongoing implementation. Tools that enable rule development, the safe addition of local modifications, incorporation of new data types and coding conventions, and efficient interoperability with other systems are essential. The foundation must be able to capitalize on new technologies and architectures with minimal disruption, and support growing organizational sophistication in applying the tools to improve care processes. In many ways, technologies and tools that enable ongoing implementation are more important than the present functionality of the application. This emphasis will affect the orientation of the application Request for Proposal (RFP) and the system selection criteria.

The RFP for an application generally centers on functionality. The RFP process for a foundation must be changed from this traditional focus to place a greater emphasis on tools, architectures, and core technologies. In addition, an implementation that never stops implies that using the RFP in an effort to fully define all functionality that will ever be needed will be misguided. It is important for an organization to be prepared to invest in ongoing iteration. Experience will be the teacher.

Assessing the return on investment (ROI) of a foundation during the process of deciding capital budgets is more difficult than determining the ROI of an application. Although it is essential to continue to evaluate the ROI, it is difficult to do, because the path of evolution is not always clear, and implementation is never-ending. In acquiring and implementing a foundation, the organization is investing in "an ability." It is difficult to assign an ROI to an ability. In a similar fashion, it is difficult to measure the ROI of a well-educated workforce or having healthy capital reserves.

24.5 Evaluation of the impact and value of knowledge management

If the organization has identified decision support as a critical strategic enabler and has, as a result, committed resources to acquiring, implementing, and maintaining needed information systems and support resources, it will ask "Have our investments been effective? How much is it costing us to achieve our gains? Where must we focus our decision support resources next?"

The evaluation of the impact and value of knowledge management must address three areas:

- The strength of alignment of the content to business goals and strategies
- Organizational performance relative to key measures
- The efficiency and effectiveness of the knowledge management function to enable rapid-cycle learning.

Evaluation does require that an organization has an approach to clinical data management and analysis. Assessing clinical performance and the impact of an intervention on that performance requires a set of well-defined data of known accuracy and timeliness. This approach must develop means to resolve issues that often plague the collection and management of necessary data.

Many health systems have poor access to clinical data for measurement and rely, instead, on billing and administrative data. The architecture of a typical transaction-oriented database is not optimized to support analysis. Further, the data that must be aggregated to enable deep analytics is typically located in many databases across an organization or in paper charts.

In the absence of a clinical data management and analysis strategy, those engaged in the process of understanding and reporting on clinical performance must often bear the cost and time delays of, for example, chart abstraction labor to collect clinical data, which consequently slows the translation of such insights into quality improvement.

24.5.1 Alignment

It is very useful for health care organizations to take a "begin with the end in mind" approach to decision support. In this way, business goals are linked to relevant measurement parameters and consequently, required decision support strategies.

Table 24.2 contains a sampling of the Acute Myocardial Infarction (AMI) National Quality Forum (NQF) measures to illustrate alignment among quality performance strategy, quality measurement, and clinical decision support components. Once the performance goals are identified and targeted, the measures are mapped to the necessary data sources of discrete data for measurement and necessary knowledge components to achieve performance improvement. Further, Figure 24.4 illustrates how the CDS logic and data definitions that underlie a performance goal should be aligned with the quality measure logic and data. As one defines the CDS content and quality measure logic that informs a goal, such as ensuring that patients with AMI are discharged on beta-blockers, one can see the importance of definition alignment between the EHR care delivery system and the quality measure and reporting system.

Such goal, measurement, and decision support "tuples" are the centerpiece of alignment. Those measures can be complemented by measures that provide a form of overall assessment of alignment. For example, measures that might serve as complements include:

- Degree of knowledge asset coverage for key business-impact measures such as Physician Quality Reporting System (PQRS), Joint Commission on

Table 24.2 Acute myocardial infarction NQF measures

Example NQF Measure	NQF Measure Description	Measurement Data Sources	Clinical Knowledge for Decision Support
NQF Measure 132	Aspirin at arrival for acute myocardial infarction (AMI)	1. For aspirin on arrival, electronic medication administration record for administration within 24 hours of arrival 2. For patient contraindications, clinical documentation, allergies, laboratory data, problem list 3. Time of admission is from Admission/ Discharge/Transfer system	1. AMI admission order set with aspirin on arrival order 2. Documentation template for aspirin contraindication capture 3. Interactive alerts to notify physician if patient has contraindication to aspirin
NQF Measure 142	Aspirin prescribed at discharge for patient with AMI	1. Discharge Orders from prescribing/ordering application or discharge planning application 2. For patient contraindications, clinical documentation, allergies, laboratory data, problem list	1. AMI discharge order set with aspirin 2. Documentation template for aspirin contraindication capture 3. Interactive alerts to notify physician if patient has contraindication to aspirin
NQF Measure 137	Angiotensin converting enzyme inhibitor (ACEI) for patients with AMI and left ventricular systolic dysfunction (LVSD)	1. Electronic medication administration record 2. For patient contraindications, clinical documentation, allergies, laboratory data, problem list 3. For LVSD, echo report has discrete field that indicates LVEF< 40%	1. Discharge order set with ACEI on discharge order if LVSD present 2. Rules that indicate ACEI order is defaulted if echo report or problem list include LVSD 3. Documentation template in echo report with field for EF < 40% 4. Documentation template for ACEI contraindication capture
NQF Measure 160	Beta-blocker prescribed at discharge for patient with AMI	1. Discharge Orders from prescribing/ordering application or discharge planning application 2. For patient contraindications, clinical documentation, allergies, laboratory data, problem list	1. AMI discharge order set with beta-blockers 2. Documentation template for beta-blocker contraindication capture 3. Interactive alerts to notify physician if patient has contraindication to beta-blocker

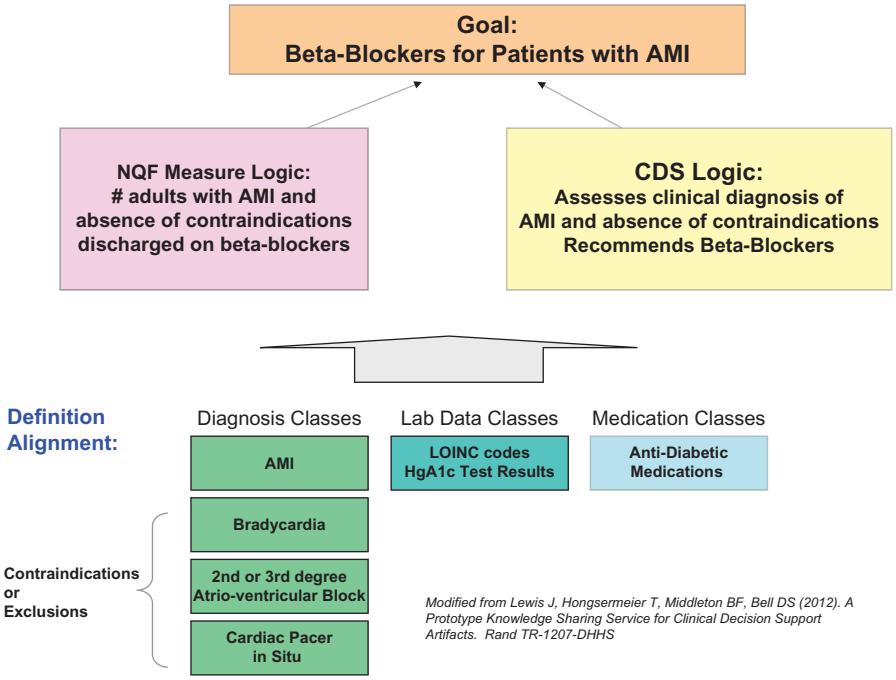

FIGURE 24.4

Example of alignment of performance goals with quality measures and CDS logic.

Accreditation of Healthcare Organizations (JCAHO), National Quality Forum (NQF), and Pay-For-Performance Contracts. For example, in order to meet the Centers for Medicare and Medicaid Services (CMS) quality reporting requirements specified for congestive heart failure, one can measure the degree of CDS knowledge coverage by the clinical documentation elements, order sets, decision support rules, and reporting algorithms in production for inpatient, case management, and outpatient systems

- Application end-user satisfaction with clinical decision support. Are clinicians satisfied with decision support content? Is the right balance achieved between quality improvement and workflow enhancement?

24.5.2 Performance

Table 24.2 also illustrates how decision support effectiveness can be measured in terms of direct impact on business performance. Effective knowledge management practices should result in better performance on key measures. Such measures can be translated into higher reimbursement on payer contracts or improved quality of

care. Following are examples of the kinds of performance measures that can be used to assess decision support effectiveness. Clinician acceptance of decision support recommendations is also a barometer. An organization should anticipate and accept some minimum override rate, because few decision support systems are so specific that recommendations are always clinically correct. Conversely, if an override rate is too high, the decision support is probably overly sensitive and task interfering.

Examples of performance measures include:

- Quality Performance: HEDIS, PQRS, JCAHO, CMS, NQF, and Pay-For-Performance contracts measures
- Adverse Event Rate: Adverse drug events, bedsores, hospital-acquired infections, peri-operative venous thromboembolism, falls, confusion, etc.
- Compliance rate with decision support: Sensitivity and specificity analysis, override rates
- Patient Experience: Patient satisfaction scores and correlation with patient use of clinical decision support tools
- Malpractice: Insurance costs and trends in claims.

24.5.3 Knowledge management function and organizational learning

Keeping an inventory of decision support knowledge current with commonly accepted standards of practice can be a costly business. It means investing in a team that conducts ongoing literature review, localizes commercial content, and ensures that changes in the standard of practice are rapidly incorporated into the decision support content. As we have already noted, the advent of molecular medicine will increase the speed of change in clinical knowledge, presenting new challenges for decision support maintenance. In addition, the knowledge engineering team must work closely with the quality improvement and analytics team that evaluates performance data to determine how decision support must change to achieve strategic objectives. They must work with end-users so that CDS is helpful and minimizes task interference. With each successive stage of decision support capability, health care performance becomes increasingly transparent. These CKM functions are critical to enabling a provider organization to become agile at self-improvement.

The organization will add to these costs of CKM the expenses of licensing fees, tools, and the sunk cost of clinical time spent on clinical decision support management.

The following lists some illustrative measures of CKM effectiveness:

- Coverage. Percentage of CDS assets with a clearly identified accountable CKM steward and business owner
- Currency. Percentage of CDS assets on an explicit updating schedule (rather than waiting for a complaint) and/or percentage of CDS assets updated on time

- Cycle time for content update. This cycle can be measured as the length of time it takes to convert an agreed-upon guideline into a decision support specification and then into production. This measure assumes there is a business cost to delayed alignment.
- Cycle time for content agreement. This measure evaluates broader organizational effectiveness in getting agreement on enterprise guidelines. For some organizations, depending on the complexity of the asset, this can take longer than converting the guideline into decision support.

24.6 Conclusions

Clinical decision support is a class of tactics for applying medical knowledge to achieve superior performance. An organization should devote strategic discussions to knowledge management overall to ensure that it has defined appropriate boundaries, understands the functions of knowledge management, and is able to prepare a business case that ensures necessary investments of organization resources.

Organization is a set of management structures and processes needed to ensure that an investment achieves desired organizational goals. Clinical decision support management structures and processes must achieve goals that include linkage to organizational strategies, prioritization of resources, and determination of the impact of clinical decision support. While there is some variation in the organizational approaches of different health care providers, common guidelines do emerge.

Clinical decision support implementation and management does require the consideration of key aspects of how an organization's clinical and business strategies drive the IT strategy. Specifically, this chapter discusses the application of clinical decision support across legacy systems, clinical decision support tools, knowledge acquisition and maintenance approaches, and the view of application systems as foundations.

Clinical decision support is utilized for one overarching goal – improving organizational performance. Achieving this goal requires ensuring strategic alignment, measuring performance relative to goals and continuous improvement of the efficiency and effectiveness of the clinical knowledge management function.

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