Organizational and Cultural Change

23

Joan S. Ash and Timothy H. Hartzog

23.1 Introduction

This chapter addresses organizational and cultural change issues related to clinical decision support (CDS). It describes how different types of settings and users may influence acceptance and therefore change strategies concerning decision support, how issues of organizational and personal control and autonomy are associated with decision support, how different stakeholders view decision support, and how an analysis can be done to assist in the development of change strategies.

Clinical decision support is a comprehensive term that could include anything from paper order sets and guidelines to computerized alerts, but in this chapter, use of the term will be limited to computer-based "passive and active referential information as well as reminders, alerts, and guidelines" (1, p. 523). In the ambulatory setting, CDS can be embedded into documentation templates, defined as "forms that guide clinicians in the capture of structured or even unstructured data, often with respect to specific clinical conditions, procedures, or administrative tasks" (2, p. 982). Our definition includes only computerized decision support because the organizational and individual behavior issues of computer-based clinical decision support are different from those of paper-based decision support. The issues become more complex when information technology enters the picture: in addition to the many governance and prioritization issues of traditional decision support, there are interface and access issues specific to information technology.

CDS may be aimed at different types of clinicians, although most research has focused on physicians. Physicians have not always embraced CDS. Physicians are highly trained, intelligent individuals whose medical education emphasizes clinical decision making. The practice of medicine *is* in fact, to a large extent, medical decision making. Any implication that physicians need help with decision making could be taken as a subtle suggestion that their professional skills are lacking. Efforts to provide clinical decision support might be seen as a threat. On a rational level, clinicians use, value, and welcome information resources they feel that they need, but on a more emotional level, they may resent it when information they may not feel they need is not only thrust upon them, but may force them to waste time better spent in other endeavors. This has been a problem with interruptive alerts, especially when

redundant, not sufficiently patient-specific, or advising about an action the physician was intending to do already. Such interruptions may lead to alert fatigue, additional effort, and irritation. A current trend to overcome these problems is to minimize alerts and maximize "in line" types of decision support, such as passive alerts and reminders (Ash et al., 2012a), e.g. by having them appear on the same screen, perhaps off to the side and highlighted in color, rather than as a popup or dialog box that needs to be dismissed. Another increasingly popular strategy to avoid overtaxing physicians is to provide CDS to nurses, pharmacists, and midlevels such as nurse practitioners or physician assistants to take the burden off physicians.

The implementation of decision support programs by organizations might best be viewed as a delicate balancing act. Acceptance of decision support depends a great deal on the type of decision support, the reason for its use, how good it is, and the value the clinician places on it at any particular point in time (Thornett, 2001; Shibl et al., 2012). With all of these variables changing over time, and with advances in technology and in medicine further complicating them, the challenge of managing decision support systems is extremely difficult and never ending. On the positive side, some organizations, even community hospitals and clinics, have now had considerable experience implementing these systems, and there are lessons we can learn from them. Organizational issues in decision support have received increasing attention over the past several years, and a number of papers have been published about them. There are some papers offering guidance based on experience (Bates et al., 2003; Feldstein et al., 2004), there is an implementation manual outlining an ideal process (Osheroff et al., 2012), there are studies about the organizational aspects of implementing clinical guidelines (Cabana et al., 1999; Davis and Taylor-Vaisey 1997; Solberg et al., 2000; Trivedi et al., 2002), and there are papers related to electronic prescribing with decision support (Miller et al., 2005). There is increasing research about CDS for clinicians other than physicians (Gooch and Roudsari 2011; Bakken et al., 2008; Hines et al., 2011). Finally, qualitative research by the first author's interdisciplinary research team over the past four years has uncovered numerous themes related to organizational issues and CDS. Through observations and interviews at ten clinical sites and interviews with individuals in five vendor organizations, the results of this research describe how the balancing act has been conducted and what has worked best (Ash et al., 2012a,b).

This chapter will outline the organizational issues related to changes instigated by decision support and suggest strategies for addressing them within a framework for transition management that has been used with success.

23.1.1 Framework for addressing organizational change and transitions

Changing clinician behavior involves changing organizational behavior. As the Institute of Medicine (IOM) study on patient safety asserts, organizational culture must be imbued with a sense of priority for safety, and the focus should be on a
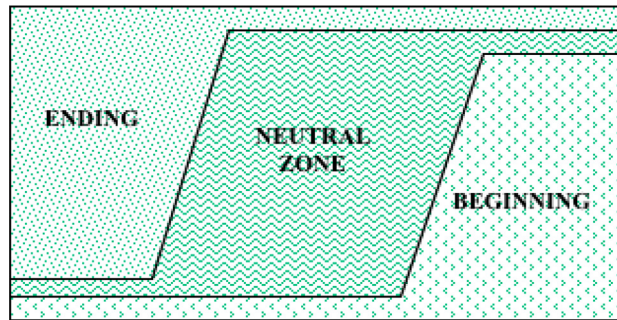
From: Bridges, W., Managing Transitions: Making the Most of Change, 1991

FIGURE 23.1
Bridges' three transition phases.

systems approach rather than on individual blame when deviations occur (Institute of Medicine Committee on Quality of Health Care in America, 2003). Garside provides further description of the organizational changes needed for safety (Garside, 1998). The need for a systems approach was underscored by a more recent IOM study about health information technology safety, which outlined a context-rich sociotechnical model (Institute of Medicine Committee on Patient Safety and Health Information Technology, 2012).

Changing an organization's culture is usually a gradual process. In the classic change theory outlined by Lewin (Lewin, 1951), change happens in three phases, when something that has been in place gets unfrozen, changes, and freezes again. This does not offer informatics professionals a very useful framework, however, because information systems are in constant flux with continuous improvements, and these systems exist in an ongoing slushy, rather than frozen, state. A more appropriate framework is that outlined by William Bridges (Bridges, 2003) and depicted in Figure 23.1. This is also a three-phase model, which progresses from 1) an ending, to 2) a neutral zone, to 3) a new beginning, and keeps recycling as people progress through a psychological readjustment. While it may seem odd to begin with an ending, it makes sense when one thinks about major life events such as a death in the family or a change of job. Bridges offers strategies for dealing with each phase, such as a definite marking of the ending (a goodbye) and identification of who is losing what. The neutral zone is a phase people go through at different rates while they are adjusting, and communication and education become important during this phase. Finally, the new beginning marks a new mental state, a point at which additional hands-on training, for example, might be even more effective than during the ending phase or neutral zone phase. The framework helps to explain why the implementation of clinical systems is accepted at different rates by different people, and why continuous communication, education, and training need to be planned.

At the organizational level, deliberate decision making to avoid imposing too much change on individuals, termed "change fatigue," can be assisted through the use of a simple tool called The Change Calendar, which can help to predict changes that affect clinicians, assess potential impact, and guide scheduling (Valusek, 2007).

23.1.2 Identifying the barriers and facilitators for implementing CDS

For our purposes, a barrier is anything that hinders acceptance of CDS system guidance. In one study, acceptance of CDS was shown to depend on perceived usefulness during the patient visit itself, the presence of facilitating conditions such as integration into workflow, and the availability of training opportunities, the CDS system's ease of use, and trust in the content of the CDS (Shibl et al., 2012). In an interview survey, subjects identified barriers that corresponded to the absence of these acceptance factors: lack of user involvement and training, out of date content, alert overload, and workflow issues (Ash et al., 2012b). Barriers differ across settings, so an analysis needs to be done prior to an organizational decision support implementation effort.

23.1.3 Stakeholder analyses and Lewin's force field analysis as useful techniques

An early step in the Bridges model is that of identifying who stands to gain or lose in any transition effort. A stakeholder analysis is also the first step recommended in the Implementer's Guide (Osheroff et al., 2012). This includes identification not only of individual groups of clinicians, information technology personnel, quality assurance personnel, and administration, but also existing committees. Such an analysis will uncover groups that can be targeted with change management efforts, and it will also help identify what the barriers are.
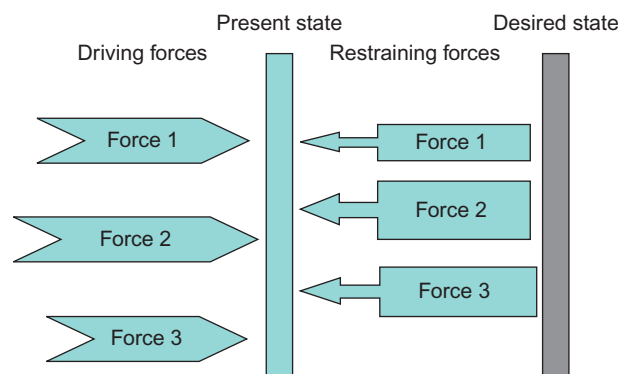

FIGURE 23.2

Force Field Analysis Model.

One aspect of the Lewin change model that can be applied to informatics implementation projects is Force Field Analysis, depicted in Figure 23.2. By first identifying the forces that facilitate the change or transition and those that provide barriers, and then by outlining strategies that can strengthen the facilitating forces and/or weaken the barriers, plans for reaching the desired state can be made. The following sections will describe barriers and facilitators to clinical systems implementation that can be addressed in such a force-field analysis, issues that need to be considered in planning efforts, and in developing, and maintaining, clinical decision support systems.

23.2 Organizational issues related to clinical decision support

23.2.1 Differences among kinds of organizations and cultures

Academic teaching hospitals differ from nonteaching (community) hospitals in a number of respects when considering decision support. In most teaching hospitals, for example, physicians still in training (interns, residents, and fellows) enter the orders (Ash et al., 1999). In some settings, in fact, others in the hierarchy such as higher-level house officers and attending/faculty physicians, are discouraged from entering orders. Therefore, the person entering the order and receiving decision support assistance is still at a learning stage of development. Interns are often quite grateful for any help that an information system can offer. They are also in a lower position in the hierarchy, where they are more accepting of requirements by the organization, even if such requirements are seen by others as taking extra time or not worthwhile. As these individuals gain in experience, they can become annoyed by alerts about things they already know, however. Many teaching hospitals with high levels of decision support capability provide everything they can at every "tier" of severity (mild, moderate, severe). The ideal would be a system that knows what level of training the clinician has. In nonteaching hospitals, clinicians are already trained and even less tolerant of annoying interruptions. Most systems have the ability to alert only for the most critical reasons, so with a three-tiered system of alerts where the third tier includes only extremely urgent messages, only the third tier would be activated in a community hospital. For example, in teaching hospitals, all medication alerts might go directly to the physician. In a community hospital, the pharmacy might screen alerts first, so that they are filtered and the physician gets fewer medication alerts to avoid alert fatigue and annoyance.

The rate of implementation of decision support capabilities might be different for nonteaching hospitals. Community hospitals may want to move slowly from reactive decision support (a severe allergy alert) to proactive types of decision support (corollary orders the physician might consider in addition to the order just entered) to full clinical pathways and protocols. There seems to be a psychological difference among the three types of interventions, and the effort needed to tailor the CDS to the setting increases also as the CDS becomes more sophisticated.

Governance and control issues that impact decision support are somewhat different in the two types of hospitals. Control issues in teaching hospitals such as trying to cut costs and encourage physicians to behave in ways the administration or quality assurance wants, may also be shared by community hospital administrators, but the latter probably need to tread more gently. This implies the need, in those settings, for even greater attention to the organizational issues involved in planning and careful implementation and maintenance.

There is increasing development and use of clinical pathways – also called adaptive care pathways – that are created in a multidisciplinary manner involving nurses and others and outlining treatment day-by-day (Gooch and Roudsari, 2011). Pathways may actually be easier to develop in a community hospital because of the stability of staff and because there are fewer clinicians and therefore fewer egos involved. In community hospitals, clinical pathways are appreciated by everyone on the health care team. When decision support can make larger numbers of staff grateful, this positive attitude can be infectious.

Making anything mandatory may be more difficult in a community hospital, although Meaningful Use incentives in the United States (US) have changed this somewhat (see Chapter 1). Physicians, who bring patients, and therefore business, to the hospital, are able to take their business elsewhere. In designing decision support interventions, then, care must be taken so that there are as few strict roadblocks as possible. There should be mechanisms for the physician to acknowledge the alert, for example, and proceed to do it his/her own way. According to the Ten Commandments (Bates et al., 2003), the clinician should not be forced to give additional information very often, since this impedes workflow. As more community hospitals employ hospitalists who use computerized provider order entry (CPOE) with CDS on a daily basis, the issues become less problematic. Like interns in teaching hospitals, hospitalists in community hospitals can be required to use the system and, because they become adept with experience, they are more accepting of changes, especially if they have been involved in decision making about them.

Certainly the organizational cultures of commercial organizations such as EHR and content vendors differ from those of the clinical organizations. This has an impact on the ability to share CDS. Commercially provided logic, especially for drug interactions, is used by virtually all hospitals and ambulatory clinics with electronic health record (EHR) systems these days. Most is supplied by content vendors separate from EHR vendors. Some is supplied by the EHR vendors, although it is developed by content vendors, but other CDS knowledge must be purchased directly from the content vendor. Some EHR vendors encourage and enable the sharing of rules among hospitals that have purchased their systems. While sharing makes sense, considering the effort needed to develop CDS, there are many reasons, usually based on competitive and legal forces, in addition to the need to tailor CDS, why sharing is difficult (Wright et al., 2009).

There are also important differences related to CDS between organizations that are standalone and those that are part of larger health systems. The larger systems generally have the resources to employ knowledge engineers or analysts as part of

consolidated informatics or information technology operations. These individuals can modify commercial CDS content to fit the local needs (Ash et al., 2012b). Standalone organizations, such as independent community hospitals or small office practices, must rely on vendor products with little customization, and clinicians must therefore either adapt their workflows accordingly, which may not be as acceptable to them, or refuse to even use the CDS.

Finally, there are large differences in the nature of CDS and its impact in inpatient vs. ambulatory settings. Ambulatory CDS, which might be offered as part of e-prescribing and documentation templates, seems to be more readily accepted than hospital system CDS for several reasons. First, clinicians use the system continuously on a daily basis and become facile with it, which has traditionally not been the case in hospital settings, though this is changing as more hospitals hire hospitalists. Second, templates, especially if clinicians personalize them to their liking, can assist workflow if they are "in line" with the way a provider practices (Ash et al., 2011). Also, CDS such as reminders can more easily be sent to nonprovider clinicians or other staff, before a visit or outside of a visit. For example, in the ambulatory setting, a reminder might be sent to a nurse or administrative assistant noting that a patient needs smoking cessation or diabetes counseling. This individual can then contact the patient and arrange for an educational intervention. This avoids sending too many reminders directly to the physician during a patient visit for an acute complaint when the physician is busy trying to make a diagnosis or develop a treatment plan for the immediate problem.

23.2.2 Issues of control, autonomy, and trust

A stakeholder analysis and determination of who stands to lose or gain is useful for identifying threats to control, power, and autonomy related to decision support (Ash et al., 2006). Those highest in the organization see decision support as a way to modify physician behavior so that the organization can save money. Those in the quality assurance arena see it as a way of gaining adherence to suggested guidelines, assuring regulatory compliance, changing clinician behavior, and tracking and monitoring adherence. An organization may want data for benchmarking, but clinicians may view such tracking as intrusive and threatening. Clinicians need to trust those who are instituting any quality initiative. Organizations may in truth be implementing systems so that the hospital overall can become more efficient: for example, cost alerts may be given to control physician medication or test ordering patterns. Organizations may seek to control physician behavior, but there are gentle ways of doing it that suggest and guide rather than mandate.

In the following we will consider implementation in terms of individual CDS knowledge modules or components (e.g. rules, order sets, or documentation templates), but often entire sets of components are implemented at one time. Implementation is easiest for CDS components or sets of components that clinicians do not care about very much and do not require extra time. It also seems to be easier when the target is a nurse or pharmacist rather than a physician. Clinical

guideline acceptance has been hampered by a sense that developers are not local and may have special interests they are promoting (Wendt et al., 2000), so customization at the local level is critical for success (Ash et al., 2012b). Decision support systems often interfere with the workflow of clinicians, a workflow that may be highly individual. It is because of this individuality that the ability to personalize CDS can make it more acceptable. For example, some commercial ambulatory products allow a clinician to turn off certain alerts if they deem them unhelpful. Even though it takes time for the clinician to build his or her own order set, it may give that clinician a sense of autonomy and control. This is also a reason why it is not difficult to get clinicians involved in building or modifying decision support components, e.g. rules or order sets: they feel they can have a positive impact on the system and, at the same time, gain back some control.

Clinicians often have a sense that those in the information technology or informatics departments are gaining control and power while they, the clinicians, are losing it (Ash et al., 2006). Though information technology staff members may be implementing a CDS component because of an administrative policy decision, it is these staff members who tend to be blamed for the change.

Many of the control, autonomy, and trust issues are related to the culture of the organization. The cultures of teaching hospitals are different from those of community hospitals. For one thing, there is a strict hierarchy associated with levels of training. For another, there are strong department chairs and differences in power, dependent on which areas bring in the most revenue. Clinicians are powerful, and those with power can exert it on house staff. Conversely, house officers who are stellar information system users can exercise power by making knowledgeable suggestions for improving the system. Cultures within different teaching hospitals vary depending on the strength of the power and fiefdoms. For decision support purposes, the power can be tapped by gaining the support of department chairs. Community hospitals are less hierarchical, with little hierarchy within the ranks of the physicians. Informal champions and opinion leaders hold power only by virtue of their expertise or personalities, yet these are the people who need to be involved in decision support efforts. Of course, cultures vary within specialties in either type of hospital: these might be considered subcultures, which may vary in their power levels. For example, results of one study of acceptance of an asthma guideline embedded in an EHR by pediatric pulmonologists indicate that these subspecialists believe that, because of their unique workflows and the complexity of their patients, guideline-based CDS cannot be very useful to them (Lomotan et al., 2012). The training of an orthopedic surgeon, a family practitioner, or an infectious disease specialist is extremely different. While an orthopedic surgeon, for example, might be very receptive to a CDS alert about the treatment of pneumonia because that is not that person's area of expertise, the infectious disease specialist would be annoyed by the same alert. Conversely, the orthopedic surgeon might complain about receiving an alert that prevents them ordering a preferred antibiotic for a bone-related infection, but the family practitioner would welcome this particular alert.

23.2.3 Difference between commercial and locally produced decision support

Locally produced decision support is hard to develop and expensive to maintain, but it is more easily accepted than generic CDS because most likely the users have helped to develop it. It can be tailored to fit the workflow and local interests (Miller et al., 2005). Most often it is fragmented, however, because it has been developed in a reactive way. When a need or gap is identified, a decision support component (e.g. a rule) is developed, often because it captures the interest of an individual developer. On the other hand, commercial decision support components, although they require extensive modification, do not need to be developed from scratch, and collections of them may cover the entire spectrum of needs in a less fragmented way. With some commercial systems which have responded actively to customer demand for more and more rules, and with the Veterans Affairs CPRS system, there may be a surfeit of riches, however, in that difficult decisions need to be made, e.g. about which CDS rules to implement. Most large organizations depend on commercial CDSs, but they also develop their own clinical pathways or other more complex CDS using vendor-supplied tools.

23.2.4 Upsides and downsides to clinical decision support from the user perspective

When doing a stakeholder analysis, the user perspective on the upsides and downsides of CDS must be considered most important (Waitman and Miller, 2004). Behaviorally, such systems can be so helpful and popular that they are the selling point for CPOE for physicians if they really aid decision making and help workflow.

There are a number of downsides of CDS, alluded to earlier, that affect not just physicians, but pharmacists and nurses as well. If it has a negative impact on workflow and therefore the clinician's time, CDS can be a dangerous impediment leading to workarounds and the ignoring of warnings. CDS should never stop a clinician from acting during an urgent situation. Decision support components can seem too controlling, and they can evoke strong emotions (Sittig et al., 2005). They can also produce unintended consequences like alert fatigue (Hines et al., 2011; Ash et al., 2004). Some experts claim that such interventions can undermine education and learning, but others say they assist these endeavors. In an astute summary, (Wendt et al., 2000) describe many reasons why decision support functions cause problems for users. These include: 1) the fact that routine work in health care needs broad knowledge support, yet most CDS provides advice on something very detailed; 2) the idea that much decision support is not patient-specific; 3) the loss of interpersonal discussion; 4) the questionable validity of some of the suggestions; 4) the questionable quality of data that the clinician has given the system; 5) the additional time on the part of the clinician; 6) the problems with interface design that is not intuitive; and 6) the lack of integration between different parts of some systems such as results retrieval and CPOE. In other words, the decision support

components may not seem relevant to a user if they are not patient-specific, they may interfere with doctor-patient communication, and they may also interfere with doctor-doctor communication by eliminating the need for "curbside" discussions. The user must believe that the information is correct, both in terms of the guidance offered and the data about the patient that have been entered into the system. Whenever the clinician is asked to enter information in response to an alert, the time this takes is problematic. Whenever the user must expend effort to evaluate the appropriateness of either a guideline, alert, or citations in a literature search, it is considered a downside.

One of the greatest barriers to clinician acceptance of CDS is simply the amount of change that CDS generates. The pace of change in medicine, with results of new studies indicating the continuous need for new treatment protocols, precipitates development of new CDS. Medication shortages or drug recalls can cause protocols to change.

23.2.5 Cognitive, emotional, and environmental issues

Since members of the health care team need discussion and psychological support when making difficult decisions, this social aspect of decision making can be turned into an advantage by those implementing decision support. One can take advantage of these needs, especially during the development of the decision support component. It was actually this kind of collaborative effort that saved the day when residents threatened to strike because of implementation of the medication ordering system at the University of Virginia in 1989 (Massaro, 1993a,b). No decision support was provided by the CPOE system, and the entry of orders was taking too long, so the system was discontinued. The house staff then started a residents' organization, leaders of that organization took it upon themselves to help build order sets in collaboration with clinical leaders and information technology staff, and the order sets became widely accepted once CPOE was reimplemented. This is also an example of how emotional these issues can become. Although decision support saved the Virginia implementation, CDS can also generate many negative emotions, including guilt, anger, sadness, hostility, and even disgust (Sittig et al., 2005). Clinicians have a tendency to blame the information system and CDS in particular for any problems they are having using the system. For example, if a physician is having difficulty navigating the system because he is unfamiliar with the screen layouts, he will become especially annoyed if he receives an alert he believes to be useless. Care must be taken to design and implement systems in ways that avoid these emotions and reactions to them as much as possible. By engaging a broad spectrum of clinicians who represent everyone from the resistant curmudgeons to the most eager champions, implementers can better predict possible reactions and attempt to mitigate them.

Many of the Ten Commandments outlined by (Bates et al., 2003) suggest ways to decrease barriers that such negative emotions might generate: be mindful of time issues, deliver information in real time at point of need, suggest and do not stop

an action, take advantage of the easy and high impact interventions by doing them first, avoid asking for more information than is absolutely necessary, be responsive to feedback, and manage the knowledge base so that physicians trust the content offered them.

Alert fatigue, or overdoses of alerts, is perhaps the greatest barrier to decision support. For example, although the VA has an extensive library of rules available to all of its hospitals, when one hospital discovered that 90% of its alerts were being overridden, most were turned off. There is debate about the greatest acceptable override rate, but something around 50% seems reasonable to most experts. Strategies for avoiding overdoses of alerts include: select levels of urgency and different responses required – avoid the extra annoying step of an explanation and ask for it only if it is really needed; turn off alerts when your monitoring discovers they are consistently ignored; fine-tune the alerts – a low override rate shows good specificity of warnings; consider having some alerts go only to pharmacy rather than physicians, for duplicate orders, for example.

23.2.6 Addressing the issues judiciously

Now that the relevant issues have been described, an example of the use of the force field analysis technique will introduce a discussion of strategies that have proven useful in decreasing the barriers and increasing the facilitating forces.

Beginning at the level of the individual clinician who is to receive the decision support, the barriers that can be lowered include emotions, lack of awareness, lack of familiarity, lack of self-efficacy, inertia, time constraints, and lack of computer skills. Emotions might be mitigated by using kinder or less authoritarian language in alerts and by improving screen designs and fine-tuning alerts. Lack of awareness, familiarity, self-efficacy, and computer skills can be addressed with education, training, and communication. Inertia can be addressed more globally through the culture and social system, including nursing and pharmacy staff, offering enthusiasm. Time constraints need addressing through a combination of better technology, education about the value of decision support, and adequate technical support. Hard-to-overcome constraints include lack of physician belief in the content/recommendation of decision support (lack of agreement) and the belief that the intervention will not be successful (e.g. smoking cessation recommendation to the patient).

Regarding technology, barriers that can be addressed are design issues, lack of clarity on how to proceed once given a decision support message, ill-timed interventions, and lack of trust in the input data. All of these can be addressed by improving systems design. For example, user-centered design methods such as Agile Development (see Figure 23.3) assure that the user perspective is considered in any new CDS design. Even the lack of trust in the data placed in the system by clinicians can be overcome. For example, physicians are well aware that it can be easy to enter orders on the wrong patient. If the screen design makes it evident who the patient is and safeguards like disallowing two patient records to be open at one time are in place, wrong patient errors will be avoided and trust in the system will increase.
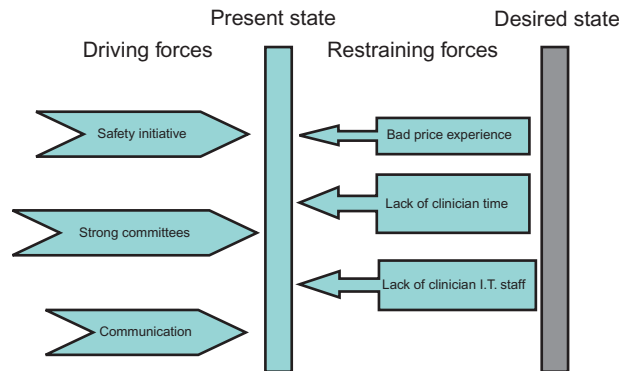
FIGURE 23.3

Force Field Analysis Example.

Finally, higher-level organizational issues of power, control, autonomy, and trust of administration need to be evaluated and addressed. They need to be viewed through the eyes of the clinicians who will be recipients of decision support, because these are all issues that are not in themselves barriers. Control of the quality measures in an organization should rest with quality assurance and administration, but whether the clinicians view that control negatively or positively is important here.

A checklist of barriers and forces to overcome them can be developed by populating the Force Field Analysis diagram as shown in Figure 23.4. First consider the driving forces that may be especially strong in the organization: these might include education, training, communication, culture and the social system, the ability to improve systems design, trust, organizational vision, and quality initiatives. Decision makers in a particular organization might consider local strengths to include a safety initiative, strong clinical systems committees, and excellent communication channels with clinical staff, for example. They may also honestly admit that restraining forces might include a negative prior experience implementing a particular decision support program, lack of clinician time so that stress levels are high, and lack of sufficient numbers of information technology staff with clinical backgrounds. The relative strengths of the forces can be assessed and resources identified to strengthen the facilitating forces and decrease the restraining forces. Once that is done, planning can incorporate mechanisms for changing the forces.

23.3 Planning with these issues in mind

Planning needs to begin early, and a structure for continuous planning needs to be in place. Like any planning effort, it needs to begin with a vision. The vision needs to mesh with that of both the knowledge management strategy and planning efforts at the organizational level. The next step is to perform a situation analysis.
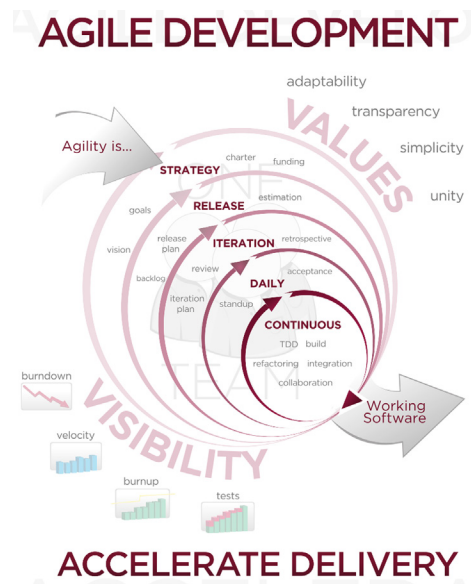
AGILE DEVELOPMENT

adaptability

transparency

simplicity

Agility is...

VALUES

charter   funding

STRATEGY

estimation

unity

goals

RELEASE

vision

release plan

ITERATION   retrospective

backlog

review

acceptance

iteration plan

DAILY

standup

CONTINUOUS

TDD   build

burndown

refactoring   integration

collaboration

Working Software

velocity

VISIBILITY

burnup

tests

ACCELERATE DELIVERY

FIGURE 23.4

Model for Agile Development.

This should include an inventory of present technology that can provide the infra-structure for the decision support program and identification of clinical infor-mation systems committees already in existence. The situation analysis would include identification of the problems or weaknesses and the strengths, many of which would be identified in the force field analysis. For the purpose of decision support, the quality gaps and needs for different pieces of decision support need to be described – these are the targets for the planning. The motivation for decision support, especially environmental trends, needs explication.

Once the targets for the plan are identified, a financial overview can be done. As outlined in Chapter 24, this is exceedingly hard to do and at the beginning of any change effort, best guesses may have to be enough. What is important at this stage is that there is agreement that both intangible benefits as well as tangible ones should be factored in. For example, costs of lab tests can be decreased with elimi-nation of duplicate lab tests, which is a tangible benefit, but the ultimate goal of better patient care is in many respects intangible and needs to be considered.

Next, the plan should include goals, objectives, and action plans. Possible inter-ventions can be listed, prioritized, selected, and scheduled. Plans for monitoring the results must be built in, as well as a plan for planning. It is never too early to iden-tify measures which will be used to define success (Ash et al., 2012a). Baseline measurements should be done so that post-implementation changes can be docu-mented. According to the Bridges model for transitions management, there should be a parallel plan for monitoring the people and organizational aspects, the effects

on the clinicians and staff, as well. The Implementer's Guide includes helpful worksheets to be completed during the planning process (Osheroff et al., 2012).

23.3.1 Vision and philosophy

The plan needs to begin with the vision statement. Along with a clearly worded vision statement such as "To be a leader in patient safety by implementing a broad range of computerized decision support entities" a philosophy, which must be part of the organizational culture or become part of it, must be behind it. Organizations with mature CDS programs tend to have philosophies that CDS should provide guardrails, should help the clinicians do the right thing, should make it easier to go down the right path, and CDS should be nearly invisible and remain in the background (Ash et al., 2012a).

For a CDS program to be successful, consideration of the Ten Commandments (Bates et al., 2003) and recognition of the following principles are recommended. The first principle should be that the clinician is always right and therefore the system must provide ways to get around any rule. Do not block or stop a clinician from doing what he feels is best for the patient, just lead him down the right path. This principle is necessary so that clinicians accept the system, but it also is a recognition that no system is perfect. In fact, another principle should be that no decision support component will be perfect, so you can only do your best and if you make it fast and build in flexibility, it can be accepted. Another principle might be that even talented knowledge engineers cannot anticipate all of the problems that can be caused by each CDS component before it is perfected, so testing must be as thorough as possible. For example, if house officers or hospitalists are available, they should be invited to test any new CDS component before it is rolled out. Not only can they provide valuable feedback, but their involvement will encourage their colleagues to accept the change more readily. Often, the cost of simple testing is low and may only include paying for a pizza lunch. In nonacademic nonhospital settings, it may be wise to pay clinicians who are outside the core implementation team to test new CDS. Many organizations use simulations for testing. For example, before a new CDS intervention is rolled out to a unit, the clinical manager of the area might copy orders out of paper charts for complex patients (blocking out patient identifiers) and have "testing clinicians" enter the orders and comment on the quality of the CDS received. However testing is accomplished, a structured testing process should be in place. Another principle is that an organization should not implement a new decision support component every time it wants to change clinician behavior. This will lead to alert fatigue and it can do more harm than good.

23.3.2 Organizing for decision making

Chapter 25 will describe various committee structures for providing a rational process for reviewing and decision making. Every organization that already has a structure in place does it differently, depending on its history, structure, and culture.

There is no recipe for a successful CDS committee structure. There are some general principles that can lead to success, however. First, multiple clinical disciplines need to be heavily involved in the work of the committees that are charged with planning and selecting decision support. This may be obvious, but because pressures for quality enhancement are put primarily on administration and quality assurance staff, and because clinicians are busy and may feel threatened by the focus on cost and error reduction, they sometimes are not involved to the extent they should be. When they are appointed to committees, they sometimes are not truly involved or heard. Getting clinicians involved in making decisions about decision support and in helping to develop decision support can be a selling point for CPOE in general, and for individual decision support components in particular. There is more to it than receiving expert clinical input – there is also the need for having clinical opinion leaders who can spread the word and encourage other clinicians to better accept the systems.

Another recommendation is to take advantage of the social needs of clinicians. Especially with the advent of information systems and the ability to enter orders and do clinical documentation remotely, clinicians have less opportunity to get together face to face than they had in the past. Decision support committees truly need their expertise, and they may need human interaction with their peers, so well-organized committees can serve both functions. The committees need to be multi-disciplinary, include committed and respected clinicians, and the members need to enjoy their work. The latter need can be met by having well-organized, on-time, well-scheduled, regular meetings with refreshments. In teaching hospitals, lunch meetings can be scheduled, but in community hospitals, early morning, before private physicians begin patient rounds, seems common. This may be unpopular with information services and operations staff, but it gives a signal to the physicians that their presence is important. In addition to standing committees making decisions about decision support, ad hoc task forces, with appointees selected for their specialized expertise, are generally present in organizations with mature CDS programs.

There is some debate about whether physicians should be paid to be part of the committee structure. Usually those who work on decision support committees must put in considerable amounts of time, so some kind of reward, even if it is not monetary, is important. This might include recognition in media, awards, and other incentives such as being the first to try out a new program.

The importance of "help at the elbow" or "elbow to elbow" support cannot be overestimated whenever significant new CDS is implemented. This means that a support staff member needs to be available on site to help clinicians at the point of care during times of intense change. Such support is most effectively accomplished in person 24/7 by trained clinicians who can come to the aid of a clinician who might be having trouble using the system at the bedside. At the second author's hospital, nurse informatics staff members have common areas they cover, and they often walk around and talk to clinical staff to gain valuable information about problems and concerns or offer on-the-spot training as needed.

A final underlying principle is that there must be a communication plan to provide background and supporting information for every decision support component that is implemented. Indeed, lack of training and communication can cause confusion, frustration, and risk (Horsky et al., 2005). There are many ways to communicate with clinical staff, and each organizational culture has its own most effective mechanisms. Sometimes the opening screens of the clinical information system are well designed and effective, so these "hello" screens can alert clinicians about updates and changes made to the decision support systems. If these screens are ignored, however, more effective and complex communication media will be needed. Many organizations make sure that changes are mentioned at all important meetings that might be attended by clinicians. Some organizations have monthly "pizza meetings" that become popular gathering times for users to talk about both problems with the system and also new enhancements and changes. This may also be an opportunity to do training, and an incentive might be to also provide continuing medical education credit. It is especially important that clinicians be trained about what alerts mean and how to handle them. This improves the clinician's sense of confidence, helping to overcome lack of self-efficacy, one of the major barriers to implementation.

23.4 Development, implementation, and modification

23.4.1 Preparing

Planning is of course the best preparation for development of an entire decision support program. For individual decision support component development, however, it is wise to first look at paper decision support. We sometimes forget that all health care organizations had some kind of decision support in place prior to information system implementation. There will be forms for order sets, and these can be gathered and inventoried. Many will no longer be in use, so they need to be carefully screened, but they can provide a starting point. These paper order sets can be compared to order sets available from a vendor, so that the vendor product can be modified to fit the local needs. A similar methodology might be used for clinical pathway development.

Computer-based information systems are often blamed when a standard policy, which has routinely been ignored, is suddenly exposed when it becomes automated. A wise strategy is to identify for each decision support component whether it embodies new enforcement of an old policy. If it does, plan to begin enforcing the policy with adequate notice prior to computerizing it. This will hopefully avert system blame.

When a new CDS component is being designed, clinician users must be included in the interface and screen design discussions. Many places have found that house officers can be paid to moonlight to do testing or hospitalists can be given incentives to do so. After all, they have a vested interest in making sure the decision support is of high quality and easy to use, because they will use it

continuously. Other members of the care team, such as nurses, laboratory staff, and pharmacists also need to be included at an early stage, both for their clinical expertise and also for their knowledge of the workflows that will be impacted by an intervention.

23.4.2 Committee work

Early decision making must include; 1) identification of what needs to be in place at both basic and more advanced levels over time, 2) decisions about who will screen for new knowledge, 3) identifying who will update and revise decision support components, and 4) decisions about who will communicate plans to clinicians. Someone needs to make these decisions about priorities, for building from scratch or for selecting and modifying vendor-supplied knowledge. There are several processes that committees can use for identifying gaps that decision support can fill: they can institute a regular process of reviewing new evidence, screening available guidelines, identifying problems that need addressing, and fielding suggestions from pharmacy and therapeutics committees and other chartered committees. Because of the nature of decision support systems and their relation to quality and safety, decisions by these committees can be viewed as policy and therefore need careful approval by decision makers. While recommendations from individuals should be welcomed, they need to go through the proper channels. They need to be vetted against the grand plan and prioritized. It is important that every suggestion that is received is not only acknowledged, but also its disposition is made clear to the person who made the suggestion. If clinicians who go out of their way to make suggestions do not receive feedback about what happened to their suggestions, they will stop making them. For rules that are already in place, there needs to be one person clearly responsible for them, so that feedback can be given to that person and so that everyone knows who the responsible party is. That person should also be part of the regular review process, on a timeline, for keeping the rule up to date.

In addition to meetings of formal committees, gatherings of clinicians to evaluate systems in the later phases of development are good from both the social and the acceptance points of view. Focus groups are immensely valuable at this point. Different decision support components will generate different levels of anxiety among clinicians. The testing, piloting, and implementation strategies need to be designed with this in mind. For alerts that might spur resentment, clinical champions should be involved at each phase. Then when the communication messages are released about the change, they can mention that physician colleagues were included in the decision making.

23.4.3 Providing resources to support and train

End-user support and training go hand in hand. At teaching hospitals, new clinical staff members are usually trained in a classroom setting, but should also be offered continuous ongoing training. This ongoing training can be in a group or individual

setting; in community hospitals, both initial and ongoing training are usually done one-on-one. This is mentioned here because it is important to realize that, since decision support components are modified over time, users need more than simple notification of this: they may need some hands-on training. This varies with the individual, but users have been known to walk away when they do not know how to respond to a suggestion. Monthly pizza sessions can provide an appropriate venue for reviewing changes with interested users and for giving instruction. Support staff, however, also need to be available so that if a clinician is tempted to walk away, he or she might be more tempted to seek help if it is nearby and responsive.

23.4.4 Strategies

There are a number of general strategies that organizations have developed and used successfully, but since each hospital or clinic has a different culture, and since each specialty and unit has its own culture, careful decisions must be made about whether each strategy fits the particular culture. Many feel that the surgery service is often a good place to start because it is more protocol-driven. Order sets, for example, can save surgeons a great deal of time. On the other hand, decision support for general medicine is harder to implement and it is less likely to be applicable because the problems are so broad and less predictable for a given patient. Another strategy is to go for the low-hanging fruit, for the most useful yet easy kinds of decision support. For example, an organization can identify common "prn" medications and configure the system so that any one of them can be ordered using only one click. At the second author's institution, this was done by first running pharmacy reports for the most heavily ordered "take as needed" medications so the ordering clinician could be offered this as an option and the nurse receiving the order could use his judgment for administering something like Tylenol, Colace, or sleep medicine at two in the morning. Many places have started with easily acceptable general order sets and have included defaults at recommended levels for suggested dosing, added alerts for things like allergies, and moved gradually towards drug/drug interactions and suggestions for corollary orders. Information resources provide another easily acceptable early means of offering decision support. Having clinicians leave a patient record and search elsewhere for reference information is not popular, however, so if the resources can be embedded within the clinical system, they will be more heavily used, such as the use of infobuttons (see Chapter 19).

Vendor user groups of physicians share experiences, and it behooves an organization to send involved clinicians to these meetings. It is a valuable social networking opportunity, and often decision support components are discussed, along with experiences regarding their success at other sites, and this knowledge can be brought back to be discussed by relevant committees. In addition, organizations should consider paying for clinical champions to enroll in an AMIA 10 × 10 program (see http://amia.org/education/10 × 10-courses) to make the champion more comfortable talking with information technology staff members and more willing to engage in meaningful discussions about technical aspects of CDS.

23.5 **Evaluation and maintenance**

There are personal and organizational issues related to both the evaluation and maintenance of decision support. As described earlier, user involvement is needed for evaluating satisfaction levels with different CDS components. However, there are other ways to gather data for evaluating the effectiveness of decision support that are more cognitive. Specifically for alerts, for example, measures should include how many alerts are being overridden and why they are being overridden.

23.5.1 **Have data to back you up and gain involvement: Impact assessment and other techniques**

In the planning stage, metrics for success should be identified and baseline data gathered. Likely candidate areas for tracking include use and usability of CDS and financial and care benefits. Numbers can be generated by the system itself for measures like how often an intervention was triggered (for alerts, for example) or sought (information references or passive guidelines). The acceptance or override rates and response time of the system can also be tracked automatically and reports can be generated. Other aspects of the system, such as acceptability to clinicians, need to be studied in other ways, however, through a concerted effort. Surveys of user satisfaction can be conducted. Observations of actual use can be done. Actual clinical outcomes are hard to measure and may call for data mining capabilities on the part of the information system or manual chart reviews. If a particular CDS component is not having an impact on care, an investigation is needed. The effectiveness of order sets is another common area to measure so that those that are not working well or are usually ignored can be improved (Ash et al., 2012b).

23.5.2 **Soliciting clinician feedback**

Each time a new decision support component is made available, clinician feedback must be encouraged. Otherwise, fine-tuning, and therefore acceptance, will be difficult. Even if the alert has been tested in a laboratory setting and been reviewed by the appropriate committees, and the clinicians are aware of it and have been trained, it may not perform as hoped when in "production." This is where the expedient of providing a feedback button and the name of the responsible clinician or committee "owner" clearly noted on the screen is very useful. Information services staff members need to be extra diligent and perhaps plan to put in extra time offering assistance and also modifications during the go-live process for a new CDS component.

23.5.3 **Knowledge management**

Knowledge management is the term used to describe the entire process of selecting, developing or buying, modifying, tracking, and maintaining CDS. Chapter 28 deals with knowledge management in depth, but there are a number of organizational and

behavioral change issues to consider here. First is the difference in emphasis on knowledge management between teaching and non-teaching hospitals, second is the autonomy struggle, and third is the importance of prior positive experience.

The main difference between knowledge management in teaching settings and others is that a major focus in teaching hospitals is knowledge, so one would expect that clinicians would be highly motivated to provide input into maintaining decision support components. This is indeed the case, although often there are disagreements and strong opinions about what improvements or other changes need to occur. Although expertise may be more easily available in an academic organization, consensus may be hard to reach. On the other hand, the business of the community hospital is much less about knowledge, so there may be less interest in providing ongoing input, but gaining agreement may be easier.

One reason that clinicians ignore alerts is that they may have found that they are out of date. When a physician receives a cost alert that is no longer a realistic figure, she tends to pay less attention to all those she receives from that time onward. Given that even a community hospital might have 75 clinical pathways and a hundred alerts, a regular review process is absolutely necessary. There must be an identified person, such as the medical director of a certain service line, responsible for each one, with support from quality assurance and information services staff. Changes should be documented and communicated with users.

Regardless of the setting, there needs to be a record, a catalogue, of decision support components so that users, information systems staff, and involved clinical decision support committees know what is available. If this effort is begun early, when there is not much in the way of decision support, the catalogue can grow gradually. Someone must be put in charge of this ongoing effort so that it does not get out of control when more advanced and complex decision support tools and content are added. Consideration should be given to assigning an expiration date on any clinical pathway, for example, so that users know if that pathway is current or if it is about to come up for review.

Knowledge management activities require significant investments in manpower. Most organizations purchase decision support from either EHR or content vendors, but customization is generally needed (Ash et al., 2012b). Staff members must be available to gather subject matter experts and decision makers, make needed changes that are allowed by the vendor, seek and modify CDS from other user organizations that are willing to share, foster relationships with the vendor staff members who deal with CDS, and communicate, train, and support users (Ash et al., 2012a).

23.5.4 The importance of ongoing organizational support

As with most initiatives, a concerted effort to build a decision support system may involve a good deal of energy in the beginning, but that energy may later wane, especially if high-level organizational management does not provide adequate resources. Unlike other system implementations, this one is ongoing and often accelerating. It seems that once decision support becomes part of the organizational culture, it

propagates. There is actually a danger that any time anyone wants to change clinician behavior, decision support is targeted as the way to do it. Demand increases, often beyond what the end-user clinicians can tolerate. Mechanisms must remain in place for making decisions about what to judiciously select for implementation.

23.6 Summary and conclusions

The delicate balancing act referred to at the beginning of the chapter is an organizational management and change management challenge. These challenges can only be met if sufficient staffing resources are available. Planning, prioritizing, training, implementing, and evaluation are activities that need talented, committed, and high-level staff members – and there must be enough of them. The organization must be willing to dedicate significant ongoing financial resources to this endeavor.

Acknowledgments

Resources

www.cpoe.org has as its primary focus computerized provider order entry, but decision support resources of interest include an annotated bibliography and a list of considerations for implementing CPOE that is more comprehensive than what has been published in the literature.

www.himss.org/asp/davies_organizational.asp provides access to papers describing winners of the Davies Award, and most describe organizational issues related to CDSS.

References

Ash, J.S., Gorman, P.G., Hersh, W.R., Lavelle, M., Poulsen, S.B., 1999. Perceptions of house officers who use physician order entry. J. Am. Med. Inf. Assoc. Suppl., AMIA Proceedings, 471–475.

Ash, J.S., Berg, M., Coiera, E., 2004. Some unintended consequences of information technology inhealth care: the nature of patient care information system related errors. J. Am. Med. Inf. Assoc. 11 (2), 104–112.

Ash, J.S., Sittig, D.F., Campbell, E., Guappone, K., Dykstra, R., 2006. An unintended consequence of CPOE implementation: shifts in power, control, and autonomy. Proc. Am. Med. Inf. Assoc. 2006, 11–15.

Ash, J.S., Sittig, D.F., Wright, A., McMullen, C., Shapiro, M., Bunce, A., et al., 2011. Clinical decision support in small community practice settings: a case study. J Am. Med. Inf. Assoc. 18, 879–882.

Ash, J.S., Sittig, D.F., Guappone, K.P., Dykstra, R.H., Richardson, J., Wright, A., et al., 2012a. Recommended practices for computerized clinical decision support and knowledge management in community settings: a qualitative study. BMC Med. Inf. Decis. Mak. 12, 6.

Ash, J.S., McCormack, J.L., Sittig, D.F., Wright, A., McMullen, C., Bates, D.W., 2012b. Standard practices for computerized clinical decision support in community hospitals: a national survey. J. Am. Med. Inf. Assoc. 19, 980–987.

Bakken, S., Currie, L.M., Lee, N.-J., Roberts, W.D., Collins, S.A., Cimino, J.J., 2008. Integrating evidence into clinical information systems for nursing decision support. Int. J. Med. Inf. 77, 413–420.

Bates, D.W., Kuperman, G.J., Wang, S., Gandhi, T., Kittler, A., Volk, L., et al., 2003. Ten commandments for effective clinical decision support: Making the practice of evidence-based medicine a reality. J. Am. Med. Inf. Assoc. 10 (6), 523–530.

Bridges, W., 2003. Managing Transitions: Making the Most of Change, second ed. Perseus Press, Cambridge, MA.

Cabana, M.D., Rand, C.S., Powe, N.R., Wu, A.W., Wilson, M.H., Abboud, P-A C, et al., 1999. Why don't physicians follow clinical practice guidelines? A framework for improvement. JAMA 282 (15), 1458–1465.

Davis, D.A., Taylor-Vaisey, A., 1997. Translating guidelines into practice: a systematic review of theoretic concepts, practical experience and research evidence in the adoption of clinical practice guidelines. Can. Med. Assoc. J. 157 (4), 408–416.

Feldstein, A., Simon, S.R., Schneider, J., Krall, M., Laferriere, D., Smith, D.H., et al., 2004. How to design computerized alerts to ensure safe prescribing practices. Joint Commission J. Qual. Saf. 30 (11), 602–613.

Garside, P., 1998. Organisational context for quality: Lessons from the fields of organizational development and change management. Qual. Health Care 7 (Supp), S8–15.

Gooch, P., Roudsari, A., 2011. Computerization of workflows, guidelines, and care pathways: A review of implementation challenges for process-oriented health information systems. J. Am. Med. Inf. Assoc. 18, 738–748.

Hines, L.E., Saverno, K.R., Warholak, T.L., Taylor, A., Grizzle, A.J., Murphy, J.E., et al., 2011. Pharmacists' awareness of clinical decision support in pharmacy information systems: an exploratory evaluation. Res. Social & Admin. Pharm. 7, 359–368.

Horsky, J., Kuperman, G.J., Patel, V.L., 2005. Comprehensive analysis of a medication dosing error related to CPOE. J. Am. Med. Inf. Assoc. 2 (4), 377–382.

Institute of Medicine Committee on Patient Safety and Health Information Technology, 2012. Health IT and Patient Safety: Building Safer Systems for Better Care. National Academy Press, Washington, D.C.

Institute of Medicine Committee on Quality of Health Care in America, 2003. Crossing the Quality Chasm: A New Health System for the 21st Century. National Academy Press, Washington, D.C.

Lewin, K., 1951. Field Theory in Social Science. Harper & Row, New York, N.Y.

Lomotan, E.A., Hoeksema, L.J., Edmonds, D.E., Ramirez-Garnica, G., Shiffman, R.N., Horwitz, L.I., 2012. Evaluating the use of a computerized clinical decision support system for asthma by pediatric pulmonologists. Int. J. Med. Inf. 81 (3), 157–165.

Massaro, T.A., 1993a. Introducing physician order entry at a major academic medical center: II. Impact on medical education. Acade. Med. 68, 25–30.

Massaro, T.A., 1993b. Introducing physician order entry at a major academic medical center: I. Impact on organizational culture and behavior. Acade. Med. 68, 20–25.

Miller, R.A., Gardner, R.M., Johnson, K.B., Hripcsak, G., 2005. Clinical decision support and electronic prescribing systems: a time for responsible thought and action. J. Am. Med. Inf. Assoc. 12 (4), 403–409.

Osheroff, J.A., Pifer, E.A., Teich, J.M., Levick, D., Saldana, L., Velasco, F., et al., 2012. Improving Outcomes with Clinical Decision Support: An Implementer's Guide, second ed. HIMSS, Chicago, IL.

Shibl, R., Lawley, M., Debuse, J., 2012. Factors influencing decision support system acceptance. Decis. Supp. Syst. 39 (14), 11775–11781. <http://dx.doi.org/10.1016/j.dss.2012.09.018>.

Sittig, D.F., Krall, M., Kaalaas-Sittig, J., Ash, J.S., 2005. Emotional aspects of computer-based provider order entry: A qualitative study. J. Am. Med. Inf. Assoc. 12 (5), 561–567.

Solberg, L.I., Brekke, M.L., Fazio, C.J., Fowles, J., Jacobsen, D.N., Kottke, T.E., et al., 2000. Lessons from experienced guideline implementers: Attend to many factors and use multiple strategies. J. Com. J. Qual. Improv. 26 (4), 171–188.

Thornett, A.M., 2001. Computerized decision support systems in general practice. Int. J. Inf. Manage. 21, 39–47.

Trivedi, M.H., Kern, J.K., Marcee, A., Grannemann, B., Kleiber, B., Bettinger, T., et al., 2002. Development and implementation of computerized clinical guidelines: Barriers and solutions. Meth. Inf. Med. 41 (5), 435–442.

Valusek, J.R., 2007. The change calendar: A tool to prevent change fatigue. Joint Comm. J. Qual. Patient Saf. 33 (6), 355–360.

Waitman, L.R., Miller, R.A., 2004. Pragmatics of implementing guidelines on the front lines. J. Am. Med. Inf. Assoc. 11 (5), 436–438.

Wendt, T., Knaup-Gregori, P., Winter, A., 2000. Decision support in medicine: A survey of problems of user acceptance. Stud. Health Technol. Inf. 77, 852–856.

Wright, A., Bates, D.W., Middleton, B., Hongsermeier, T., Kashyap, V., Thomas, S.M., et al., 2009. Creating and sharing clinical decision support content with Web 2.0: issues and examples. J. Biomed. Inf. 42, 334–346.