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TECHNICAL REPORT

Developing a Framework for Establishing Clinical Decision Support Meaningful Use Objectives for Clinical Specialties

Cheryl L. Damberg, Justin W. Timbie, Douglas S. Bell, Liisa Hiatt, Amber Smith, Eric C. Schneider

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HEALTH

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PREFACE

The federal electronic health record (EHR) incentive program includes clinical decision support (CDS) as a central requirement of improving health outcomes; however, a process for identifying and prioritizing the most-promising targets for CDS has not been established.[1] CDS provides those involved in care processes with general and person-specific information, intelligently filtered and organized, at appropriate times, to enhance health and health care.

This report describes a protocol for eliciting high-priority targets for electronic CDS for individual clinical specialties, which could serve to inform policymakers' deliberations and establishment of CDS meaningful use objectives. Researchers from the RAND Corporation tested the protocol with four clinical specialties: oncology, orthopedic surgery, interventional cardiology, and pediatrics. A CDS target was defined as a clinical performance gap having one or more CDS opportunities that can be implemented to address the gap.[2] A CDS opportunity is defined as a specific CDS intervention that could be expected to address a clinical performance gap. CDS opportunities include existing CDS tools or interventions that might be developed in the short term.[3]

Identification of candidate performance gaps and CDS opportunities was based on a review of the literature and expert clinical input from the members of each of the four clinical specialty panels. The candidate performance gaps and associated candidate CDS opportunities

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[1] CDS is a process for enhancing health-related decisions and actions with pertinent, organized clinical knowledge and patient information to improve health and health care delivery. Information recipients can include patients, clinicians, and others involved in patient care delivery; information delivered can include general clinical knowledge and guidance, intelligently processed patient data, or a mixture of both; and information delivery formats can be drawn from a rich palette of options that include data- and order-entry facilitators, filtered data displays, reference information, and alerts. See Healthcare Information and Management Systems Society, forthcoming.

[2] An individual *performance gap* along with its associated *CDS opportunities* jointly define a *CDS target* that could potentially be used to set a CDS meaningful use objective. A clinical performance gap is defined as a clinical area in which actual practice does not conform to optimal achievable practice. A clinical performance gap statement specifies a potential or known quality problem that may or may not exist as a formal quality measure. A CDS opportunity is a description of a specific CDS intervention that could be expected to address a clinical performance gap. An example of a CDS opportunity is "Smart form that captures pain intensity (for oncology patients) and generates pain management plan based on patient preference and particular history." CDS opportunities include existing CDS tools or interventions that might be developed in the short term that can close one or more performance gaps.

[3] The six CDS tool types are (1) documentation forms and templates, (2) relevant data presentation, (3) order and prescription creation facilitators, (4) protocol and pathway support, (5) reference information and guidance, and (6) alerts and reminders.

were prioritized by the specialty panels using a modified Delphi process for eliciting expert ratings. High-priority CDS targets were the performance gaps that the panels rated as highly important and as having one or more CDS opportunities that could have a high impact on closing the performance gap and were considered compatible with clinical workflow, either as currently configured or as redesigned to achieve optimal outcomes.

This report summarizes lessons learned from testing the protocol. Using the experience gained during testing and feedback provided by panel participants and the federal Health IT Policy Committee (HITPC), we have outlined a general framework that could be used to identify candidate CDS objectives that are clinically meaningful and implementable with either existing CDS tools or short-term opportunities for tool development.

This project was conducted under contract with the Office of the National Coordinator for Health Information Technology (ONC) in the U.S. Department of Health and Human Services. The intended audiences for the report are clinicians, policymakers, and health information technology (IT) vendors.

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SUMMARY

Information technology has the potential to transform health care in the United States (President's Council of Advisors on Science and Technology, 2010). The automation of patient data—through electronic health records (EHRs)—is central to many health information technology applications (Institute of Medicine, 2001). One such EHR-enabled application is clinical decision support (CDS), which provides critical information and prompts at key points in clinical workflows to address clinical delivery failures that produce gaps in care. Various studies have demonstrated that CDS can influence clinical practice by helping clinicians improve diagnosis (Gorry and Barnett, 1968; Shortliffe et al., 1975; Berner et al., 1999; Friedman et al., 1999; Samore et al., 2005; Graber and Mathew, 2008; Elkin et al., 2010), improve quality and patient safety (Institute of Medicine, 2006; Hunt et al., 1998; Bates, Pappius, et al., 1999; Kuperman, Teich, et al., 2001; Garg et al., 2005; Kawamoto et al., 2005; Schedlbauer et al., 2009; Amarasingham et al., 2009; Jaspers, 2011), adhere to guidelines for prevention and treatment (McDonald and Overhage, 1994; Overhage et al., 1997; Maviglia et al., 2003; Sintchenko et al., 2004; Eslami, Abu-Hanna, and Keizer, 2007; Pearson et al., 2009; Shojania et al., 2009), and avoid medication errors (Bates, Teich, et al., 1999; Teich et al., 2000; Bates, Cohen, et al., 2001; Kaushal, Shojania, and Bates, 2003; Kuperman, Bobb, et al., 2007; Kaushal, Kern, et al., 2010). The Health Information Technology for Economic and Clinical Health (HITECH) Act (Pub. L. 111-5, 2009), authorized the Centers for Medicare and Medicaid Services (CMS) to provide incentive payments to eligible providers who successfully demonstrate meaningful use of EHRs (Blumenthal and Tavenner, 2010). In the notice of proposed rule making (NPRM) that proposed specific meaningful use (MU) requirements for stage 1 of the EHR Incentive Program, providers would have been required to implement five CDS rules relevant to their specialty or considered high clinical priority, along with the ability to track compliance with those rules. The proposed rule anticipated that implementing CDS interventions was likely to improve performance as reflected by results of quality measures included in stage 1 MU requirements. However, in response to comments from providers who raised concerns about the availability of CDS interventions relevant to their top priorities for improvement and to the MU quality measures most relevant to their hospital or practice, the final MU objectives required each hospital or eligible professional provider to implement only one CDS rule (CMS, 2009). Moving into future stages of MU requirements, the Office of National Coordinator for Health Information Technology (ONC) has signaled strong interest in identifying CDS objectives that are *clinically*

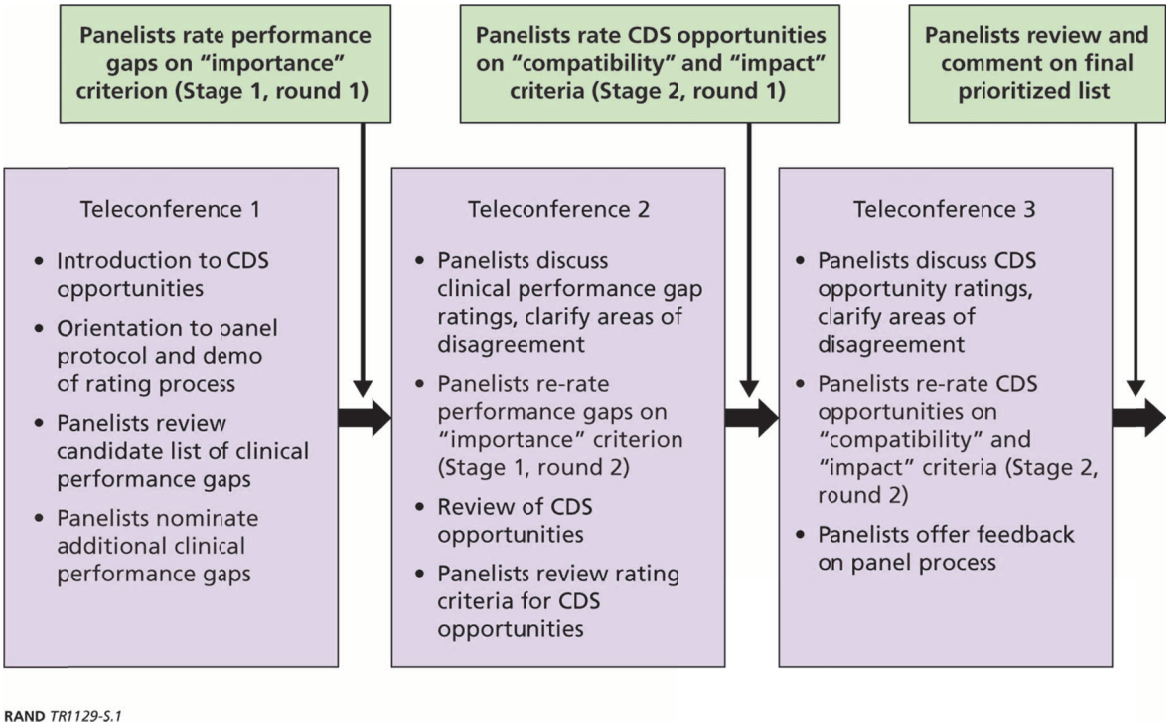
relevant and meaningful to a variety of clinical specialties and that are *implementable and measurable*.

A central question is how to identify high-priority targets for CDS for different clinical specialties to inform the selection and prioritization of national CDS MU objectives and to guide EHR vendors in developing tools. Although a variety of approaches could be devised, any process to define high-priority, specialty-specific CDS targets should include the following core elements:

- a systematic, evidence-based process to prioritize the clinical performance gaps within each specialty
- an evaluation of existing CDS tools or opportunities for CDS tool development that might address the prioritized gaps
- a rigorous process for eliciting expert feedback to prioritize performance gaps and associated CDS opportunities.

The approach we devised incorporates these three core elements in its design and provides a flexible protocol that can be used to elicit from any group of specialists the *high-priority clinical performance gaps* for the specialty and potential *CDS opportunities* for closing those gaps. Clinical performance gaps represent potential targets for CDS; however, these gaps affect population health to different degrees, and not all targets will be amenable to CDS if existing tools are either ineffective or incompatible with clinical workflows. Workflow and process must be considered when selecting and designing CDS interventions. Our protocol solicits ratings from experts on multiple dimensions to provide a consensus set of CDS targets. This report describes the development and testing of that protocol. The protocol involved a two-stage modified Delphi expert panel rating process, illustrated in Figure S.1. The first stage identified high-priority performance gaps based on expert ratings of each gap's importance to patient care within the specialty. Within stage 1, panelists engaged in two rounds of rating of candidate performance gaps. In the second stage, panelists rated (in two rounds of rating) the potential impact and compatibility of CDS opportunities for addressing each performance gap that was rated as *important* in the first stage. In assessing *compatibility*, panelists were instructed to consider the average clinical practice rather than their own practice and the extent to which the tool could be inserted in any workflow (i.e., either as currently designed or redesigned).

Figure S.1. Expert Panel Protocol



For each performance gap, panelists rated between two and four descriptions of specific example CDS opportunities (both existing CDS tools and hypothetical interventions) that might close the gap. They also provided an overall rating of the *collection* of CDS opportunities to address the gap, including both CDS opportunities embodied in the specific examples prepared in advance of the panel and any other opportunities envisioned by each panelist. *High-priority CDS targets* were defined as the clinical performance gaps that the panel rated as highly important and as having CDS opportunities that would have a high impact on closing the performance gap and that were compatible with clinical workflows (either as currently configured or as redesigned).

Four specialties were selected to pilot test the protocol: one medical specialty (oncology), one surgical specialty (orthopedic surgery), one nonsurgical procedural specialty (interventional cardiology), and one primary care specialty (pediatrics). Each panel successfully completed the two-stage rating process and compiled a prioritized list of CDS targets. Table S.1 shows the number of experts who began the panel process and the number of experts who completed all rating cycles.

Table S.1. Participation in Each Specialty Expert Panel

Panel	Number of Panelists Who Started the Panel Process	Number of Panelists Who Completed the Panel Process
Oncology	14	12
Orthopedics	20	17
PCI	15	13
Pediatrics	15	12

NOTE: *Completion* means that panelists completed both rounds of ratings in each of the two steps of our rating protocol. PCI = percutaneous coronary intervention.

Across the four panels, the first stage of ratings produced between six and 15 performance gaps for which panelists agreed that the gap was *highly important* for their specialty (median rating 7–9, on a scale of 1–9 with 1 being low importance and 9 being high importance). In the second stage of ratings, between three and 14 of the highly important gaps emerged as high-priority CDS targets, based on panel agreement that CDS would significantly impact the performance gap and would be compatible with workflows in their specialty. In generating overall CDS opportunity ratings, the expert panels considered from 16 to 44 specific example CDS opportunities. Among these, the panels rated between four and 31 as having both high potential impact and being highly compatible with workflow (see Table S.2). Although these individual CDS opportunities would, in most cases, be too specific for constructing CDS MU objectives, they are provided to help guide future CDS development by vendors.

Table S.2. Overall Summary of Panel Ratings

Panel	CDS Targets Considered	CDS Targets Rated High Priority	Individual CDS Opportunities Considered	Individual CDS Opportunities Rated High Priority
Oncology	15	14	44	31
Orthopedics	6	3	16	4
PCI	11	4	34	11
Pediatrics	11	3	35	10

NOTE: High-priority CDS targets were the performance gaps rated as highly *important* and as having CDS opportunities that could have a high *impact on closing the performance gap* and are *compatible with clinical workflow*. Each potential target was presented as the performance gap statement paired with example CDS opportunities.

Table S.3 summarizes for each of the four specialty panels, the high-priority CDS targets, and individual CDS opportunities that our panels rated highly and with agreement on the dimensions of impact and compatibility with workflow. The rating results at this more granular level could be useful for EHR vendors considering what types of CDS opportunities practitioners rated highest and viewed as potentially helpful in addressing high-priority performance gaps.

Table S.3(a). Summary of High-Priority Clinical Decision Support Targets by Specialty Panel: Oncology Panel

High-Priority CDS Targets	Highly Rated Example CDS Opportunities for This Target
Many patients receiving chemotherapy are at risk of experiencing adverse events due to errors in chemotherapy ordering.	Smart ordering forms that help reduce errors Alert at time of ordering or infusion if chemotherapy orders differ from accepted standards
Cancer patients often have poorly documented information on staging.	Cancer-specific documentation template that supports accurate staging for the type of cancer Info button to check latest staging criteria at the time that cancer diagnoses are being entered
Patients undergoing chemotherapy often fail to have a current care plan documented.	Pathway based on standard multicycle regimens with order sets and appropriate refinements for each step Smart form for chemotherapy that prompts documentation of current care plan and reasons for deviation from previous plan Timeline display of prior adverse reactions and therapy adjustments that should inform current care plan
Prescribed chemotherapy regimens are not always concordant with standard regimens (as defined by evidence or consensus groups).	Order tool for cancer-specific chemotherapy regimens (including combinations and specific doses) that are consistent with local standards and that allow overrides Documentation template for explaining deviation from standard regimen at the time of ordering Alert at time of ordering or infusion if chemotherapy plan differs from accepted standards
Many patients undergoing chemotherapy do not receive supportive care therapies, including potent antiemetic therapy and granulocyte-colony stimulating factor.	Order sets for chemotherapy regimens that include recommended antiemetic and other supportive care therapies.
Patients are often unaware of the risks and benefits of chemotherapy, and their understanding of the treatment's intent (palliative versus curative) is often inadequately documented.	Display inputs to and results from predictive models of treatment benefit at time of chemotherapy decisionmaking
Many patients who begin treatment with oral antineoplastic therapies (e.g., tamoxifen, aromatase inhibitors) do not receive treatment for the recommended duration.	Alert for low adherence based on medication utilization data
Among patients of reproductive age, infertility risks and fertility preservation options are inadequately discussed prior to chemotherapy.	Treatment plan suggestions in accordance with patient's documented fertility preferences
Many breast cancer patients who are candidates for trastuzumab do not receive the therapy, and patients who receive the therapy are not always followed for possible safety problems.	Breast cancer order set that searches for a patient's HER2+ status (or queries provider for it) Alert if left ventricular EF assessment has not been conducted on schedule or is trending unfavorably for patients receiving trastuzumab
Following curative resection, cancer patients do not always receive adequate surveillance or testing.	Automatically generated, diagnosis specific follow-up order sets Automated generation of cancer-specific survivorship care plan that includes all necessary tests (and responsible physician) that can be shared with patients
Chemotherapy and radiotherapy treatment summaries are not always fully documented or provided to patients or physicians providing continuing care.	Documentation template for treatment summary that includes content required by CCHIT that can be transmitted electronically (to physicians) or in hard copy (to patients) Patient-specific treatment summary automatically generated with order entry
Patients started on long-acting opioids do not always receive short-acting opioid formulations for breakthrough pain, and patients receiving chronic opioids do not always receive bowel regimens.	Order sets for long-acting or chronic opioid therapy that include appropriate medications required for breakthrough pain and bowels Distinct pain management display accessible by nurses and physicians that highlights missing orders and graphically charts patient's recent pain history

High-Priority CDS Targets	Highly Rated Example CDS Opportunities for This Target
The presence of pain and its intensity are inadequately assessed or quantified in cancer patients receiving chemotherapy or radiation therapy, and pain management plans are not routinely documented.	Display cancer pain history with intensity levels and current and prior treatments for pain Order set for cancer pain medication that results in a comprehensive management plan Pathway to guide initial selection of pain medication and to guide escalation of therapy when required Reminders to assess and to quantify pain at appropriate moments in workflow
Many cancer patients receive chemotherapy within the last two weeks of life, and many patients do not have discussions with their providers about hospice or palliative care within the last two months of life.	EHR smart form for patient's end-of-life preferences and performance status assessment Palliative care order sets, including recommended therapies Reminder to assess and document end-of-life care preferences triggered by data on performance status
Many patients do not undergo KRAS mutation testing before initiating anti-EGFR therapy.	Order set for anti-EGFR therapy that checks KRAS test result or requires input of test result Reminder to conduct KRAS test triggered by order for anti-EGFR therapy

NOTE: HER2 = human epidermal growth factor receptor 2; HER2+ indicates that the cancer tests positive for this protein. EF = ejection fraction. CCHIT = Certification Commission for Health Information Technology. KRAS = Kirsten rat sarcoma. EGFR = epidermal growth factor receptor.

Table S.3(b). Summary of High-Priority Clinical Decision Support Targets by Specialty Panel: Orthopedics Panel

High-Priority CDS Targets	Highly Rated Example CDS Opportunities for This Target
Patients are not always assessed preoperatively for their bleeding and VTE risks, resulting in prophylaxis that does not match the patient's risk.	Smart form that captures bleeding and VTE risk factors and recommends a prophylaxis strategy in accordance with guidelines
Patients undergoing total hip or total knee replacement surgery may not receive VTE prophylaxis when it is indicated.	Order set for VTE prophylaxis that recommends treatment customized to patient's bleeding risk and that conforms to guidelines
Patients who undergo total hip or total knee replacement surgery may not receive certain necessary preoperative tests, while others may undergo unnecessary testing.	Preoperative order set that includes recommended preoperative tests based on a patient's medical history and review of systems
Many patients who undergo surgery for hip fracture fail to receive follow-up risk assessment and therapy to prevent future osteoporotic fractures.	Smart form that captures risk factors for subsequent fractures and recommends orders for tests or treatments or both based on results
Antibiotic prophylaxis recommendations for the National Surgical Infection Prevention project and the American Academy of Orthopedic Surgeons may not be consistently followed for patients undergoing total hip or total knee replacement surgery.	Order set that recommends guideline-based antibiotic treatment customized to patient characteristics Reminder to stop antibiotic administration at the appropriate time prior to surgery

NOTE: VTE = venous thromboembolism.

Table S.3(c). Summary of High-Priority Clinical Decision Support Targets by Specialty Panel: Pediatrics Panel

High-Priority CDS Targets	Highly Rated Example CDS Opportunities for This Target
Children and adolescents fail to receive all recommended immunizations.	Display immunization history and highlight missing immunizations Tool to facilitate scheduling of immunizations according to recommended sequence and timing Alert for missing immunizations, with link to order set
Children with asthma are not routinely monitored for control of their condition.	Pathway to guide dose escalation or medication substitution
Children with ADHD who initiate medications may not receive optimal dose titration.	Smart form for ADHD encounter that captures changes in symptoms and medication side effects and recommends options for dose titration
Diagnosis of ADHD is often made without adequate documentation of DSM-IV or DSM-PC criteria.	Diagnostic assessment template for ADHD that includes all DSM-IV criteria Reminder to document DSM criteria triggered by new diagnosis of ADHD
Many sexually active adolescent women do not receive periodic chlamydia screening.	Order form that includes chlamydia test as part of routine screening tests based on patient's age and sexual history Reminder to conduct yearly chlamydia screening on patients who report being sexually active
Children with ADHD who are in the maintenance phase of medication therapy often receive inadequate follow-up care to reassess behavioral symptoms.	Tool that automatically develops a care plan (including dose titration) over multiple visits

NOTE: ADHD = attention deficit hyperactivity disorder. DSM-IV = Diagnostic and Statistical Manual of Mental Disorders, 4th Edition. DSM-PC = Diagnostic and Statistical Manual for Primary Care.

Table S.3(d). Summary of High-Priority Clinical Decision Support Targets by Specialty Panel: PCI Panel

High-Priority CDS Targets	Highly Rated Example CDS Opportunities for This Target
Nearly half of patients with STEMI receive no reperfusion therapy or receive delayed reperfusion (>12 hours after onset).	Alert to inform ED physician and staff of possible ACS diagnosis triggered by abnormal biomarkers Display ECG data, TIMI/GRACE scores, and likely time of symptom onset
Many patients undergoing PCI are not prescribed statins at discharge despite having no contraindications.	Order set that includes statins along with other medications commonly prescribed at discharge from the catheterization laboratory Reminder followed by alert to prescribe statin prior to discharge if not yet ordered
Many patients discontinue clopidogrel therapy within six months of DES implantation (12 months of continuous therapy are recommended).	Alert if prescriptions not refilled within expected window
Many high-risk patients with non-STEMI fail to receive early invasive care, while many low-risk patients receive early invasive care unnecessarily.	Display TIMI or GRACE risk scores and other clinical data that facilitate triage
Wide regional variation in rates of elective PCI suggests that some patients may not be appropriate candidates for elective PCI.	Order tool that requires input of data elements and returns appropriateness rating Display appropriateness rating or elements needed to determine appropriateness rating
The indications for PCI and stent selection (e.g., angina status, prior medical therapy, anatomical findings, flow) are often poorly documented.	Reminder to document indication for procedure or device prior to the procedure
Many STEMI patients who are candidates for thrombolysis receive the treatment outside of the recommended door-to-needle time (i.e., 30 minutes).	Thrombolysis order set for STEMI to guide physician through what is needed, how to administer, and what to monitor
Many patients undergoing PCI have limited understanding about the relative benefits and risks of the procedure.	Automated consent form that includes patient-specific benefit/risk data

NOTE: STEMI = ST segment elevation myocardial infarction. ED = emergency department. ACS = acute coronary syndrome. ECG = electrocardiogram. TIMI = thrombolysis in myocardial infarction. GRACE = Global Registry of Acute Coronary Events. DES = drug-eluting stent.

As panelists reviewed candidate CDS opportunities, there were some areas in which panelists noted an uncertain role for EHRs in resolving some performance gaps and the potential for EHR use to create more complexity. The panel process provides an opportunity for clinical experts to identify important workflow issues outside the scope of CDS that might be a function of structural problems that require addressing at an organizational level (e.g., training staff on how to perform a diagnostic test and interpret the results). This suggests that it would be important to discuss early in the process whether a clinical performance gap is amenable to CDS as a mechanism to close the gap. CDS is not always the answer to closing a performance gap; rather, workflow and clinical process may be the root of problem and require redesign to address the problem.

There were other important issues raised by the panelists as they considered the potential application of CDS to close high-priority clinical performance gaps. Some of the issues centered

on workflow and compatibility with currently configured workflows. A critical factor related to the success or failure of CDS implementation is an understanding of the unique aspects of workflow within specialty and for the clinical process identified. Workflow does vary by specialty, even for related processes. Additionally, the successful implementation of CDS, and health information technology (IT) more generally, likely requires the reevaluation and redesign of current workflows and processes. It might be challenging for panelists to see beyond their own workflows and consider alternatives to current workflow design as they consider potential CDS interventions. Therefore, background materials provided to panelists, including explanations of workflows and examples of workflow within the conditions, episodes, or procedures they were to consider, were designed to help panelists consider how and where CDS could be embedded into the workflow. Moreover, the panel composition should represent relevant care settings and consider differences across settings in incorporating CDS into the workflow.

Another key issue flagged by panelists was concern about CDS tools creating more work, rather than support. In various areas, physicians highlighted the tension between implementing tools that enhance care without increasing the workload and, in turn, the likelihood that the CDS tool would not be used. Successful implementation of CDS might require discussion and changes to existing workflow—for example, ensuring that the CDS intervention is targeted to the optimal person in the appropriate role. The Healthcare Information and Management Systems Society (HIMSS) "CDS Five Rights" highlights that effective CDS often involves changes to workflow to put the clinical information in the right hands at the right time (HIMSS, undated). Panelists also noted the potential for CDS to create too many false positives, which would lead to alert fatigue. Comments, such as these related to implementation and operational issues, can highlight shortcomings of EHR systems that could help vendors design CDS tools to be more useful to practicing clinicians.

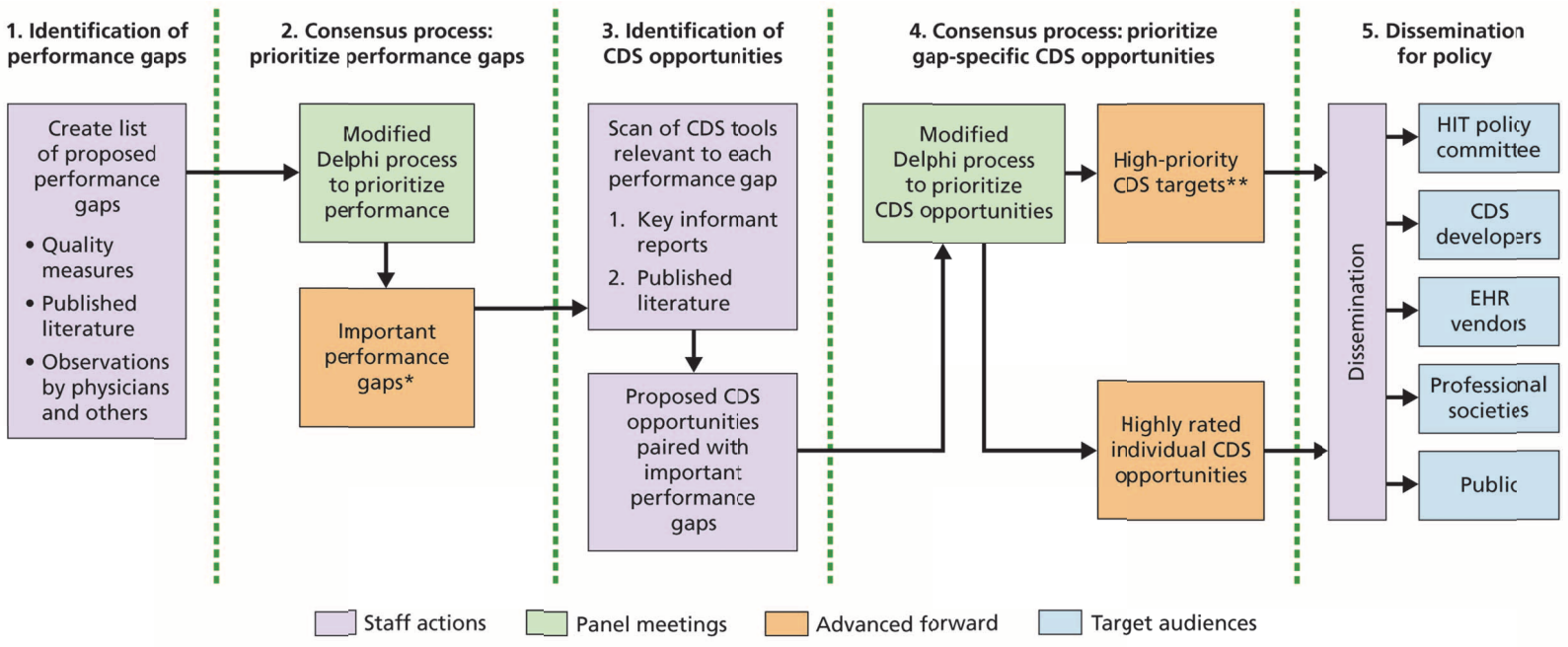
Panelists highlighted the lack of available standard order sets and the lack of support in some EHRs for order sets. During this discussion, panel members thought there would be potential for establishing a national clearinghouse for order sets from different sources to be shared to facilitate standardization.

Panelists felt that some performance gaps were inadequately specified as written (e.g., "comprehensive" radiologic evaluation, "metabolic derangement," and "postoperative hemorrhage") to allow the gap to be considered important. This issue could be better addressed at the front end of the panel process by ensuring adequate specificity when describing gaps and interventions.

Overall, the pilot testing demonstrated the successful use of a protocol that embodies a systematic, evidence-based expert consensus process to prioritize performance gaps that are

unique to individual specialties and that are likely to be amenable to CDS. The larger framework, of which the protocol is a key element, is illustrated in Figure S.2. The framework involves five phases: (1) identifying performance gaps, (2) implementing a consensus process to prioritize performance gaps, (3) identifying CDS opportunities, (4) implementing a consensus process to prioritize CDS opportunities associated with specific gaps, and (5) dissemination of high-priority CDS targets and individual CDS opportunities for policymaking and tool development. In each of these phases, the pilot testing identified areas that could result in a more robust process for eliciting high-priority CDS targets.

Figure S.2. Proposed Framework for Selecting High-Priority, Specialty-Specific Clinical Decision Support Targets



* Performance gaps rated with agreement as important targets for CDS; performance gaps not rated as important are dropped and do not move to CDS opportunity consideration.

** High-priority CDS targets are the performance gaps that were rated highly with agreement and that had high impact and compatible CDS opportunities; highly rated gaps without high impact and compatible CDS opportunities were dropped.

NOTE: HIT = health information technology.

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RECOMMENDATIONS FOR FUTURE SPECIALTY PANELS

Although the expert panel protocol that we constructed and tested is feasible and robust and produces quantitative and qualitative results that enhance the transparency of the expert panel process, we recommend the following additional actions for enhancing future specialty panels.

Composition of Expert Panels

- *Convene a multistakeholder "steering committee" with broad representation of potential end users to select the specialties, subspecialties, and clinical content topics to be addressed by future specialty panels.* In the pilot project, the selection of specialties and clinical topics was determined by the research team in consultation with ONC staff. However, this process should be guided by a broader set of perspectives for a variety of reasons. There are potentially hundreds of combinations of specialty and clinical topic combinations that could be used to form panels. Clearly, some of these combinations might yield greater benefit than others in terms of closing performance gaps. If population health improvement and costs of care are prominent considerations, the selection of panels should be informed by inclusion of government, public, and payer representatives and not just by specialty representatives. The most promising near-term opportunities for CDS development may be difficult to predict, so the steering committee should include experts with comprehensive knowledge of CDS development. It should also include experts in performance measurement who can assist in strategic planning for measurements that will be used to assess the impact of CDS on performance gaps in the future.
- *Create panels based on the intersection of four dimensions of interest: (1) specialties, (2) conditions, (3) treatments or procedures, (4) care delivery settings.* Any choice within one of these dimensions invariably constrains the others. For example, selecting knee pain as a condition could involve primary care, rheumatology, and orthopedic specialists. Choosing a knee pain panel comprised of orthopedic specialists could constrain the panel to consideration of arthroscopy, surgery, and rehabilitation. Each of these configurations will have implications for the types of performance gaps, CDS opportunities, and, ultimately, CDS objectives that can be generated.

Identification of Performance Gaps

- *In identifying the preliminary list of performance gaps, draw on population health and clinical delivery system gaps that may not yet be codified in performance measures.* Once the framework for identifying performance gaps has been defined, there are three important sources for identifying candidate performance gaps for the panel to consider: (1) quality measures (either nationally endorsed or locally implemented), (2) published literature (primarily epidemiology and health services research studies), and the (3) observations of practicing clinicians about gaps in care delivery. It seems desirable to ground the identification of performance gaps in the current set of nationally endorsed quality measures. However, this set typically comprises measures that can be implemented using administrative data and might not reflect gaps in care that can be assessed only through patient surveys, medical records, or other means. Important gaps in daily practice may be

ideal CDS targets but have not yet been specified as quality measures because of the lack of a data collection system.

- *Develop a method for querying practicing clinicians or their representative societies about performance gaps that have not yet been identified in peer-reviewed literature or reflected in nationally endorsed quality measures.* The experiences of practicing clinicians working on the front lines of care delivery are sometimes overlooked as a source of important clinical performance gaps. Astute clinicians can observe directly the processes of care that are prone to break down within a specialty practice, across teams of specialists, and across settings of care. They may also observe directly which processes of care are especially amenable to CDS interventions because of their knowledge of the workflow that produces high-quality services for patients with specific conditions. There is not as yet a straightforward process for obtaining this sort of feedback from clinicians. Not all physicians have the perspective or background to identify these gaps. Although members of the expert panels can also provide this feedback, they may not fully capture the diversity of perspectives within their specialty. A strategy for querying broadly to professional organizations might also be useful. Electronic surveys of practicing clinicians asking them to nominate clinical performance gaps that might be amenable to CDS may produce ideas for actionable CDS applications.

Identification of Clinical Decision Support Opportunities

- *Develop templates for describing CDS tools in a standardized format so that panelists are fully informed during discussion and rating tasks.* The portrayal of CDS tools may significantly influence panelists' ratings of those tools. CDS applications are complex, and many cannot be easily described in one or two sentences. A standard description of the key features of a CDS application and the evidence base that supports it may help to expedite the work of panelists and increase the validity and reliability of ratings of CDS opportunities.
- *Enhance panelist knowledge and consideration of clinical workflows before rating CDS opportunities.* The rating of CDS opportunities involves consideration of a variety of workflows and settings. Workflow engineering is not a typical expertise of most clinical specialists. It may be useful to insert a step that identifies the high-leverage workflow insertion points for CDS and presents those insertion points in a more highly structured manner or to include a workflow specialist on each panel. Additionally, the process could include some formal education of panelists in workflow analysis to help them assess CDS opportunities in a more informed manner. Alternatively, a small group of technical experts could evaluate the final list of CDS opportunities and targets and identify those that are most likely to be implemented in the short term.
- *Create opportunities for panelists and outside experts to nominate additional CDS opportunities for the candidate performance gap statements.* This could be done prior to the panel process by consulting with clinicians with expertise in the area of clinical practice and with knowledge of CDS, as well as during the panel process drawing on the panelists' expertise. Building in sufficient time prior to and during the panel process for broader input regarding candidate CDS opportunities for identified performance gaps would expand and strengthen the final set of CDS opportunities that panelists rate.

Use of Consensus Process to Prioritize Performance Gaps and Clinical Decision Support Opportunities

- *Consider convening separate panels to prioritize performance gaps and CDS opportunities.* Each of the panels we convened considered and rated clinical performance gaps and then considered and rated CDS opportunities associated with the list of high-priority gaps. It may be preferable to convene two separate panels—one that prioritizes performance gaps and can include broader specialty or stakeholder representation and a second panel that has technical expertise relevant to the prioritized subset of performance gaps that emerges from the first panel. This can ensure that relevant expertise is available to address specific conditions, cross-specialty, or setting-specific issues. Under this approach, the first panel could consider and rate performance gaps without being inhibited by the constraints of current systems, while the second panel could focus on what is feasible and achievable.
- *Allow adequate time within the modified Delphi process to enable thorough discussion of the performance gaps and CDS opportunities between rating tasks.* Methodological approaches developed for rating the appropriateness of care provides a transparent and rigorous basis for rating performance gaps and CDS opportunities. However, there are many nuances for panelists to consider in assessing performance gaps and significant complexity for panelists in assessing dozens of CDS opportunities. Thorough exchange between CDS experts and clinical practitioners appeared to identify CDS opportunities that might have little compatibility or impact in some specialty care settings. Allowing sufficient time for these discussions and opportunities to refine the specification of performance gaps and CDS tools will undoubtedly enhance the practical applicability (and hence the impact) of CDS. Panelists may also request additional evidence based on these discussions. Allowing more than one discussion period could enable panelists to consider additional evidence and strengthen the validity of subsequent ratings.

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Oncology Panel

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Jennifer Malin, M.D. (co-chair)	David Geffen School of Medicine at the University of California, Los Angeles (UCLA)
Steven L. Chen, M.D., M.B.A., F.A.C.S.	City of Hope National Medical Center
Leon Dragon, M.D.	NorthShore University HealthSystem
Stephen Edge, M.D.	Roswell Park Cancer Institute
Patricia Ganz, M.D.	David Geffen School of Medicine at UCLA; UCLA School of Public Health
James Hayman, M.D., M.B.A.	University of Michigan; American Society for Radiation Oncology (ASTRO)
Jonathan Myles, M.D.	American Pathologists Economic Affairs Committee; Cleveland Clinic
B. W. Ruffner, M.D.	Tennessee Medical Association; private practice
Lawrence A. Solberg, Ph.D., M.D.	American Society of Hematology Practice Committee, 2008–2011; Department of Hematology and Oncology, Mayo Clinic
Marilou Terpenning, M.D.	John Wayne Cancer Institute; David Geffen School of Medicine at UCLA
Paul E. Wallner, D.O.	American Board of Radiology; 21st Century Oncology

Orthopedics Panel

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Thomas Clark Barber, M.D. (co-chair)	Kaiser East Bay
Kevin J. Bozic, M.D., M.B.A.	University of California, San Francisco Department of Orthopaedic Surgery and Philip R. Lee Institute for Health Policy Studies
W. Timothy Brox, M.D.	University of California, San Francisco, Fresno, Orthopaedic Surgery
Richard M. Dell, M.D.	Orthopedic surgeon, Kaiser Permanente
David Halsey, M.D.	University of Vermont Department of Orthopaedics and Rehabilitation; American Association of Hip and Knee Surgeons, health policy chair

Christopher Kauffman, M.D.	Tennessee Orthopedics
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Charles E. Rhoades, M.D.	Dickson-Diveley Midwest Orthopaedic Clinic and Kansas City Orthopaedic Institute
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Nelson SooHoo, M.D.	UCLA School of Medicine, Department of Orthopaedic Surgery
Richard P. Strain, M.D.	Orthopaedic Associates of South Broward
Michael Wasylik, M.D.	Florida Orthopedic Society
PCI Panel	
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John R. Windle, M.D. (co-chair)	University of Nebraska Medical Center
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Joseph P. Drozda Jr., M.D.	Mercy Health Research; American College of Cardiology
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Calin Maniu, M.D.	Bon Secours Health System
Michael O'Toole, M.D., F.A.C.C.	Advocate Medical Group
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ABBREVIATIONS

AAOS	American Academy of Orthopaedic Surgeons
ACC	American College of Cardiology
ACCP	American College of Chest Physicians
ACI-TIPI	acute coronary ischemia time-insensitive predictive instrument
ACI-TIPI-IS	acute coronary ischemia time-insensitive predictive instrument information system
ACS	acute coronary syndrome
ACSETS	Acute Coronary Syndrome Emergency Treatment Strategies
ADHD	attention deficit hyperactivity disorder
AHA	American Heart Association
AJCC	American Joint Committee on Cancer
AKI	acute kidney injury
AMA	American Medical Association
AMA PCPI	American Medical Association Physician Consortium for Performance Improvement
AMI	acute myocardial infarction
AOE	acute otitis externa
ARI-IT	Acute Respiratory Illness Interactive Template
ASCO	American Society for Clinical Oncology
ASD	autism spectrum disorder
ASP	antimicrobial stewardship program
ASTRO	American Society for Radiation Oncology
BMI	body mass index
CAD	coronary artery disease
CARDSS	Cardiac Rehabilitation Decision Support System
CCHIT	Certification Commission for Health Information Technology
CCU	cardiac care unit
CDC	Centers for Disease Control and Prevention
CDS	clinical decision support
CDSS	clinical decision support system
CHD	coronary heart disease
CHF	congestive heart failure
CK-MB	creatine kinase–MB
CMS	Centers for Medicare and Medicaid Services
CPOE	computerized provider order entry
C-PORT	Cardiovascular Patient Outcomes Research Team
CR	cardiac rehabilitation
CRUSADE	Can Rapid Risk Stratification of Unstable Angina Patients Suppress Adverse Outcomes with Early Implementation of the American College of Cardiology/American Heart Association Guidelines
CT	computed tomography

CTA	computed tomography angiography
CVD	cardiovascular disease
DES	drug-eluting stent
dL	deciliter
DNA	deoxyribonucleic acid
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders, 4th edition
DSM-PC	Diagnostic and Statistical Manual for Primary Care
ECG	electrocardiogram
ECOG	Eastern Cooperative Oncology Group
ED	emergency department
EF	ejection fraction
EGFR	epidermal growth factor receptor
EHR	electronic health record
EMT	emergency medical technician
EPSDT	Early Periodic Screening, Diagnosis, and Treatment
ESRD	end-stage renal disease
FDA	U.S. Food and Drug Administration
g	gram
GAO	U.S. Government Accountability Office
GRACE	Global Registry of Acute Coronary Events
HEDIS	Healthcare Effectiveness Data and Information Set
HELP	Health Evaluation Through Logical Processing
HER2	human epidermal growth factor receptor 2
Hgb	hemoglobin
HIMSS	Healthcare Information and Management Systems Society
HIT	health information technology
HITECH	Health Information Technology for Economic and Clinical Health
HITPC	Health IT Policy Committee
HIV	human immunodeficiency virus
HMO	health maintenance organization
ICIS	Integrating Clinical Information System
ICU	intensive care unit
IDA	iron-deficiency anemia
IT	information technology
IV	intravenous
KRAS	Kirsten rat sarcoma
L	liter
LBBB	left bundle branch block
LMWH	low–molecular weight heparin
LUMPS	Liver Unit Management Protocol System
MDD	major depressive disorder

MI	myocardial infarction
MRI	magnetic resonance imaging
MU	meaningful use
NASS	North American Spine Society
NCC	National Cancer Coalition
NCCN	National Comprehensive Cancer Network
NCDR	National Cardiovascular Data Registry
NCQA	National Committee for Quality Assurance
NHANES III	National Health and Nutrition Examination Survey (third)
NICCQ	National Initiative on Cancer Care Quality
NICHQ	National Initiative for Children's Healthcare Quality
NPRM	notice of proposed rule making
NRMI	National Registry of Myocardial Infarction
OB/GYN	obstetrician/gynecologist
OME	otitis media with effusion
ONC	Office of the National Coordinator for Health Information Technology
ONS	Oncology Nursing Society
OR	odds ratio
PCI	percutaneous coronary intervention
PCI-TPI	Percutaneous Coronary Intervention Thrombolytic Predictive Instrument
PCP	primary care physician
PE	pulmonary embolism
PedNSS	Pediatric Nutrition Surveillance System
PEFR	peak expiratory flow rate
PHQ	Patient Health Questionnaire
PICU	pediatric intensive care unit
PID	pelvic inflammatory disease
pRIFLE	Pediatric Risk, Injury, Failure, Loss, End-Stage Kidney Disease
QOPI	Quality Oncology Practice Initiative
ROS	review of systems
SD	standard deviation
SES	socioeconomic status
SSRI	selective serotonin reuptake inhibitor
STEMI	ST segment elevation myocardial infarction
SUNY	State University of New York
TETAMI	Treatment with Enoxaparin and Tirofiban in Acute Myocardial Infarction
TIMI	thrombolysis in myocardial infarction
TNM	tumor, node, metastasis
UA	unstable angina
UCLA	University of California, Los Angeles
UFH	unfractionated heparin

URI	upper respiratory infection
URTI	upper respiratory tract infection
VA	U.S. Department of Veterans Affairs
VTE	venous thromboembolism
WHO	World Health Organization

CHAPTER ONE. METHODOLOGY FOR ELICITING HIGH-PRIORITY CLINICAL DECISION SUPPORT TARGETS

We were tasked by the Office of the National Coordinator for Health Information Technology (ONC) with developing a framework for eliciting high-priority targets for clinical decision support (CDS) for clinical specialties that could inform the establishment of CDS meaningful use (MU) objectives. This chapter describes the prototype methodology we tested with four clinical specialty panels, detailing the following:

- conceptual framework for specifying high-priority targets for CDS based on clinical performance gaps and CDS opportunities
- composition of each specialty panel and the process used to identify candidates
- approach used to identify candidate performance gaps for each clinical specialty
- approach used to identify candidate CDS opportunities targeting the performance gaps
- protocol for prioritizing candidate performance gaps and CDS opportunities, including an expert panel process and rating criteria.

The expert panel protocol we developed and tested was designed to ensure a rigorous method for identifying priorities and addressing some practical considerations and constraints.

We elected to use a modified Delphi rating process, which engages a carefully selected group of experts and iterative rounds of rating and discussion of structured lists of measures or tools (Fitch et al., 2001). The Delphi process enables prioritization of a list of measures or tools by creating a framework in which available evidence is brought to a group of experts for interpretation, and it then allows the experts to fill gaps in this evidence base using their expertise. The panel members independently consider the provided evidence and rate the measures in a first round of ratings. The full panel reconvenes to review the summary ratings from the first round of ratings, and its members discuss the reasons for their ratings. At the conclusion of the discussion, panel members are asked to independently re-rate the measures. Through this process, it is expected that the range of ratings will decrease and converge toward the correct answer.

The practical constraints that factored into the protocol design included creating a process that would be feasible for implementation across potentially dozens of specialties on an ongoing basis and minimizing clinical experts' time commitment, both during and between meetings, to facilitate experts' volunteering their time for this effort.

CONCEPTUAL FRAMEWORK FOR SPECIFYING HIGH-PRIORITY CLINICAL DECISION SUPPORT TARGETS

Objectives for the MU of electronic health records (EHRs) are generally formulated as descriptions of EHR features that providers could be required to make use of. *CDS* is a term that encompasses several specific types of EHR features, including order sets, alerts and reminders,

documentation templates, relevant data displays, "info buttons" (to access context-sensitive reference information), and clinical protocols or pathways.[4] These features are essential for EHRs to provide the clinical guidance or knowledge that is tailored based on specific patient information or the workflow context to affect care processes or outcomes. However, the clinical knowledge that should underlie CDS recommendations and the technology available to deliver the knowledge are both rapidly changing, making it difficult to specify precise objectives for CDS. In the notice of proposed rule making (NPRM) that proposed specific MU requirements for stage 1 of the EHR Incentive Program, providers were required to implement five CDS rules relevant to their specialty or considered high clinical priority (CMS, 2009). The proposed rule anticipated that implementing CDS interventions was likely to improve performance as reflected by results of quality measures included in stage 1 MU requirements. However, in response to comments from providers who raised concerns about the availability of CDS interventions relevant to their top priorities for improvement and to the MU quality measures most relevant to their hospitals or practices, the final MU objectives required each hospital or eligible professional provider to implement only one CDS rule (CMS, 2009).

The selection of a CDS rule to implement was left to providers, who could take into account their workflow, patient population, and quality improvement efforts. This was recognized to be an interim step taken in the absence of consensus standards for clinically specific CDS requirements. To address the need for rigorously derived standards, we set out to develop a process for eliciting clinically detailed, specialty-specific priorities that could be used in setting CDS objectives.

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[4] According to Healthcare Information and Management Systems Society (HIMSS), forthcoming, CDS is a process for enhancing health-related decisions and actions with pertinent, organized clinical knowledge and patient information to improve health and healthcare delivery. Information recipients can include patients, clinicians and others involved in patient care delivery; information delivered can include general clinical knowledge and guidance, intelligently processed patient data, or a mixture of both; and information delivery formats can be drawn from a rich palette of options that includes data and order entry facilitators, filtered data displays, reference information, alerts, and others. CMS defines CDS as "an HIT functionality that builds upon the foundation of an EHR to provide persons involved in care processes with general and person-specific information, intelligently filtered and organized, at appropriate times, to enhance health and health care."

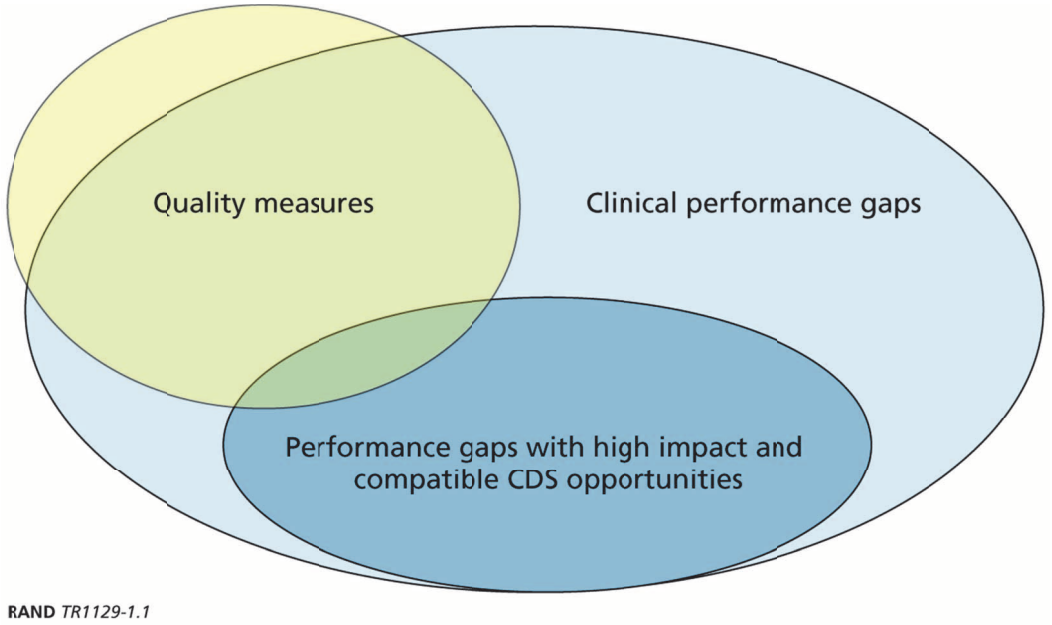
Table 1.1. Definitions of Terms

Term	Definition
Clinical performance gap	A clinical area in which actual practice does not conform to optimal achievable practice. A clinical performance gap statement specifies a potential or known quality problem that may or may not exist as a formal quality measure.
CDS opportunity	A description of a specific CDS intervention that could be expected to address a clinical performance gap. CDS opportunities include existing CDS tools or interventions that might be developed in the short term that can close one or more performance gaps. An example of a CDS opportunity is "Smart form that captures pain intensity (for oncology patients) and generates pain management plan based on patient preference and particular history."
CDS type	(1) Documentation forms and templates, (2) relevant data presentation, (3) order and prescription creation facilitators, (4) protocol and pathway support, (5) reference information and guidance, and (6) alerts and reminders
CDS target	An individual *performance gap* along with its associated *CDS opportunities* jointly define a *CDS target* that could potentially be used to set a CDS MU objective.
High-priority CDS targets	Performance gaps that were both rated by the expert panel with high *importance* and for which the CDS opportunities to close the gap were rated as having high *potential impact* and being highly *compatible* with clinical workflows

We conceptualized a *CDS target* as a *clinical performance gap* having one or more *CDS opportunities* that can be implemented to address the performance gap. A *clinical performance gap* is a clinical area in which actual practice does not conform to optimal achievable practice. As shown in Figure 1.1, many performance gaps have been embodied in quality measures, at least for some specialties. However, the number of performance gaps far exceeds the current number of quality measures due to technical challenges in measurement, incomplete documentation of evidence, and the slow pace of measure development within many specialties. Furthermore, some quality measures may no longer represent important performance gaps if quality improvement efforts to date have succeeded in closing the gap. CDS opportunities include existing CDS tools or interventions that might be developed in the short term that can close one or more performance gaps. The types of CDS opportunities might include alerts, order sets, and documentation templates. Only a subset of CDS opportunities might be truly amenable to addressing a particular performance gap, due to either the effectiveness of current CDS technology or to the compatibility of those technologies with the unique aspects of workflow within the specialty. Workflow varies by specialty, even for related processes; therefore, a clear understanding of the workflow for a given specialty is a critical factor in the success or failure of CDS.

The main task of the panel was to consider, separately, the importance of performance gaps, based on existing quality measures or gaps in care suggested by the panelists themselves, and then to consider the strength of the CDS opportunities for the highest-rated gaps. *High-priority CDS targets* were those performance gaps that were both rated with high *importance* and for which the CDS opportunities to close the gap were rated as having high *potential impact* and being highly *compatible* with clinical workflows.

Figure 1.1. Illustration of the Relationship between Performance Gaps, Quality Measures, and Performance Gaps with High Impact and Compatible Clinical Decision Support Opportunities



Selection of Panels for the Pilot Test

We selected four panels with different characteristics to maximize the amount of information learned during the pilot. Key factors that we considered in the selection of the focus, content, and membership of our panels were as follows:

Testing Specialty-Specific and Condition-Specific Panels

Constructing a panel first involves selecting the clinicians and other stakeholders who could be involved. Conceptually, the focus of CDS prioritization could be on a single specialty that manages multiple conditions (e.g., gastroenterology), or it could focus on a condition managed by multiple specialties (e.g., multiple sclerosis). The definition of *specialty* is multifaceted. Many specialties deal with a very wide variety of conditions. Some subspecialties include very narrow scopes of practice (e.g., cardiac electrophysiology, radiation oncology).

We tested variations on the definition of a panel's area of clinical focus. We selected (1) one medical specialty (oncology), (2) one surgical specialty (orthopedic surgery), (3) one nonsurgical procedural specialty (interventional cardiology), and (4) one primary care specialty (pediatrics). Although future MU objectives for CDS are likely to be specialty specific, priorities derived from specialty-specific panels might reinforce the "silo" nature of medicine by failing to include other relevant perspectives on the management of certain conditions (discussed more fully in Chapter Seven). A condition-specific approach would provide an opportunity to bring

together a broad set of specialists with unique views about clinical priorities and the design of CDS that might enhance the process; however, this approach could require convening substantially more panels.

Ensuring Diversity of Clinical Workflows

The four panels were deliberately selected to represent a diverse set of workflows with known performance gaps potentially amenable to CDS. These workflows included (1) managing transitions between inpatient and ambulatory care settings (orthopedic surgery, percutaneous coronary intervention [PCI], oncology); (2) care coordination with other specialists (oncology, PCI, pediatrics); (3) care coordination during emergency situations (PCI); (4) selecting and implementing treatment protocols when the evidence base may be rapidly evolving (oncology); (5) care provided by nonphysician staff with specialized training (orthopedic surgery); (6) workflows specific to different phases of illness (oncology); and (7) long-term follow-up and management (oncology, pediatrics) potentially facilitated by the use of registries (PCI, oncology).

Variation in the Use of Electronic Health Records and Clinical Decision Support

We also selected specialties that were known to be relatively advanced users of CDS (oncology), as well as those that were not known for having a high level of CDS development or EHR adoption (orthopedic surgery) (DesRoches et al., 2008; Agency for Healthcare Research and Quality, 2010; Yu, 2011).

Addressing National Priority Areas

We anchored the panelists' consideration of clinical priorities to recommendations from the National Priorities Partnership (Fitch et al., 2001). The six priority domains are patient and family engagement, population health, safety, care coordination, palliative and end-of-life care, and elimination of overuse. For example, our selection of PCI addresses a procedure that, according to previous studies, may be overused.

Panel Composition and Scope

Each panel had two co-chairs, one of whom had expertise in CDS. Early in the process, we consulted with the panel co-chairs regarding each panel's scope. Given the project's limited time frame and the overarching goal of testing a process for eliciting high-priority CDS targets, we limited the clinical scope of each panel by selecting a narrow set of subspecialties, clinical conditions, or both. We therefore recognize that the results summarized in this report do not reflect an assessment of CDS for the entire scope of clinical conditions managed by various specialties. Table 1.2 displays the scope of the four panels we included for testing the prototype

framework, the number of panelists who completed all ratings for each panel, and the subspecialty composition of panel members.

Table 1.2. Designated Scope of the Panels and Representation of Subspecialties

Panel	Designated Clinical Focus	Subspecialty Composition
Oncology (n = 12)	Colorectal cancer and breast cancer	Pathology (1) Hematology (3) Medical oncology (5) Surgical oncology (1) Radiation oncology (2)
Orthopedics (n = 17)	Total knee replacement surgery, total hip replacement surgery	General orthopedics (4) Hand specialist (3) Hip and knee replacement (3) Orthopedic surgery (2) Shoulder and elbow specialist (1) Spine specialist (1)
Pediatrics (n = 12)	All pediatric conditions treated predominantly in primary care	Family medicine (1) General pediatrics (5) Hospitalist/critical care (2) Pediatric allergy (1) Pediatric behavioral health (2) Otolaryngology (AOE/OME) (1)
PCI (n = 13)	ACS, stable coronary artery disease	Interventional cardiology (6) Cardiology (4) Internal medicine (1) Electrophysiology (2)

NOTE: AOE = acute otitis externa. OME = otitis media with effusion. ACS = acute coronary syndrome.

Oncology Panel

The oncology panel focused on medical oncology, in recognition of the fact that medical oncologists are responsible for the largest share of all health expenditures for oncology. Because of the large number of different cancers that could be addressed within oncology and time and resource constraints within this contract, we narrowed the focus of this panel to two of the most prevalent cancers, breast and colorectal cancer. Therefore, the results are specific to these two types of cancers and do not reflect CDS opportunities that potentially exist more broadly for other cancers managed by medical oncologists. Although radiation oncologists and surgical oncologists have very different workflows that may be associated with different CDS opportunities, we included two radiation oncologists and two surgeons on the panel to address the fact that medical oncologists commonly coordinate patient care with physicians from these other specialties.

Orthopedics Panel

The scope of the orthopedics panel was confined to total hip and total knee replacement surgery, two of the most common procedures within the specialty. Although we recognize that these two procedures do not reflect all types of orthopedic surgery, many workflows and performance gaps associated with total joint replacement were also thought to be representative of other types of orthopedic surgery. We included a small number of spinal and hand surgeons, as well as some general orthopedic surgeons to understand areas in which performance gap/CDS opportunities might be common across these other areas.

Pediatric Panel

Although our pediatrics panel consisted entirely of pediatricians, a small number of panelists had expertise in selected pediatric clinical areas, such as allergy and behavioral health. The scope of the panel was restricted to pediatric conditions that were treated mainly in primary care settings.

Percutaneous Coronary Intervention Panel

For the PCI panel, we focused on the management of both ACS and stable coronary artery disease (CAD) and excluded consideration of primary care–related performance gaps, such as the management of cholesterol levels. Within this panel that was focused on a specific condition, we sought to explore the impact of soliciting input from a wide range of specialties by including interventional and noninterventional cardiologists, as well as internists and electrophysiologists.

Identifying Specialty Representatives

Panel members were selected for their clinical expertise, community influence (i.e., in professional organizations for their specialty and serving on advisory panels related to quality of care, practice improvement, or use of health information technology [IT]), and the diversity of settings in which they practice (both academic and community practice). We started by selecting members from existing American Medical Association Physician Consortium for Performance Improvement (AMA PCPI) performance measurement panels—including those relating to breast cancer, colorectal cancer, and PCI. Many of the individuals had been nominated by their specialty organizations for the AMA PCPI panel work. From the existing AMA PCPI panel rosters, we selected individuals with the relevant expertise given the predefined scope of each panel. We then supplemented each panel with additional clinical experts who were identified based on outreach to specialty organizations, use of key informants, and personal knowledge of experts by the project team. Because orthopedic surgeons were not heavily represented on any existing AMA PCPI panels, we requested assistance from the American Academy of Orthopaedic Surgeons

(AAOS) and the North American Spine Society (NASS) to identify suitable experts, and particularly those individuals who had expertise with EHRs or CDS. AAOS engaged in an open call to its membership, while NASS recommended specific candidates.

The panel size was not fixed across panels. We selected approximately 14 to 17 members per panel to ensure that we would have a minimum of nine panelists to complete the Delphi rating process after attrition (i.e., reduction in panel size accounting for dropping panel members who did not complete all three meetings and the two separate rounds of rating).

Identifying Candidate Clinical Performance Gaps and Clinical Decision Support Opportunities to Address Performance Gaps

Clinical Performance Gaps

We defined a clinical performance gap as a clinical area in which actual practice does not conform to optimal achievable practice. Performance gaps might include the following:

- failures to deliver care when indicated
- inappropriate use of diagnostic tests or procedures
- preventable adverse events
- disparities or unwanted variations in care delivery
- deficiencies in patient engagement or experience.

A clinical performance gap statement specifies a potential or known quality problem that may or may not exist as a formal quality measure. Although performance gap statements are preferably evidence based (i.e., known based on the results of rigorous empirical research), they may also be based on clinical epidemiology or anecdotal observation. In contrast, quality measures have explicit criteria for defining numerators and denominators, and they need to be rigorously tested to ensure their validity and reliability. Many performance gaps in specialty care do not have associated quality measures because measure development for some areas of specialty care has not yet been undertaken. Additionally, the absence of quality measures for a known performance gap may reflect uncertainty in how to measure a particular concept (e.g., coordination of care) or a lack of valid and reliable data sources. Thus, there are important performance gaps for which performance measures do not exist but that still represent opportunities for improving the quality of care.

We used four approaches to identify candidate clinical performance gaps:

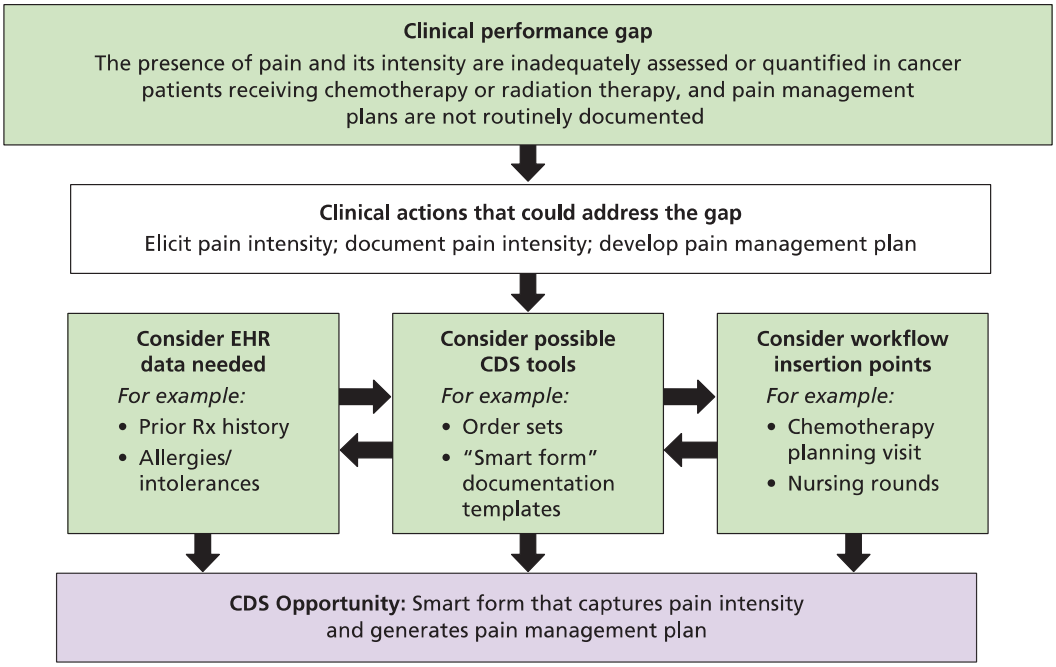
- *Environmental scan:* We scanned the existing quality measures from the National Quality Measures Clearinghouse, National Quality Forum, Physician Quality Reporting System, National Committee for Quality Assurance, AMA PCPI, Hospital Inpatient Quality Reporting Program, Premier Hospital Quality Incentive Demonstration, and the draft quality measures selected for reporting for the EHR Incentive Program.

- *Panel co-chair input:* We reviewed the preliminary list of performance gaps with the panel co-chairs, who recommended additions and revisions to the list.
- *Literature review:* We conducted a literature review to collect data, where available, on the prevalence of each performance gap and the clinical implications of each gap (e.g., mortality, morbidity, and cost effects), to be able to provide panelists with a source of objective information about the relative importance of each gap prior to the rating.
- *Panelist input:* During the first meeting with the panelists, we asked panelists to nominate additional clinical performance gaps, which were then included in the list of gaps rated by the panel.

Clinical Decision Support Opportunities

The second step in the process was to identify CDS opportunities for each of the performance gaps. A *CDS opportunity* is a description of a specific CDS intervention (i.e., existing CDS tool or intervention that might be developed) that could be expected to close a clinical performance gap. The linkage from a clinical performance gap to the relevant CDS opportunities (Figure 1.2) takes place by first understanding the clinical actions that physicians and other health care professionals could take to address the clinical performance gap and then considering how CDS tools could support providers in taking those clinical actions. These considerations include both the clinical workflow and the information needed by clinicians to address a specific clinical performance gap. As shown in Figure 1.2, we defined CDS targets with respect to specific performance gaps, using medical oncology to illustrate. Individual performance gaps along with their associated CDS opportunities jointly define a *CDS* target that could potentially be used to set a CDS MU objective.

Figure 1.2. What Is a Clinical Decision Support Target? Pain Management Example



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Not all clinical performance gaps represent ideal targets for CDS. For example, CDS may not be easily integrated into the provider's workflow, or there may be system changes other than CDS that would have more impact on closing the performance gap. In Table 1.3, we provide examples of the workflow elements, which include the task, what actors or persons would be involved to take action, and the settings in which the task might occur.

Table 1.3. Examples of Workflow Elements

Element	Examples
Task	Prescribing, ordering a test, gathering clinical data from a patient, interpreting a test result, generating a note or consult report, receiving a consult report, communicating results to a patient, discharging a patient
Person	Specialist, physician's assistant, nurse, advanced practice registered nurse, administrative assistant, visiting nurse, patient, family, or caregiver
Setting	Office, ambulatory clinic, hospital, emergency department, ambulatory surgery center, patient web portal

We started our identification of CDS opportunities by conducting a review of the published literature. Although this approach cannot provide information on tools in development or unpublished tools, CDS tools appearing in the published literature often provide data on their effectiveness and their impact on workflow, which could support panelists' ratings. We

supplemented the literature review findings by working with our co-chairs to specify additional hypothetical CDS interventions that might reasonably be developed to address the information needs for each performance gap. We considered both existing CDS tools and hypothetical interventions as valid CDS opportunities, recognizing the fact that there may be enough lead time to allow the development of some high-priority CDS tools before later stages of MU objectives are released. We considered a wide range of CDS types, and the only inclusion criterion we had was that the CDS opportunity make use of patient-specific information. Due to time constraints in testing the protocol, we did not provide panelists with an opportunity to add candidate CDS opportunities.

From these sources, we constructed a matrix in which individual performance gaps were linked with specific CDS opportunities to address the performance gap. We used an existing CDS typology developed by Osheroff and colleagues (2005) to classify potential CDS opportunities into one of six types. Table 1.4 shows the CDS types in this classification scheme and illustrates each type with example CDS opportunities drawn from our four panels.

Table 1.4. Types of Clinical Decision Support with Examples of Clinical Decision Support Opportunity Statements

CDS Type	Panel	Example
Documentation forms and templates	Oncology	Smart form that captures pain intensity and generates pain management plan based on patient preference and particular history
Relevant data presentation	PCI	Display ECG data, TIMI/GRACE scores, and likely time of symptom onset for patients with STEMI
Order and prescription creation facilitators	Oncology	Order set that mandates documentation of palliative versus curative intent and provides appropriate tailoring of regimen
Protocol and pathway support	Pediatrics	Protocol for antidepressant switching or dose escalation for treatment-resistant depression
Reference information and guidance	Orthopedics	Appropriate preoperative test–based risk stratification
Alerts and reminders	Pediatrics	Alert to PCP about elevated suicide risk if patient is being seen by non-PCP

NOTE: The CDS tool typology has been updated and expanded from what the four panels were asked to consider. See HIMSS (forthcoming) for the expanded typology. ECG = electrocardiogram. TIMI = thrombolysis in myocardial infarction. GRACE = Global Registry of Acute Coronary Events. STEMI = ST segment elevation myocardial infarction. PCP = primary care physician.

Appendix A contains the candidate performance gaps, evidence table, and performance gap/CDS opportunity matrix for each specialty panel.

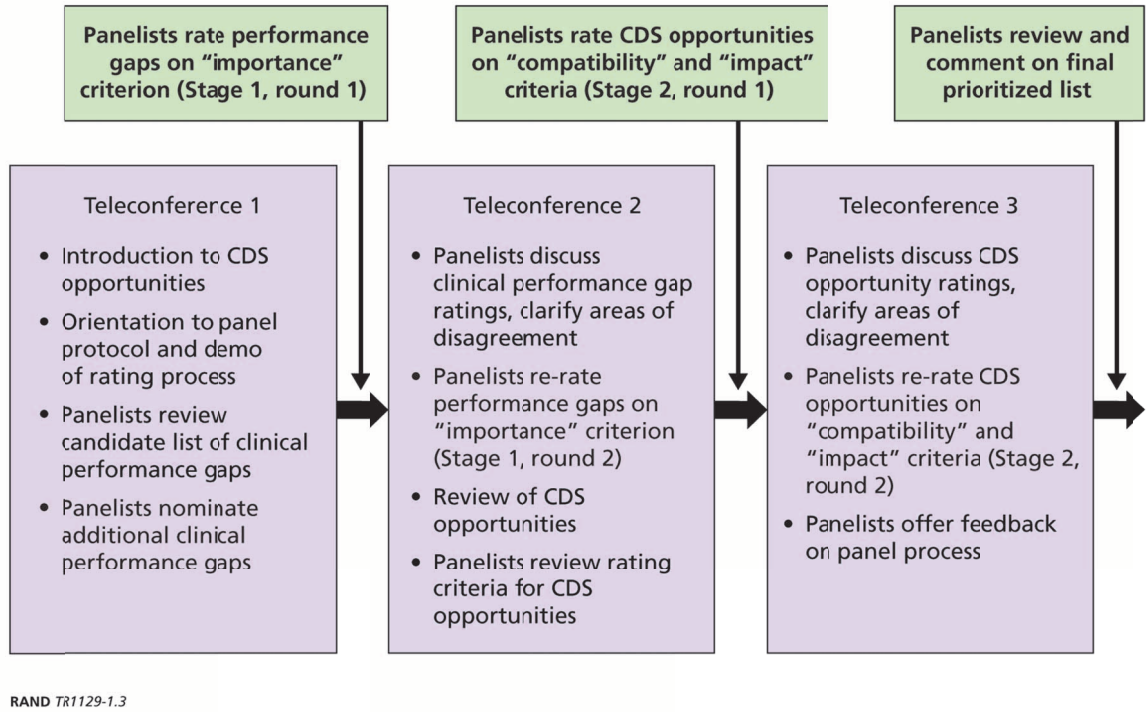
Expert Panel Protocol

The goal of the panel process was to arrive at a narrow list of high-priority targets for CDS, based on first identifying high-priority performance gaps and then, within the high-priority performance gaps, high-priority CDS opportunities.

Meeting Format and Rating Process

We used a teleconference meeting format with webinar, hosting three 90-minute teleconferences with each of the four panels (see Figure 1.3). The meetings occurred between January and March 2011. Across these three meetings, the panelists completed two modified Delphi rating processes. In stage 1, the panel focused on rating the *importance* of each candidate performance gap, and, in stage two, the panel focused on rating, for each important performance gap, the *compatibility* of CDS with clinical workflow and the *potential impact* for CDS to close the performance gap. Each rating process began with an initial round of ratings that the panelists conducted on their own. Panelist ratings were then compiled for review and discussion on a panel teleconference, and the discussion was then followed immediately by a second round of ratings, which the panelists were asked to complete before leaving the call. Panelists submitted their ratings electronically to facilitate data collection, ensure completeness of data, and expedite the analysis. In both rounds of rating, panelists rated the gaps or CDS opportunities independently and confidentially.

Figure 1.3. Expert Panel Protocol



Panelists received a summary of the first round of ratings prior to attending the second and third calls to allow them to review their ratings relative to those of other panelists. Figure 1.4 shows a one-page example of a report from the first round of ratings of the oncology CDS opportunities. Panelists could see the distribution of initial ratings by looking at the numbers above the 1 to 9 rating line, which shows counts of the number of panelists who used each rating. For example, two panelists assigned a rating of 6 for compatibility to the first CDS opportunity, a smart form that captures pain intensity. Each panelist received a different printout; the distribution of ratings was the same on all reports, but the caret (^) below the rating line showed the initial rating assigned by an individual panelist.

Figure 1.4. Sample Panelist's Rating Report

Oncology Gap/CDS Opportunities Round 1 - panelist #13

Oncology Gaps/CDS Opportunities	Compatibility	Potential Impact
Gap #3: The presence of pain and its intensity are inadequately assessed or quantified in cancer patients receiving chemotherapy or radiation therapy, and pain management plans are not routinely documented		
Smart form that captures pain intensity and generates pain management plan based on patient preference and particular history.	1 2 3 4 5 6 7 8 9 1 1 2 5 3 ^	1 2 3 4 5 6 7 8 9 1 3 3 4 1 ^
Display cancer pain history with intensity levels and current/prior treatments for pain.	1 2 3 4 5 6 7 8 9 1 2 1 1 6 1 ^	1 2 3 4 5 6 7 8 9 1 2 2 3 2 2 ^
Order set for cancer pain medication that results in a comprehensive management plan.	1 2 3 4 5 6 7 8 9 3 3 4 2 ^	1 2 3 4 5 6 7 8 9 1 3 6 2 ^
Pathway to guide initial selection of pain medication and to guide escalation of therapy when required	1 2 3 4 5 6 7 8 9 2 4 3 3 ^	1 2 3 4 5 6 7 8 9 1 1 4 5 1 ^
Reminders to assess and to quantify pain at appropriate moments in workflow.	1 2 3 4 5 6 7 8 9 1 1 3 6 1 ^	1 2 3 4 5 6 7 8 9 1 1 6 4 ^
Overall rating	1 2 3 4 5 6 7 8 9 1 1 5 4 1 ^	1 2 3 4 5 6 7 8 9 1 1 3 6 1 ^

During the second and third teleconferences, the discussion of first-round gap and CDS opportunity ratings was led by a clinician on the team who was involved in developing the initial list of gap statements and associated CDS opportunities; he was assisted by another physician with an informatics background who was also involved in the development of gap statements and associated CDS opportunities. In one of the panels (i.e., orthopedics), the co-chair led the discussions. The discussion in the second and third teleconferences focused on those items that, after analysis of the first round of ratings, were given an "indeterminate" rating based on the dispersion in the panelists' ratings. After discussion, the panelists were then asked to independently and confidentially re-rate all of the gaps (teleconference 2) and gap/CDS opportunity pairs both individually and as a set of opportunities for a given gap statement (teleconference 3).

Rating Criteria

We developed three criteria for panelists to use to rate individual performance gaps and CDS opportunities (see Table 1.5). In defining the *importance* criterion, we looked to the National Priorities Partnership framework to identify potential dimensions of importance, from which we selected three: (1) population health (i.e., prevalence, health impact on individuals), (2) patient engagement, and (3) efficiency. We also included an additional dimension, the extent to which evidence supports specific scientific actions to address each performance gap. In assessing *compatibility* with workflow, panelists were instructed to consider the average clinical practice rather than their own practice and the extent to which the tool could be inserted in any workflow. This criterion was considered important because the timing with which CDS is introduced in a workflow and its level of intrusiveness could affect the overall utility of the tool. In assessing the *potential impact* of CDS on the performance gap, panelists were asked to imagine how CDS tools would promote actions to address each gap. Panelists used a nine-point scale with the following anchors: for *gap ratings* (1 = not at all important, 5 = equivocal, 9 = extremely important) and for *CDS opportunities* (1 = not at all compatible/no potential impact, 5 = equivocal, 9 = extremely compatible/extremely high potential impact).

Table 1.5(a). Rating Criterion Used to Elicit Priority Performance Gaps

Criterion	Description
1: importance	The performance gap affects a relatively large number of patients (prevalence). On average, there are significant consequences to the patient in terms of increased morbidity, mortality, or risk. Poor performance leads to inefficient use of resources and waste in health care spending. The gap may be addressed by patient engagement and delivery of more patient-centered care. Scientific evidence or professional consensus exists on one or more actions to address the performance gap.

Table 1.5(b). Rating Criteria Used to Elicit Priority Clinical Decision Support Opportunities

Criterion	Description
2: compatibility of CDS with workflow	One or more of the CDS tools within the opportunity set can be readily introduced into a specialist's workflow or the workflow of others on the care team. The specialist or other members of the care team are likely to use the CDS tools in daily practice.
3: potential impact of CDS on the performance gap	Information deficiencies or low-reliability systems are the main contributor to the performance gap rather than clinical uncertainty, insufficient scientific evidence, or other factors. The CDS tool can provide the majority of the information needed to address the clinical gap.

Items that received a "disagreement" rating (see below) were not discussed after the first round of ratings; items receiving disagreement were classified as "uncertain" per the appropriateness scoring methodology (Fitch et al., 2001). After the second round of rating the performance gap statements for each panel, we moved forward the eight (plus or minus four gaps) highest-rated gap statements that achieved "agreement" for having the panels consider CDS opportunities mapped to highly rated performance gaps. This cut point was set to allow adequate time to discuss the one or more CDS opportunities mapped to each performance gap in the third teleconference, given the 90-minute phone call constraint.

ANALYSIS OF RATINGS

Following the modified Delphi method (Fitch et al., 2001), we classified a performance gap as "unimportant," "equivocal," or "important" in accordance with (1) the *median* panel rating and (2) the mean absolute deviation from the median. The median was used to measure the central tendency for the panelists' ratings, and the mean absolute deviation from the median is a measure of the *dispersion* of panel ratings (i.e., the level of disagreement among raters). Classification depends only on the median and the presence or absence of disagreement.

Indications with median ratings in the top third of the nine-point scale are classified as *important*, those with median ratings in the bottom third are classified as *unimportant*, and those with intermediate median ratings are *equivocal*. A similar procedure was used in rating the CDS opportunities paired with high-priority gaps, as shown in Table 1.6. Gap statements or CDS opportunities for which the dispersion of ratings indicates that the panelists disagree about whether or not to recommend the gap statement or CDS opportunity were classified as *uncertain*. Gap statements with a panel median rating of 7–9 without disagreement moved on to the second stage of ratings for the CDS opportunities paired with rated "high-priority" gaps.

Table 1.6. Classification Based on Median Rating of Performance Gap or Clinical Decision Support Opportunity

Median Rating	Performance Gaps: Importance	CDS Opportunities: Compatibility	CDS Opportunities: Potential Impact
1–3	Unimportant	Incompatible with clinical practice	Low potential impact
4–6	Equivocal	Equivocal	Equivocal
7–9	Important	Compatible with clinical practice	High potential impact

In a typical nine-member Delphi panel, the "classic" definitions for agreement and disagreement are as follows:

- *Agreement:* No more than two panelists rate the indication outside the three-point region (1–3, 4–6, 7–9) containing the median.
- *Disagreement:* At least three panelists rate the indication in the 1–3 region, and at least three panelists rate it in the 7–9 region.

However, for this project, we had panels composed of more than nine members. Because our panels ranged in size from a low of 12 to a high of 17, we followed the approach identified in the RAND Delphi method document (Fitch et al., 2001) for what constitutes *disagreement* and *agreement* with larger panels, as shown in Table 1.7.

Table 1.7. Definitions of Agreement and Disagreement for Different Panel Sizes

Panel Size	Disagreement: Number of Panelists Rating in Each Extreme (1–3 and 7–9)	Agreement: Number of Panelists Rating Outside the Three-Point Region Containing the Median (1–3, 4–6, 7–9)
8–10	≥3	≤2
11–13	≥4	≤3
14–16	≥5	≤4

From the two sets of ratings, we compiled a list of high-priority targets for CDS from each of the four expert panels. Performance gaps that were highly rated on *importance* and for which the set of CDS tools or concepts were rated as having a high *potential impact* on addressing the performance gap, as well as high *compatibility* with clinical workflow, along with statistical agreement on all criteria, were designated high-priority CDS targets. CDS targets that had either indeterminate agreement or equivocal median ratings for any one of the three dimensions were not considered high priority.

The summary of each panel's findings are found in Chapters Two through Five, with the full set of ratings for both gap statements and CDS opportunities available for review in the appendixes of this report.

Chapter Two. Oncology Results

Panel Composition

Oncology was selected as a specialty to test the draft protocol due to its rapidly evolving evidence base; the diversity of its workflows, which include managing transitions between settings and coordinating therapies and management with other specialists; treating different phases of illness; and the complexity of treatment protocols. Oncology workflows are unique in several ways, and that fact has posed a challenge for EHR vendors to adapt their systems to support oncology workflows. Chemotherapy administration involves multiple orders for intravenous medications with complex rules regarding infusion volume, rates, and order of administration, which are bundled together with supportive care drugs, such as antiemetics. The process involves a chain of providers, including the ordering provider, insurance verification staff, scheduler, pharmacist, and infusion nurses, with documentation required at each step. This is much more complicated than e-prescribing an oral medication to the patient's pharmacy. Hospital workflows differ markedly from ambulatory care patient workflows, and hospital-based EHRs cannot be easily carried over into the ambulatory environment.

Although several types of clinical specialists treat cancer, the panel was structured to focus on medical oncology and, according to discussions with our panel co-chairs, limited to the management of colorectal and breast cancer. This decision was partly driven by the time constraints of this project, which precluded consideration of a larger set of cancers, and the fact that these two types of cancers are among the most prevalent.

The composition of the panel was more heavily focused on medical oncology but also included radiation oncologists, hematologists, surgical oncologists, and a pathologist. At the start of the three-panel meeting process, the panel consisted of 14 physicians, including two panel co-chairs, one of whom had expertise in CDS. Of the 14 physicians, 12 completed the full set of ratings of both the performance gaps and CDS opportunities paired with high-priority performance gaps. Table 2.1 shows the composition of the panel by area of practice.

Table 2.1. Oncology Panel Composition by Specialty

Specialty	Number
Breast and genitourinary pathology	1
Hematology	3
Medical oncology	5
Surgical oncology	1
Therapeutic radiology and oncology	2
Total number of panelists	12

GAP STATEMENT IMPORTANCE RATINGS

A total of 22 performance gaps statements were rated by the oncology panel, which had been nominated by the project staff, co-chairs, or panelists during the prerating review of performance gaps at the first panel meeting. The gaps covered a broad array of issues, including history documentation, pain assessment and management, documentation of staging, chemotherapy ordering, infertility risk assessment and counseling, palliative care, surveillance, adherence to oral therapies, and evaluation and follow-up care. To assist the panelists with their evaluation of the performance gaps, study staff compiled evidence about the magnitude and consequences for the 22 nominated performance gaps (see Appendix A).

Table 2.2 shows the rating results from the oncology Delphi panel process, with the gap statements ordered by their median importance rating. Eighteen of the 22 performance gap statements ended with a median rating in the clearly *important* range (7–9), and, among these, 16 met the statistical criteria for *agreement* among the panelists. The other two gaps rated as *important* showed *indeterminate* agreement. The remaining four gap statements were given *equivocal* importance ratings by virtue of having medians in the 4–6 range—all of which exhibited *indeterminate* agreement. No clinical performance gaps met the formal criteria for *disagreement*.

KEY THEMES EMERGING FROM THE DISCUSSION OF CLINICAL PERFORMANCE GAPS BY THE ONCOLOGY PANEL

Performance Gaps Focused Heavily on Processes Rather Than Outcomes

It was noted that the candidate performance gaps the panelists were asked to rate focused on processes of care rather than outcomes, and many of these are embodied in quality measures. Although outcomes are of vital interest, it was noted that process measures typically are based on high-quality evidence linking the process to an outcome. Moreover, because CDS is designed to support specific clinical actions that may not be taken due to information gaps or the lack of

prompting, process-of-care quality measures often serve as a useful starting point for CDS targets.

Definitional Issues Presented Challenges

Gap statements that included such language as "having drug regimens that conform to locally approved standards" (gap 4) raised issues about how to define local standards and how to define such standards for small practices. When operationalizing performance gaps and their associated CDS opportunities, more-precise definitions to terms, such as "standard" or "appropriate," will be needed.

Table 2.2(a). Final Oncology Gap Statement Ratings: Gap Statements Rated Important with Agreement

Gap	Gap Statement	Median	Dev
1	Patients undergoing chemotherapy often fail to have a current care plan documented.	9.0	0.5
2	Cancer patients often have poorly documented information on staging.	9.0	0.8
3	Many patients receiving chemotherapy are at risk of experiencing adverse events due to errors in chemotherapy ordering.	9.0	0.8
4	Prescribed chemotherapy regimens are not always concordant with standard regimens (as defined by evidence or consensus groups).	8.5	0.7
5	Among patients of reproductive age, infertility risks and fertility preservation options are inadequately discussed prior to chemotherapy.	8.5	0.8
6	Many patients who begin treatment with oral antineoplastic therapies (e.g., tamoxifen, aromatase inhibitors) do not receive treatment for the recommended duration.	8.5	0.8
7	Many patients undergoing chemotherapy do not receive supportive care therapies, including potent antiemetic therapy and granulocyte-colony stimulating factor.	8.5	0.9
8	Patients are often unaware of the risks and benefits of chemotherapy, and their understanding of the treatment's intent (palliative versus curative) is often inadequately documented.	8.5	1.2
9	After surgical excision of a malignant colorectal tumor, many patients do not receive colonoscopy or barium enema to assess for the presence of synchronous tumors or polyps.	8.0	0.6
10	Many breast cancer patients who are candidates for trastuzumab do not receive the therapy, and patients who receive the therapy are not always followed for possible safety problems.	8.0	0.6
11	Following curative resection, cancer patients do not always receive adequate surveillance or testing.	8.0	0.7
12	Chemotherapy and radiotherapy treatment summaries are not always fully documented or provided to patients or physicians providing continuing care.	8.0	0.8
13	The presence of pain and its intensity are inadequately assessed or quantified in cancer patients receiving chemotherapy or radiation therapy, and pain management plans are not routinely documented.	8.0	1.0
14	Patients started on long-acting opioids do not always receive short-acting opioid formulations for breakthrough pain, and patients receiving chronic opioids do not always receive bowel regimens.	8.0	1.0
15	Many cancer patients receive chemotherapy within the last two weeks of life, and many patients do not have discussions with their providers about hospice or palliative care within the last two months of life.	8.0	1.0
16	Many patients do not undergo KRAS mutation testing before initiating anti-EGFR therapy.	7.5	1.3

NOTE: SD = standard deviation. KRAS = Kirsten rat sarcoma. EGFR = epidermal growth factor receptor. Dev = mean absolute deviation from median.

Table 2.2(b). Final Oncology Gap Statement Ratings: Gap Statements Rated Important but with Indeterminate Agreement

Gap	Gap Statement	Median	Dev
17	As part of end-of-life care, dyspnea is inadequately assessed or treated.	7.5	1.3
18	Cancer patients often have poorly documented medical and surgical histories.	7.0	1.9

NOTE: Dev = mean absolute deviation from median.

Table 2.2(c). Final Oncology Gap Statement Ratings: Gap Statements Rated in the Equivocal Range

Gap	Gap Statement	Median	Dev
19	Cancer patients often have poorly documented family histories.	6.5	1.3
20	Breast cancer patients with bone metastases do not routinely receive treatment with IV bisphosphonates; among those who do, renal function is not routinely assessed between the first and second administrations.	6.0	0.8
21	Cigarette smoking status is inadequately documented, and smoking cessation counseling therapy is not routinely provided to cancer patients.	6.0	1.4
22	Some patients do not have at least 12 regional lymph nodes removed and pathologically examined for resected colon cancer.	5.5	1.7

NOTE: IV = intravenous. Dev = mean absolute deviation from median.

Absence of Patient-Centric Performance Gaps

There was general consensus among the panelists that the list of candidate gap statements lacked gaps that were patient-centric and that these should be added. Gap areas that panelists suggested to address this issue included (1) failure to receive cancer diagnosis in a timely fashion; (2) infrequent measurement of Eastern Cooperative Oncology Group (ECOG) performance status; (3) limited use of screening for depression using instruments, such as the Patient Health Questionnaire (PHQ) 9; (4) lack of assessment for availability of community support; (5) limited use of personal health records and patient portals to facilitate pain and treatment toxicity assessments so that patients could evaluate the care they received; (6) patients' and providers' failure to understand treatment risks and goals; and (7) underuse of personalized prognosis, molecular profiling, and genetic screening tools.

Concerns about Chemotherapy Errors

Panelists raised concerns about underdosing, as well as toxicity for some standard regimens of chemotherapy, and recommended the addition of a gap to address chemotherapy errors (added gap 3). One panelist summarized that the overarching goal was to have an order system in place so that ordering is not done ad hoc and that documentation of deviation from the standard regimen is critical; details about what constituted "standard regimens" and the doses of these regimens were less important.

Modifications to Gap Statements

The gap statement "Many patients who begin treatment with oral antineoplastic therapies (e.g., tamoxifen, aromatase inhibitors) do not receive treatment for the recommended duration" was broadened beyond just breast cancer to include oral antineoplastic therapies more generally and not simply tamoxifen (gap 6). Another modification was to add supportive care therapies to the statement (gap 7) "Many patients undergoing chemotherapy do not receive supportive care therapies, including potent antiemetic therapy and granulocyte-colony stimulating factor."

Need to Link Staging to Appropriate Therapy

The focus of only documenting staging (gap 2) was viewed by panelists as missing the important link to appropriate therapy for a given stage. Panelists emphasized that staging requires rigor and, when done correctly, drives subsequent treatment decisions, outcomes, and use of resources. Accordingly, panelists gave this gap a median rating of 9.0 (the highest possible score).

Clinical Decision Support Opportunity Compatibility and Importance Ratings

A total of 16 performance gaps ultimately achieved ratings of *important* with statistical *agreement*. However, due to delays in receiving final ratings, only 15 gaps advanced to the second step in the panel process (i.e., the rating of CDS opportunities paired with high-priority performance gap statements).[5]

Panelists were provided a list of example CDS opportunities for each highly rated performance gap. The list of candidate CDS opportunities was not exhaustive, and panelists were asked to consider these examples or others they could imagine would be helpful in closing the performance gap. Panelists were then instructed to provide ratings of the CDS opportunities at two levels for each of the 15 performance gaps:

- *Overall for the collection of example candidate CDS opportunities for an individual gap.* Panelists were given examples of possible CDS opportunities for each gap statement and asked to consider whether these examples or other potential CDS opportunities would make the specified performance gap a high-priority target for CDS (see Table 2.3).
- *At the level of the individual candidate CDS opportunities,* presented as example CDS tools or CDS concepts for each gap. Panelists were asked to consider whether

[5] At the time the study team constructed the panel materials for the rating of CDS opportunities, one panel member's second ratings on the performance gaps had not yet been received. Based on the results of 11 panelists' second ratings of performance gaps, gap 9 was deemed *important* but *indeterminate*; however, after inclusion of the 12th panelist's second ratings, gap 9 was deemed *important* and achieved *agreement*. The time commitment for physicians participating in several rounds of ratings highlights one of the difficulties in completing this type of project.

this specific CDS opportunity would be rated highly as a means to close the specific performance gap (see Table 2.4).

Table 2.3 shows the *overall* CDS compatibility and impact ratings for the 15 highly rated gap statements. Of the 15, 14 ended with a median rating in the high range (7–9) for *both potential impact* and *compatibility* and met the criterion for *agreement* for both criteria among the panelists. *These overall rated sets are considered high-priority CDS targets.* Although the CDS set of opportunities paired with gap 8 achieved higher median ratings (7–9), it satisfied only the threshold for statistical *agreement* for the potential impact criterion; ratings exhibited *indeterminate* agreement for the compatibility criterion.

Among the *individual CDS opportunities* paired with high-priority performance gaps, 31 out of a total of 44 opportunities received scores indicating *both* high *potential impact* and high *compatibility* (median ratings between 7 and 9) and achieved *agreement* (Table 2.4). Twelve received either indeterminate or disagreement ratings on one or both criteria. Of the 31 highly rated individual CDS opportunities achieving *agreement*, ten are order sets, seven are alerts or reminders, five are documentation forms or templates, one is a smart link to reference information, four are for relevant data presentation, and four are for protocol or pathway support. The rating results at this more granular level may be useful for EHR vendors considering what types of CDS interventions practitioners rated highest and viewed as potentially helpful in addressing high-priority performance gaps.

The information contained in Table 2.4 is a subset of the information shown in Table 2.3. Table 2.4 contains only the individual CDS opportunities that were rated with agreement and were rated 7–9 on potential impact and compatibility. These highly rated CDS opportunities may differ from the high-priority gap statement/CDS opportunity sets highlighted in Table 2.3. This occurs when an individual CDS opportunity received a high rating but the overall set of opportunities did not. For example, for gap statements 5, 6, 7, and 8, a single CDS opportunity among the set of opportunities considered was found to exceed our cutoffs for potential impact and workflow compatibility.

Table 2.3. High-Priority Clinical Decision Support Targets for Oncology: Important Performance Gaps Rated as Having High-Impact and Highly Compatible Clinical Decision Support Opportunities Overall

Gap	CDS Target (gap statement with example CDS opportunities)	Potential Impact: Median	Potential Impact: Dev	Potential Impact: Agreement	Compatibility: Median	Compatibility: Dev	Compatibility: Agreement
3[a]	Many patients receiving chemotherapy are at risk of experiencing adverse events due to errors in chemotherapy ordering a. Smart ordering forms that help reduce errors b. Alert at time of ordering or infusion if chemotherapy orders differ from accepted standards.	9.0	0.5	A	9.0	0.3	A
2[a]	Cancer patients often have poorly documented information on staging. a. Cancer-specific documentation template that supports accurate staging for the type of cancer b. Info button to check latest staging criteria at the time that cancer diagnoses are being entered c. Reminder to complete staging information prior to initiation of therapy	8.0	1.1	A	9.0	0.8	A
1[a]	Patients undergoing chemotherapy often fail to have a current care plan documented. a. Pathway based on standard multicycle regimens with order sets and appropriate refinements for each step b. Smart form for chemotherapy that prompts documentation of current care plan and reasons for deviation from previous plan c. Timeline display of prior adverse reactions and therapy adjustments that should inform current care plan	8.0	0.6	A	8.0	0.6	A
4[a]	Prescribed chemotherapy regimens are not always concordant with standard regimens (as defined by evidence or consensus groups). a. Order tool for cancer-specific chemotherapy regimens (including combinations and specific doses) that are consistent with local standards and that allow overrides b. Documentation template for explaining deviation from standard regimen at the time of ordering c. Alert at time of ordering or infusion if chemotherapy plan differs from accepted standards.	8.0	0.3	A	8.0	0.5	A
7[a]	Many patients undergoing chemotherapy do not receive supportive care therapies, including potent antiemetic therapy and granulocyte-colony stimulating factor. a. Order sets for chemotherapy regimens that include recommended antiemetic and other supportive care therapies b. Info button during ordering to access ASCO, ONS, or NCCN antiemetic recommendations based on emetogenic potential of chemotherapy	8.0	0.5	A	8.0	0.6	A

Gap	CDS Target (gap statement with example CDS opportunities)	Potential Impact: Median	Potential Impact: Dev	Potential Impact: Agreement	Compatibility: Median	Compatibility: Dev	Compatibility: Agreement
8	Patients are often unaware of the risks and benefits of chemotherapy, and their understanding of the treatment's intent (palliative versus curative) is often inadequately documented. Furthermore, alternative options are often not provided. a. Patient consent form template that includes alternative options, risk/benefit information, and intent of treatment b. Display inputs to and results from predictive models of treatment benefit at time of chemotherapy decisionmaking c. Order set that mandates documentation of palliative versus curative intent and provides appropriate tailoring of regimen d. Info button at the time of chemotherapy planning linking to reference data on treatment risks and benefits based on stage and treatment history	7.5	0.9	A	8.0	0.9	I
6[a]	Many patients who begin treatment with oral antineoplastic therapies (e.g., tamoxifen, aromatase inhibitors) do not receive treatment for the recommended duration. a. Self-administered patient questionnaire regarding compliance and reasons for noncompliance b. Order set for hormonal therapy that triggers reminder for education regarding compliance c. Alert for low adherence based on medication utilization data	7.5	0.8	A	7.5	0.8	A
5[a]	Among patients of reproductive age, infertility risks and fertility preservation options are inadequately discussed prior to chemotherapy. a. Fertility preference smart form entry that can be utilized for automated cross-checks b. Chemotherapy order set that cross-checks patient's reproductive plans c. Treatment plan suggestions in accordance with patient's documented fertility preferences	7.0	1.1	A	7.0	1.1	A
10[a]	Many breast cancer patients who are candidates for trastuzumab do not receive the therapy, and patients who receive the therapy are not always followed for possible safety problems. a. Breast cancer order set that searches for a patient's HER2+ status (or queries provider for it) b. Alert if EF assessment has not been conducted on schedule or is trending unfavorably for patients receiving trastuzumab	8.0	1.0	A	8.0	0.9	A
11[a]	Following curative resection, cancer patients do not always receive adequate surveillance or testing. a. Automatically generated, diagnosis specific follow-up order sets b. Automated generation of cancer-specific survivorship care plan that includes all necessary tests (and responsible physician) that can be shared with patients c. Alert if surveillance activities deviate from survivorship care plan	8.0	0.4	A	8.0	0.3	A

Gap	CDS Target (gap statement with example CDS opportunities)	Potential Impact: Median	Potential Impact: Dev	Potential Impact: Agreement	Compatibility: Median	Compatibility: Dev	Compatibility: Agreement
12[a]	Chemotherapy and radiotherapy treatment summaries are not always fully documented or provided to patients or physicians providing continuing care. a. Documentation template for treatment summary that includes content required by CCHIT that can be transmitted electronically (to physicians) or in hard copy (to patients) b. Patient-specific treatment summary automatically generated with order entry c. Reminder to generate and submit report to patient and providers triggered by termination of chemotherapy care plan (or as part of radiotherapy visit checklist)	8.0	0.7	A	8.0	0.7	A
14[a]	Patients started on long-acting opioids do not always receive short-acting opioid formulations for breakthrough pain, and patients receiving chronic opioids do not always receive bowel regimens. a. Order sets for long-acting or chronic opioid therapy that include appropriate medications required for breakthrough pain and bowels b. Distinct pain management display accessible by nurses and physicians that highlights missing orders and graphically charts patient's recent pain history c. Alert when pain management orders have expired with easy automatic renewal	8.0	0.8	A	8.0	0.5	A
13[a]	The presence of pain and its intensity are inadequately assessed or quantified in cancer patients receiving chemotherapy or radiation therapy, and pain management plans are not routinely documented. a. Smart form that captures pain intensity and generates pain management plan based on patient preference and particular history b. Display cancer pain history with intensity levels and current and prior treatments for pain c. Order set for cancer pain medication that results in a comprehensive management plan d. Pathway to guide initial selection of pain medication and to guide escalation of therapy when required e. Reminders to assess and to quantify pain at appropriate moments in workflow	8.0	1.1	A	7.0	0.8	A
15[a]	Many cancer patients receive chemotherapy within the last two weeks of life, and many patients do not have discussions with their providers about hospice or palliative care within the last two months of life. a. EHR smart form for patient's end-of-life preferences and performance status assessment b. Palliative care order set, including recommended therapies c. Reminder to assess and document end-of-life care preferences triggered by data on performance status	7.5	0.7	A	8.0	0.5	A
16[a]	Many patients do not undergo KRAS mutation testing before initiating anti-EGFR therapy. a. Reminder to conduct KRAS test triggered by order for anti-EGFR therapy. b. Order set for anti-EGFR therapy that checks KRAS test result or requires input of test result	8.0	0.8	A	8.5	0.8	A

NOTE: In the agreement columns, A = agreement and I = indeterminate. ASCO = American Society for Clinical Oncology. ONS = Oncology Nursing Society. NCCN = National Comprehensive Cancer Network. HER2 = human epidermal growth factor receptor 2; HER2+ indicates that the cancer tests positive for this protein. EF = ejection fraction. CCHIT = Certification Commission for Health Information Technology. Dev = mean absolute deviation from median.

[a] Meets criterion for high-priority CDS target by virtue of having the potential for CDS with high impact and high workflow compatibility.

KEY THEMES EMERGING FROM THE DISCUSSION OF CLINICAL DECISION SUPPORT OPPORTUNITIES BY THE ONCOLOGY PANEL

Uncertain Role for Electronic Health Records in Resolving Some Performance Gaps, with the Potential for Electronic Health Record Use to Create More Complexity

Several panelists commented that using CDS to make patients aware of the risks and benefits of chemotherapy and to improve their understanding of the treatment's intent (palliative versus curative) (gap 8) is challenging and that EHRs may not be the best strategy to ensure that this happens. Panelists agreed that it was an important goal, but some were unsure whether a consent form template would communicate the issues as effectively as a discussion between patient and physician or whether having an order set that requires documenting palliative versus curative intent was overly simplistic because patients' preferences are likely to change over time. Several noted the complexity of loading this information into the EHR and the difficulty of having predesigned sets. One panelist expressed concern that this would go from a short, understandable consent process to a 50-page document that creates more fear than is necessary; he did not want the documentation to become onerous and put off consent to participate in trials. Additionally, treatments and treatment goals evolve, and obtaining consent would need to be an ongoing activity. However, several panelists countered these arguments saying that having forms that list potential options and side effects associated with radiation therapy would engender discussion with the patient and make sure that options and side effects are not overlooked. One noted that it should be feasible to build a customizable report into the regimen for patients to review the side effects.

Concerns about Data Completeness and Implications for Use of Clinical Decision Support

There were instances in which panelists flagged concerns about data completeness that raised implications for clinical decisionmaking. For example, the CDS opportunity "displaying cancer pain history with intensity levels and current treatment plan" (gap 3) was rated low by one panelist because of concerns about how complete, reliable, and current the information in the EHR might be. This physician indicated that he would need to have a high level of trust before using something like this type of tool and that he was not clear how a CDS tool could pull this information out of physician notes. He suggested that an alternative approach could be a tool that calls the patient and has the patient enter pain information daily.

A Need for Support, Not More Work

In various areas, physicians highlighted the tension between implementing tools that enhance care without dramatically changing workflow and increasing the workload. One panelist

commented, “Every time you create a smart form, someone has to take care of the data and perhaps someone might look at it. In the real world, if it creates more work then the CDS tool won’t be used.” This same panelist felt that order set, pathway tools, or links that give information about management have high utility, whereas smart forms had only moderate value.

Value in Tools That Help Physicians Practice More Efficiently and Improve the Workflow

Given that oncology patients are often seen by multiple physicians and different physicians might occasionally manage each other’s patients, panelists saw value in tools that would display real-time information to enable better patient management. Panelists thought that a smart form for chemotherapy that prompts documentation of the current care plan and provides the exact reasons for deviation from previous plan (e.g., why the physician changed the dose) would help address gap 6 (“Current care plan documented”). Similarly, a pathway based on standard multicycle regimens with order sets and appropriate refinements for each step would be valuable in both improving practice workflow and optimizing patient outcomes because panelists highlighted missed chemotherapy visits as a significant problem.

Better to Include the Order Sets Than to Have Only Information Links to Guidelines

In considering the opportunities for gap 7 (“Many patients undergoing chemotherapy do not receive supportive care therapies, including potent antiemetic therapy and granulocyte-colony stimulating factor”) panelists recommended that these therapies be built into chemotherapy order sets rather than requiring a stand-alone order. Providers often browse National Cancer Coalition (NCC) guidelines or even use Google to identify appropriate supportive care therapies (although, in some institutions, access to the Internet is prohibited), so a button would make accessing the information easier; however, order sets were considered to be preferable to allowing providers to search for information and determine their own orders. One panelist went further, saying that order sets should be linked into the local formularies of the institution.

Table 2.4. High-Priority Individual Clinical Decision Support Opportunities for Oncology Rated as Having High Impact and Compatibility (Targeting Important Performance Gaps)

CDS Opportunity	Gap Statement with Highly Rated Individual CDS Opportunities	CDS Opportunity Type	Potential Impact: Median	Potential Impact: Dev	Compatibility: Median	Compatibility: Dev
1a	Pathway based on standard multicycle regimens with order sets and appropriate refinements for each step (addressing gap 1: "Patients undergoing chemotherapy often fail to have a current care plan documented")	P	8.0	0.6	8.5	0.7
1b	Smart form for chemotherapy that prompts documentation of current care plan and reasons for deviation from previous plan (addressing gap 1)	D	8.0	0.8	8.0	0.6
1c	Timeline display of prior adverse reactions and therapy adjustments that should inform current care plan (addressing gap 1)	R	7.5	1.7	8.0	1.5
2a	Cancer-specific documentation template that supports accurate staging for the type of cancer (addressing gap 2: "Cancer patients often have poorly documented information on staging")	D	8.5	0.8	9.0	0.7
2b	Info button to check latest staging criteria at the time that cancer diagnoses are being entered (addressing gap 2)	S	8.0	1.5	9.0	0.8
3a	Smart ordering forms that help reduce errors (addressing gap 3: "Many patients receiving chemotherapy are at risk of experiencing adverse events due to errors in chemotherapy ordering")	O	9.0	0.4	9.0	0.4
3b	Alert at time of ordering or infusion if chemotherapy orders differ from accepted standards (addressing gap 3)	A	8.5	0.8	8.0	0.5
4a	Order tool for cancer-specific chemotherapy regimens (including combinations and specific doses) that are consistent with local standards and that allow overrides (addressing gap 4: "Prescribed chemotherapy regimens are not always concordant with standard regimens (as defined by evidence or consensus groups")	O	9.0	0.6	9.0	0.5

CDS Opportunity	Gap Statement with Highly Rated Individual CDS Opportunities	CDS Opportunity Type	Potential Impact: Median	Potential Impact: Dev	Compatibility: Median	Compatibility: Dev
4b	Documentation template for explaining deviation from standard regimen at the time of ordering (addressing gap 4)	D	8.0	0.7	8.0	0.7
4c	Alert at time of ordering or infusion if chemotherapy plan differs from accepted standards (addressing gap 4)	A	8.0	0.5	8.0	0.8
5c	Treatment plan suggestions in accordance with patient's documented fertility preferences (addressing gap 5: "Among patients of reproductive age, infertility risks and fertility preservation options are inadequately discussed prior to chemotherapy")	P	7.5	1.4	7.5	1.3
6c	Alert for low adherence based on medication utilization data (addressing gap 6: "Many patients who begin treatment with oral antineoplastic therapies [e.g., tamoxifen, aromatase inhibitors] do not receive treatment for the recommended duration")	A	7.5	1.1	8.0	0.8
7a	Order sets for chemotherapy regimens that include recommended antiemetic and other supportive care therapies (addressing gap 7: "Many patients undergoing chemotherapy do not receive supportive care therapies, including potent antiemetic therapy and granulocyte-colony stimulating factor")	O	8.5	0.6	9.0	0.3
8b	Display inputs to and results from predictive models of treatment benefit at time of chemotherapy decisionmaking (addressing gap 8: "Patients are often unaware of the risks and benefits of chemotherapy, and their understanding of the treatment's intent [palliative versus curative] is often inadequately documented")	R	8.5	1.0	8.0	0.8

CDS Opportunity	Gap Statement with Highly Rated Individual CDS Opportunities	CDS Opportunity Type	Potential Impact: Median	Potential Impact: Dev	Compatibility: Median	Compatibility: Dev
10a	Breast cancer order set that searches for a patient's HER2+ status (or queries provider for it) (addressing gap 10: "Many breast cancer patients who are candidates for trastuzumab do not receive the therapy, and patients who receive the therapy are not always followed for possible safety problems")	O	8.0	1.4	8.0	1.2
10b	Alert if EF assessment has not been conducted on schedule or is trending unfavorably for patients receiving trastuzumab (addressing gap 10)	A	8.0	0.9	8.0	0.7
11a	Automatically generated, diagnosis-specific follow-up order sets (addressing gap 11: "Following curative resection, cancer patients do not always receive adequate surveillance or testing")	O	8.0	0.8	8.0	0.3
11b	Automated generation of cancer-specific survivorship care plan that includes all necessary tests (and responsible physician) that can be shared with patients (addressing gap 11)	P	8.0	0.5	8.0	0.4
12a	Documentation template for treatment summary that includes content required by CCHIT that can be transmitted electronically (to physicians) or in hard copy (to patients) (addressing gap 12: "Chemotherapy and radiotherapy treatment summaries are not always fully documented or provided to patients or physicians providing continuing care")	D	8.0	0.6	8.0	0.7
12b	Patient-specific treatment summary automatically generated with order entry (addressing gap 12)	O	8.0	0.8	8.0	0.8
13b	Display cancer pain history with intensity levels and current and prior treatments for pain (addressing gap 13: "The presence of pain and its intensity are adequately assessed or quantified in cancer patients receiving chemotherapy or radiation therapy, and pain management plans are not routinely documented")	R	7.0	0.8	8.0	0.7

CDS Opportunity	Gap Statement with Highly Rated Individual CDS Opportunities	CDS Opportunity Type	Potential Impact: Median	Potential Impact: Dev	Compatibility: Median	Compatibility: Dev
13c	Order set for cancer pain medication that results in a comprehensive management plan (addressing gap 13)	O	8.0	0.9	8.0	0.8
13d	Pathway to guide initial selection of pain medication and to guide escalation of therapy when required (addressing gap 13)	P	7.0	1.2	8.0	0.9
13e	Reminders to assess and to quantify pain at appropriate moments in workflow (addressing gap 13)	A	7.0	1.2	8.0	0.9
14a	Order sets for long-acting or chronic opioid therapy that include appropriate medications required for breakthrough pain and bowels (addressing gap 14: "Patients starting on long-acting opioids do not always receive short-acting opioid formulations for breakthrough pain, and patients receiving chronic opioids do not always receive bowel regimens")	O	8.0	0.5	8.0	0.3
14b	Distinct pain management display accessible by nurses and physicians that highlights missing orders and graphically charts patient's recent pain history (addressing gap 14)	R	7.5	1.0	7.5	0.7
15a	EHR smart form for patient's end-of-life preferences and performance status assessment (addressing gap 15: "Many cancer patients receive chemotherapy within the last two weeks of life, and many patients do not have discussions with their providers about hospice or palliative care within the last two months of life")	D	8.0	0.9	8.0	0.9
15b	Palliative care order set, including recommended therapies (addressing gap 15)	O	8.0	0.7	8.0	0.5
15c	Reminder to assess and document end-of-life care preferences triggered by data on performance status (addressing gap 15)	A	7.5	1.2	8.0	0.8

CDS Opportunity	Gap Statement with Highly Rated Individual CDS Opportunities	CDS Opportunity Type	Potential Impact: Median	Potential Impact: Dev	Compatibility: Median	Compatibility: Dev
16a	Order set for anti-EGFR therapy that checks KRAS test result or requires input of test result (addressing gap 16: "Many patients do not undergo KRAS mutation testing before initiating anti-EGFR therapy")	O	8.0	0.8	8.5	0.6
16b	Reminder to conduct KRAS test triggered by order for anti-EGFR therapy (addressing gap 16)	A	8.0	0.6	8.5	0.9

NOTE: In the "CDS Opportunity Type" column, A = alerts or reminders, D = documentation forms or templates, O = order set or ordering tool, P = protocol or pathway support, R = relevant data presentation, and S = smart links to reference information. Dev = mean absolute deviation from median.

CHAPTER THREE. ORTHOPEDICS RESULTS

PANEL COMPOSITION

The panel's designated clinical focus was total knee replacement surgery and total hip replacement surgery. Panelists were nominated by AAOS based on their expertise in some combination of total joint replacement, health IT, quality management, and epidemiology or outcomes research in orthopedics. All panelists were board-certified orthopedists. Seventeen panelists completed participation, and two others withdrew after participating in the initial rating steps.[6] Table 3.1 categorizes the panelists according to their expertise. Additionally, two of the members had current expertise with orthopedics in small practice environments.

Table 3.1. Orthopedics Panel Composition by Specialty (n = 14 members)

Subspecialty	Panelists
General orthopedics	4
Hand specialist	3
Hip and knee replacement	3
Orthopedic surgery	2
Shoulder and elbow specialist	1
Spine specialist	1
Total number of panelists	14

GAP STATEMENT IMPORTANCE RATINGS

The panel rated a total of 28 performance gap statements that had been nominated by the co-chairs, project staff, or panelists during the prerating review process. The gaps were categorized as pertaining to preoperative care (14), infection prevention (two), operative care (four), and postoperative care (eight). Study staff was able to compile evidence about the magnitude or consequences for ten of the 28 nominated performance gaps. (See Table B.2 in Appendix B for a complete listing.)

Table 3.2 shows the rating results from the Delphi panel process, with the gap statements ordered by their median importance rating. Sixteen of the gap statements ended with a median rating in the clearly *important* range (7–9). However, among these, only six met the criterion for

[6] The multiple panel meeting process requires commitment by panelists to participate in all meetings to have their ratings counted in the final tabulations.

agreement among the panelists; agreement was *indeterminate* for the other ten *important* gap statements, meaning, for this panel, that five or more panelists had given a rating outside of the 7–9 range. The remaining 12 gap statements were given *equivocal* importance ratings (medians in the 4–6 range) and met criteria for indeterminate agreement or, in one case, disagreement.

Table 3.2(a). Final Orthopedics Gap Statement Ratings: Gap Statements Rated Important with Agreement

Gap	Gap Statement	Median	Dev
1	Some patients taking coumadin or clopidogrel do not always discontinue their therapy or switch to short-term anticoagulation therapy in advance of total hip or total knee replacement surgery.	9.0	1.3
2	Patients are not always assessed preoperatively for their bleeding and VTE risks, resulting in prophylaxis that does not match the patient's risk.	8.0	0.7
3	Patients undergoing total hip or total knee replacement surgery may not receive VTE prophylaxis when it is indicated.	8.0	0.7
4	Many patients who undergo surgery for hip fracture fail to receive follow-up risk assessment and therapy to prevent future osteoporotic fractures.	8.0	0.9
5	Patients who undergo total hip or total knee replacement surgery may not receive certain necessary preoperative tests, while others may undergo unnecessary testing.	7.0	0.8
6	Patients who undergo total hip or total knee replacement surgery may not receive written discharge instructions, including plans for follow-up, activity restriction, anticoagulation, and dental prophylaxis.	7.0	0.9

NOTE: VTE = venous thromboembolism. Dev = mean absolute deviation from median.

Table 3.2(b). Final Orthopedics Gap Statement Ratings: Gap Statements Rated Important but with Indeterminate Agreement

Gap	Gap Statement	Median	Dev
7	Patients are not always assessed preoperatively for noncardiac comorbidities (e.g., hepatitis, HIV) or for the associated risk of morbidity from surgery.	8.0	1.1
8	Antibiotic prophylaxis recommendations from the National Surgical Infection Prevention Project and AAOS may not be consistently followed for patients undergoing total hip or total knee replacement surgery.	8.0	1.1
9	Reviews of systems conducted prior to total hip or total knee replacement surgery by orthopedic surgeons may be lacking or may not be comprehensive and are often incompletely documented in the medical record.	8.0	1.5
10	Patients undergoing total hip or total knee replacement surgery may not always have discussions with their surgeons about their preferences, prognosis, or the risks and benefits of surgery, and these discussions may not be documented in their medical record.	7.0	1.1
11	Patients undergoing total hip or total knee replacement surgery may experience complications requiring readmission.	7.0	1.1
12	Patients undergoing total hip or total knee replacement surgery may not always receive coordinated, multidisciplinary care from the time of operation through discharge and may not receive important tests, consultations, and education.	7.0	1.2
13	Prior to undergoing total hip or total knee replacement surgery, patients may not receive sufficient education about the procedure or about their postdischarge care.	7.0	1.2
14	Prior to undergoing total hip or total knee replacement surgery, patients may not receive an appropriate preoperative cardiovascular evaluation, including cardiovascular risk stratification, and may lack documentation of any further cardiac evaluation that was performed.	7.0	1.3
15	VTE prophylaxis is not always maintained for a sufficient time interval postoperatively.	7.0	1.5
16	Patients who have undergone total hip or total knee replacement surgery may not have operative notes in their medical record that document findings from the final examination.	7.0	1.6

NOTE: HIV = human immunodeficiency virus. Dev = mean absolute deviation from median.

Table 3.2(c). Final Orthopedics Gap Statement Ratings: Gap Statements Rated in the Equivocal Range

Gap	Gap Statement	Median	Dev
17	Patients are not always informed about the possibility of receiving regional anesthesia before total hip or total knee replacement surgery.	6.0	1.1
18	Patients undergoing total hip or total knee replacement surgery may experience physiologic or metabolic derangement.	6.0	1.3
19	Patients undergoing total hip or total knee replacement surgery may not have information from physical exams documented completely in their medical record.	6.0	1.4
20	Information from diagnostic radiographs is not always fully documented in a patient's medical record prior to total hip or knee replacement surgery.	6.0	1.5
21	Patients may not have a comprehensive radiographic evaluation performed following total hip or total knee replacement surgery.	6.0	1.5
22	Patients undergoing total hip or total knee replacement surgery may experience postoperative hemorrhage or postoperative hematoma.	6.0	1.9
23	Patients undergoing total hip or total knee replacement surgery may not have the indication for surgery documented in their medical record.	6.0	2.1
24	Patients who have undergone total hip or total knee replacement surgery may not have radiographs taken at recommended intervals following the operation.	5.0	1.4
25	Patients who are recovering from total joint replacement surgery may not be closely monitored for changes in neurological functioning.	5.0	1.6
26	Patients who have undergone total hip or total knee replacement surgery may not have follow-up visits at recommended intervals following the operation.	5.0	1.7
27	Patients undergoing total hip or total knee replacement surgery may not have hair removed according to recommended techniques.	4.0	1.7

NOTE: Dev = mean absolute deviation from median.

Table 3.2(d). Final Orthopedics Gap Statement Ratings: Gap Statements Rated with Disagreement

Gap	Gap Statement	Median	Dev
28	Patients undergoing total hip or total knee replacement surgery may not have their history of present illness completely documented in their medical record.	5.0	1.6

NOTE: Dev = mean absolute deviation from median.

KEY THEMES EMERGING FROM THE DISCUSSION OF CLINICAL PERFORMANCE GAPS BY THE ORTHOPEDICS PANEL

Evidence Was Considered Insufficient for Addressing Some Performance Gaps

Comments about the strength of evidence, especially related specifically to orthopedics, were among the most common concerns expressed by panelists. It is not uncommon for physicians to question the data and the evidence. These concerns were expressed about several gaps that ended with "equivocal" importance ratings (e.g., those related to intervals between radiographs [gap 24] or follow-up visits [gap 26]), as well as gaps rated in the "important" range but with indeterminate agreement (e.g., evidence being inadequate to know which review of systems questions are important [gap 9], what nonspecific cardiac comorbidities should be

assessed to risk-stratify patients for orthopedic operations, and what precise duration of anticoagulant therapy is needed for particular operations, such as knee versus hip replacement [gap 15]). For the one gap statement that met the formal criterion for disagreement, some panelists argued that key facts were often not documented in the history of present illness (gap 28), whereas others argued that we do not have the evidence to specify precisely what facts must be documented. Some also worried that regulators already take documentation specifications beyond what is clinically necessary. There was also concern that the evidence supporting osteoporotic fracture prevention (gap 4) might not generalize specifically to secondary prevention in post joint replacement patients.

Concerns Were Raised by Some about the Scope of the Surgeon's Responsibility

Several proposed gaps fell in areas of preoperative and postoperative care that at least some orthopedists considered to be the responsibility of PCPs or anesthesiologists. These included the gaps related to discontinuing anticoagulants (gap 1), secondary prevention of future fractures (gap 4), and readmissions in general (gap 11). For gaps 1 and 4, some panelists countered that these were still important opportunities for orthopedists to make a difference, and these ended with high median importance ratings. The gap related to cardiovascular risk stratification (gap 14) was also questioned due to belief that this responsibility lies more with the anesthesiologist and PCP, as well as a sense that this is already a well-established standard of care that is not frequently overlooked. By contrast, panelists were enthusiastic about the gap regarding the assessment of bleeding risks (gap 2) because of the potential to tailor therapy according to risk factors, addressing surgeons' specific concerns about bleeding from postoperative anticoagulation.

Some Gaps Would Be Better Targeted with System Changes Other Than Clinical Decision Support

For three gaps, panelists commented that they would be better addressed through system changes other than CDS. These were the gaps dealing with hair removal (gap 27), care coordination (gap 12), and documentation of radiology findings in the medical record (gap 20).

Some Gaps Were Considered to Be Clinically Inconsequential or Infrequent

At least some panelists questioned the clinical relevance for several of the proposed gaps. These included those related to documentation of surgical indications (gap 23), physical exams (gap 19), and findings in operative notes (gap 16). The gap related to offering regional anesthesia (gap 17) was questioned by some, who felt that the choice probably does not affect clinical outcomes. Finally, as mentioned earlier, some panelists considered the gap related to preoperative cardiovascular workup (gap 14) to be relatively infrequent.

Some Gaps Were Inadequately Specified as Written

Panelists commented that the concepts of a "comprehensive" radiologic evaluation (gap 21), a "metabolic derangement" (gap 18), and "postoperative hemorrhage" (gap 22) were not defined with sufficient specificity for the gap statement to be considered important.

Finally, there was no discussion to indicate why the proposed gap related to preoperative antibiotic prophylaxis (gap 8) did not achieve agreement on importance.

Clinical Decision Support Opportunity Compatibility and Importance Ratings

Based on initial importance ratings, 11 gaps were taken into the next stage for the completion of specific CDS opportunity statements. However, after late rating submissions were collected from a few panel members, five of these 11 dropped into the indeterminate agreement range. We nonetheless proceeded with CDS opportunity rating for all 11 gap statements.

Panelists were provided a list of example CDS opportunities for each highly rated performance gap. The list of candidate CDS opportunities was not exhaustive, and panelists were asked to consider these examples or others they could imagine would be helpful in closing the performance gap. Panelists were then instructed to provide ratings of the CDS opportunities at two levels for each of the 11 performance gaps:

- *Overall for the collection of example candidate CDS opportunities for an individual gap.* Panelists were given examples of possible CDS opportunities for each gap statement and asked to consider whether these examples or other potential CDS opportunities would make the specified performance gap a high-priority target for CDS (see Table 3.3).
- *At the level of the individual candidate CDS opportunities,* presented as example CDS tools or CDS concepts for each gap. Panelists were asked to consider whether this specific CDS opportunity would be rated highly as a means to close the specific performance gap (see Table 3.4).

Table 3.3 shows the *overall* CDS compatibility and impact ratings for the six gap statements that were rated with agreement as good CDS opportunities (medians in the 7–9 range). Among these, only three were rated with agreement among the panel as having CDS opportunities that would have high impact and be compatible with workflow. Thus, the panel results imply that CDS targeting bleeding risk stratification (gap 2), administration of VTE prophylaxis (gap 3), and preoperative testing (gap 5) should be considered the highest priority for implementation. Agreement was indeterminate for the workflow compatibility of CDS targeting the preoperative discontinuation of anticoagulants (gap 1), for the potential impact of CDS targeting the prevention of future osteoporotic fractures (gap 4), and for both the impact and compatibility of CDS targeting improved discharge instructions (gap 6).

Among the *individual CDS opportunities* presented as examples, only four were rated with agreement as having both high potential impact and high compatibility (Table 3.4). Two of these are order sets (for VTE prophylaxis with customization based on the patient's bleeding risk and for preoperative laboratory testing) and two are "smart-form" documentation templates (for VTE risk factors and for future fracture risk and prophylaxis prior to discharge).

The information contained in Table 3.4 is a subset of the information shown in Table 3.3. Table 3.4 contains only the individual CDS opportunities that were rated with agreement and were rated 7–9 on potential impact and compatibility. These highly rated CDS opportunities may differ from the high-priority gap statement/CDS opportunity sets highlighted in Table 3.3. This occurs when an individual CDS opportunity received a high rating but the overall set of opportunities did not. For example, for gap statements 2, 3, 4, and 5, a single CDS opportunity among the set of opportunities considered was found to exceed our cutoffs for potential impact and workflow compatibility.

Table 3.3. High-Priority Clinical Decision Support Targets for Orthopedics: Important Performance Gaps Rated as Having High-Impact and Highly Compatible Clinical Decision Support Opportunities Overall

Gap	CDS Targets (gap statement with example CDS opportunities)	Potential Impact: Median	Potential Impact: Dev	Potential Impact: Agreement	Compatibility: Median	Compatibility: Dev	Compatibility: Agreement
2[a]	Patients are not always assessed preoperatively for their bleeding and VTE risks, resulting in prophylaxis that does not match the patient's risk. a. Smart form that captures bleeding and VTE risk factors and recommends a prophylaxis strategy in accordance with guidelines b. Alert if prophylaxis plan is inadequate for estimated VTE risk.	8.0	0.6	A	9.0	0.7	A
3[a]	Patients undergoing total hip or total knee replacement surgery may not receive VTE prophylaxis when it is indicated. a. Automatically calculate and display estimate of VTE risk based on patient's lab values and medical history. b. Order set for VTE prophylaxis that recommends treatment customized to patient's bleeding risk and that conforms to guidelines c. Alert if prophylaxis plan is inadequate for estimated VTE risk.	8.0	0.7	A	8.0	0.9	A
5[a]	Patients who undergo total hip or total knee replacement surgery may not receive certain necessary preoperative tests, while others may undergo unnecessary testing. a. Preoperative order set that includes recommended preoperative tests based on a patient's medical history and review of systems b. Link to guidelines specifying appropriate preoperative tests c. Alert for incomplete or undocumented test result that is recommended based on patient's medical history and review of systems.	7.0	0.8	A	8.0	0.6	A
1	Some patients taking coumadin or clopidogrel do not always discontinue their therapy or switch to short-term anticoagulation therapy in advance of total hip or total knee replacement surgery. a. Preoperative visit follow-up form that gauges understanding of what patient needs to do prior to surgery b. Reminder to contact patient at the time when anticoagulation therapy should be discontinued	7.0	1.2	A	8.0	1.1	I
4	Many patients who undergo surgery for hip fracture fail to receive follow-up risk assessment and therapy to prevent future osteoporotic fractures. a. Smart form that captures risk factors for subsequent fractures and recommends orders for tests and treatments based on results b. Display fracture history, risk factors, and current fracture-prevention medications. Alert triggered by delay or inaction on positive finding from follow-up risk assessment.	7.0	1.4	I	7.0	1.3	A

Gap	CDS Targets (gap statement with example CDS opportunities)	Potential Impact: Median	Potential Impact: Dev	Potential Impact: Agreement	Compatibility: Median	Compatibility: Dev	Compatibility: Agreement
6	Patients who undergo total hip or total knee replacement surgery may not receive written discharge instructions, including plans for follow-up, activity restriction, anticoagulation, and dental prophylaxis.	7.0	1.0	I	7.0	0.9	I
	a. Discharge care planning tool covering multiple visits that can be tailored based on patient's needs						
	b. Links to educational materials that can be tailored to patient's needs and given to patients						
	c. Reminder to generate and review discharge care plan with patient prior to discharge						

NOTE: In the "Potential Impact: Agreement" and "Compatibility: Agreement" columns, A = agreement; I = indeterminate. Dev = mean absolute deviation from median.

[a] Meets criterion for high-priority CDS target by virtue of having the potential for CDS with high impact and high workflow compatibility.

Table 3.4. High-Priority Individual Clinical Decision Support Opportunities for Orthopedics Rated as Having High Impact and Compatibility (Targeting Important Performance Gaps)

CDS Opportunity	Gap Statement with Highly Rated CDS Individual Opportunities	CDS Opportunity Type	Potential Impact: Median	Potential Impact: Dev	Compatibility: Median	Compatibility: Dev
1	Some patients taking coumadin or clopidogrel do not always discontinue their therapy or switch to short-term anticoagulation therapy in advance of total hip or total knee replacement surgery. None of the individual CDS opportunities considered had agreement on both the impact and compatibility rating criteria.[a]	n/a	n/a	n/a	n/a	n/a
2a	Smart form that captures bleeding and VTE risk factors and recommends a prophylaxis strategy in accordance with guidelines (addressing gap 2: "Patients are not always assessed preoperatively for their bleeding and VTE risks, resulting in prophylaxis that does not match the patient's risk")	D	8.0	0.6	8.0	0.7
3b	Order set for VTE prophylaxis that recommends treatment customized to patient's bleeding risk and that conforms to guidelines (addressing gap 3: "Patients undergoing total hip or total knee replacement surgery may not receive VTE prophylaxis when it is indicated")	O	9.0	1.1	8.0	1.1
4a	Smart form that captures risk factors for subsequent fractures and recommends orders for tests and/or treatments based on results (addressing gap 4: "Many patients who undergo surgery for hip fracture fail to receive follow-up risk assessment and therapy to prevent future osteoporotic fractures")	D	8.0	1.1	8.0	0.8
5a	Preoperative order set that includes recommended preoperative tests based on a patient's medical history and review of systems (addressing gap 5: "Patients who undergo total hip or knee replacement surgery may not receive certain necessary preoperative tests, while others may undergo unnecessary testing")	O	8.0	0.8	8.0	0.5
6	Patients who undergo total hip or total knee replacement surgery may not receive written discharge instructions, including plans for follow-up, activity restriction, anticoagulation, and dental prophylaxis. None of the individual CDS opportunities had agreement on both the impact and compatibility rating criteria.[b]	n/a	n/a	n/a	n/a	n/a

NOTE: In the "CDS Opportunity Type" column, A = alerts or reminders, D = documentation forms or templates, O = order set or ordering tool, P = protocol or pathway support, R = relevant data presentation, and S = smart links to reference information. Dev = mean absolute deviation from median.

[a] CDS opportunities the panel reviewed for gap 1 were (1) preoperative visit follow-up form that gauges understanding of what the patient needs to do prior to surgery and (2) reminder to contact the patient at the time when anticoagulation therapy should be discontinued.

[b] CDS opportunities the panel reviewed for gap 6 were (1) discharge care planning tool covering multiple visits that can be tailored based on the patient's needs, (2) links to educational materials that can be tailored to the patient's needs and given to the patient, and (3) reminder to generate and review the discharge care plan with the patient prior to discharge.

Key Themes Emerging from the Discussion of Clinical Decision Support Opportunities by the Orthopedics Panel

Many Had Concerns about Burdensome Workflows

Several panelists expressed concerns about the "uncompensated work" and other burdens that could be introduced by CDS—in particular, those targeting the gaps in performing reviews of systems (gap 2), discontinuation of anticoagulants (gap 1), and prevention of readmissions (gap 11). CDS for acting postoperatively to prevent readmission (gap 11) was considered worrisome by orthopedists because it implied responsibility for obtaining and acting on information, such as medication adherence; this has not traditionally been in the surgeon's domain. Several gaps also had to do with the PCP interface, and orthopedists were uncertain that CDS interventions would sufficiently improve this interface.

Concerns about the Availability of Standard Order Sets

A concern specific to order sets (in particular, gap 5, for preoperative testing) was the lack of available standard order sets and the lack of support in some EHRs for order sets. However, a counter comment was that there would be potential for establishing a national clearinghouse for order sets from different sources to be shared.

Concern about Validity of Automated Assessments

One concern specifically raised related to CDS questionnaires that would automatically document the patient's understanding of surgical informed consent (gap 11) was that the assessment might not be valid and yet it would tie the surgeon's hands or create liability if it suggested that the patient did not understand the informed consent. A similar concern was expressed for smart forms that would aid in preoperative noncardiac risk stratification (gap 7).

CHAPTER FOUR. PEDIATRICS RESULTS

PANEL COMPOSITION

The pediatrics panel was designed to elicit CDS MU targets for children and adolescents who are typically treated in primary care settings. Unlike our approach for the oncology and orthopedic surgery panels, we placed few restrictions on the clinical focus of the pediatrics panel with one exception: We focused on conditions that were most likely to be managed by general pediatricians rather than pediatric specialists. Thus, although numerous quality measures have been developed in the areas of childhood cancers, pediatric end-stage renal disease (ESRD), pediatric HIV, and pediatric gastroenteritis, to name a few, we excluded these conditions because they might represent only a small proportion of cases seen by general pediatricians. Separate panels might be convened in the future to develop CDS targets for pediatric subspecialists.

The AMA PCPI had not previously convened a panel of general pediatricians to develop performance measures on multiple clinical conditions, so we constructed a panel of pediatricians by selecting from members of existing panels that focused on pediatric asthma, major depressive disorder (MDD), and diabetes. We also invited additional experts in pediatric health services research to ensure a broader representation of clinical areas. We recruited a total of 15 experts to serve on the panel, including two panel co-chairs. Table 4.1 summarizes the specialties of the 12 panelists who completed all ratings.

Table 4.1. Pediatric Panelists by Specialty

Specialty	Panelists
Family practice	1
General pediatrics	5
Hospitalist/critical care	2
Pediatric allergy	1
Pediatric behavioral health	2
Pediatric otolaryngology	1
Total number of panelists	12

GAP STATEMENT IMPORTANCE RATINGS

Table 4.2 displays the rating results from the pediatrics Delphi panel process, with the gap statements ordered by their median importance rating. Twenty-four of the 28 performance gap statements ultimately attained a median rating in the *important* range (median score 7–9), but, among these, only 15 met the criterion for statistical *agreement* among panelists. The other nine

gaps rated as *important* exhibited *indeterminate* agreement. The remaining four gap statements were given *equivocal* importance ratings. All four statements had medians in the 4–6 range; three showed *indeterminate* agreement, while one satisfied the formal criteria for *disagreement*. The one area that provoked disagreement among panelists was on the relative importance of failing to provide recommended levels of lead screening (gap 28).

Table 4.2(a). Final Pediatrics Gap Statement Ratings: Gap Statements Rated Important with Agreement

Gap	Gap Statement	Median	Dev
1	Children and adolescents fail to receive all recommended immunizations.	9.0	0.6
2	Children with MDD often receive inadequate follow-up care after receiving initial prescription for antidepressants.	9.0	0.9
3	Children with asthma treated in inpatient or ED settings may not receive adequate follow-up care or discharge planning.	8.5	0.8
4	Children with asthma are not routinely monitored for control of their condition.	8.0	0.5
5	Many children presenting with acute respiratory tract infection symptoms are inappropriately diagnosed with bacterial illness.	8.0	0.6
6	Many children receive antibiotics for pharyngitis without first being tested for group A streptococcus.	8.0	0.6
7	Children with ADHD who initiate medications may not receive optimal dose titration.	8.0	0.6
8	Diagnosis of ADHD is often made without adequate documentation of DSM-IV or DSM-PC criteria.	8.0	0.7
9	Many sexually active adolescent women do not receive periodic chlamydia screening.	8.0	0.8
10	Children with ADHD who are in the maintenance phase of medication therapy often receive inadequate follow-up care to reassess behavioral symptoms.	8.0	0.9
11	Children are inadequately assessed for risk of suicide.	8.0	1.0
12	Children do not always undergo developmental and behavioral screening using standardized assessments.	7.5	1.3
13	Many children with autism spectrum disorders are not diagnosed in a timely manner.	7.0	0.7
14	Many children are not screened for depression.	7.0	0.9
15	Children and their parents are not routinely screened for tobacco use, and, among children and their parents who smoke, providers often fail to ask about their interest in quitting, to give advice to quit, or to offer tobacco cessation interventions.	7.0	1.1

NOTE: ED = emergency department. ADHD = attention deficit hyperactivity disorder. DSM-IV = Diagnostic and Statistical Manual of Mental Disorders, 4th Edition. DSM-PC = Diagnostic and Statistical Manual for Primary Care. Dev = mean absolute deviation from median.

Table 4.2(b). Final Pediatrics Gap Statement Ratings: Gap Statements Rated Important but with Indeterminate Agreement

Gap	Gap Statement	Median	Dev
16	Not all non–critically ill hospitalized children receiving nephrotoxic medications are monitored for nephrotoxic medication associated acute kidney injury.	8.0	1.2
17	Many children with asthma fail to have spirometry performed to assess asthma control and severity as outlined in national guidelines, resulting in undertreatment with controller medications.	8.0	1.4
18	Many children treated for bacterial upper respiratory infections receive second-line antibiotics rather than first-line antibiotics.	7.0	0.7
19	Infants and children are inadequately screened and treated for iron deficiency anemia.	7.0	0.9
20	Diagnoses of MDD are often made without the use of patient interviews.	7.0	1.1
21	DSM-IV criteria are often poorly documented among patients with MDD.	7.0	1.1
22	Many children at risk for developmental delays do not receive adequate follow-up care.	7.0	1.3
23	Environmental risks are not routinely assessed for children with asthma, and parents are not always advised on risk mitigation.	7.0	1.4
24	Children often fail to receive nutrition and physical activity counseling.	7.0	1.6

NOTE: Dev = mean absolute deviation from median.

Table 4.2(c). Final Pediatrics Gap Statement Ratings: Gap Statements Rated in the Equivocal Range

Gap	Gap Statement	Median	Dev
25	Children under the age of six years are not routinely monitored for fluoride intake.	6.0	1.1
26	Many children hospitalized with a diagnosis of bronchiolitis inappropriately receive systemic corticosteroid therapy.	6.0	1.1
27	Children often have poor documentation of their BMI and the corresponding percentile of the population distribution.	5.5	1.8

NOTE: BMI = body mass index. Dev = mean absolute deviation from median.

Table 4.2(d). Final Pediatrics Gap Statement Ratings: Gap Statements Rated with Disagreement

Gap	Gap Statement	Median	Dev
28	Children fail to receive recommended levels of lead screening.	4.5	1.8

NOTE: Dev = mean absolute deviation from median.

KEY THEMES EMERGING FROM THE DISCUSSION OF CLINICAL PERFORMANCE GAPS BY THE PEDIATRICS PANEL

Performance Gaps May Be Due to Variation in Resources Across Settings and May Not Be Amenable to Clinical Decision Support

Certain performance gaps may be caused by structural problems of the health care delivery system rather than information deficiencies and therefore may not be amenable to CDS. Panelists indicated that inadequate referral for follow-up care is a challenge in practice settings with limited resources. For example, developmental specialists and psychiatrists may not be readily available

in these settings and may contribute to low rates of referral for follow-up care for children at risk of developmental delays (gap 22) and for children with depression (gap 2). Lack of insurance coverage for certain services may also limit a physician's ability to secure additional follow-up care. Two areas that were cited by panelists were referrals for children with developmental delays and referral for spirometry testing (gap 17). Subsequent discussion of the CDS opportunities for gaps associated with follow-up care focused on enhancing communication between providers rather than promoting greater levels of care because the lack of resources for follow-up care in a community may make such an outcome unattainable. One panelist recommended that CDS opportunities to address these types of gaps should provide some form of guidance in cases in which specialty referral is an unlikely option; otherwise, CDS would add little value.

Financial and Nonfinancial Incentives and Provider Perceptions, Rather Than Information Problems, May Cause Many Gaps

Performance gaps that result from misaligned incentives may also be poor targets for CDS. Panelists identified the underuse of spirometry testing (gap 17) as one gap associated with such causes. Panelists indicated that the failure to perform spirometry tests was mainly a problem of lack of staff training in how to do the test and how to interpret it, and the gap "would not change no matter what CDS is delivered." Part of the explanation might be that physicians believe that the test adds little beyond their own physical examination. Another panelist argued that providers are reluctant to refer patients to pulmonologists for spirometry testing because they end up "taking our patients" and causing pediatricians to "lose business." Panelists also felt that inappropriate diagnosing of bacterial infection (gap 5) may not be a suitable target for CDS. Some panelists believed that physicians were not making diagnostic errors but were deliberately changing diagnoses to justify the use of antibiotics (presumably because doing so provided reassurance to patients). Others thought that there was some information component to this gap and that CDS that improved the accuracy of diagnosing bacterial and viral infections (particularly around sinusitis) would have some benefit.

Need for Screening Gaps as Well as Treatment Gaps

Performance gaps for many childhood conditions may involve both inadequate screening and inadequate treatment for a given condition. The need for a gap relating to depression screening, to serve as a complement to gap 10, which involved follow-up care for children receiving antidepressant medication, emerged during the first teleconference and was appended before the first rating of gaps (gap 14). Gaps relating to documentation might ultimately enhance screening, but panelists might not have rated these gaps highly if they perceived that documentation alone would not lead to better care. For example, poor documentation of BMI

(gap 27) was given relatively low priority (median 5.5) because some panelists felt that "documentation doesn't do anything; counseling is needed."

Gaps Associated with Shifting Evidence or Limited Evidence May or May Not Be Considered High Priority

One panelist questioned whether poor documentation of BMI (gap 27) should be considered by the panel because the utility of BMI is "currently being questioned in the literature." Another panelist agreed, arguing that "docs were pushing back hard on this measure" at a recent pediatric advisory panel. A third panelist argued that prioritizing the 15-minute dietary or exercise counseling visit, which is not evidence based, may have unintended consequences by "taking something else that is evidence-based off the patient agenda for that session." One panelist also raised the concern that practice guidelines do not address the cost-effectiveness of strep testing and that CDS applications that encouraged greater use of strep testing prior to issuing antibiotic prescriptions (gap 6) may have limited value. On the other hand, panelists indicated that criteria used to assess asthma control have been a moving target in the guidelines and that CDS opportunities that facilitate monitoring of asthma control according to guidelines (gap 4) would be valuable.

Some Gaps Were Inadequately Specified

Greater specification of gaps might have changed panelists' focus and suggested different types of CDS opportunities. One panelist argued that inadequate follow-up care following the prescribing of antidepressants (gap 2) should be more concretely defined in terms of specific assessments, including sleep, stress, and school performance; assessment of suicidality; and response to medication; all of which should occur within a couple of weeks of prescribing. Similarly, panelists indicated that there are specific guidelines about the type of follow-up care that is recommended shortly after prescribing a new ADHD medication (gap 7). To some panelists, gaps would have been better specified had they emphasized early follow-up rather than focusing on "inadequate levels of treatment." One panelist argued that the "use of patient interviews" to diagnose MDD (gap 20) was inadequately specified and that the contents of the interview needed to be described in greater detail.

Difficulty Specifying the Target Population

The significant disagreement we observed about the importance of lead screening (gap 28) seemed to revolve around the specification of the appropriate target population. Although many recognized that screening was easy and the consequences of lead poisoning were lethal, others argued that lead screening had low specificity. Moreover, one panelist argued that this was an

important gap in some geographic areas (e.g., large metropolitan areas) but not others. Some panelists felt that focusing on high-risk patients would be helpful and that this represented an ideal CDS opportunity by being able to target screening to high-risk patients. Another example is that panelists felt that it would be difficult to operationalize a definition of "at risk for developmental delay" and would therefore be challenging to identify these children to refer them for additional follow-up care (gap 22).

Disagreement about the Appropriate Action That Clinical Decision Support Should Prompt

CDS is designed to support one or more clinical actions to address a particular performance gap. However, because panelists varied in their perception of the effectiveness of certain actions, they did not always agree on the most appropriate clinical action that CDS should be prompting. Some panelists felt that nutrition and physical activity counseling (gap 24) was important, while others were concerned that CDS should not be "forcing this intervention on physicians" because the effectiveness of counseling "depends highly on the patient's unique social and economic environment." In addition, panelists tended to view the key obstacle to achieving higher childhood immunization rates as the completeness of patients' records. Thus, the gap might have focused on this aspect and CDS opportunities might have focused on actions involving better communication rather than alerting or ordering applications.

CLINICAL DECISION SUPPORT OPPORTUNITY COMPATIBILITY AND IMPORTANCE RATINGS

A total of 14 performance gaps were advanced to the second step in the panel process, in which panelists rated CDS opportunities paired with these high-priority clinical performance gaps. Ratings were conducted both on the overall *set* of CDS opportunities for each of the 14 performance gaps and on the individual CDS opportunities within each set. Table 4.3 shows the overall CDS compatibility and impact ratings for 11 of the 14 gap statements for which panelists ultimately agreed that the gap was *important*.[7]

Panelists were provided a list of example CDS opportunities for each highly rated performance gap. The list of candidate CDS opportunities was not exhaustive, and panelists were

[7] Although 15 performance gaps were ultimately rated as important with agreement, three panelists submitted their performance gap ratings after the first round of CDS opportunity ratings had commenced. Thus, the set of performance gaps for which CDS opportunities were rated did not reflect the final set of 15 high-importance gaps. A total of 14 performance gaps proceeded to the second stage of rating (CDS opportunity ratings), and only 11 of these gaps were ultimately rated as important with agreement when the scores from all panelists were tallied. We present the CDS opportunity ratings for these 11 gaps but present key themes from all 14 CDS opportunity sets considered by the panel.

asked to consider these examples or others they could imagine would be helpful in closing the performance gap. Panelists were then instructed to provide ratings of the CDS opportunities at two levels for each of the 11 performance gaps:

- *Overall for the collection of example candidate CDS opportunities for an individual gap.* Panelists were given examples of possible CDS opportunities for each gap statement and asked to consider whether these examples or other potential CDS opportunities would make the specified performance gap a high-priority target for CDS (see Table 4.3).
- *At the level of the individual candidate CDS opportunities,* presented as example CDS tools or CDS concepts for each gap. Panelists were asked to consider whether this specific CDS opportunity would be rated highly as a means to close the specific performance gap (see Table 4.4).

Table 4.3 shows the *overall* CDS compatibility and impact ratings for the 11 gap statements. Only three of the 11 gaps had a median rating in the high range (7–9) for both potential *impact* and *compatibility* and met the criterion for *agreement* for both criteria among the panelists. *These overall rated sets are considered high-priority CDS opportunities.* Of the remaining sets of CDS opportunities, four had equivocal ratings on potential impact or compatibility with workflow (none had equivocal ratings on both). Meanwhile, four CDS opportunity sets were rated as having high impact and being highly compatible, but panelists failed to attain statistical agreement on one of the two criteria (*potential impact* in each case).

Among the *individual CDS opportunities* paired with each high-priority performance gap, ten out of a total of 35 received high median rating scores (7–9) indicating high *potential impact* and high *compatibility* and that statistical *agreement* was reached on both dimensions (Table 4.4). Eighteen CDS opportunities received equivocal ratings on one or both criteria, while seven received either indeterminate or disagreement ratings on one or both criteria. Of the ten highly rated individual CDS opportunities achieving *agreement*, two are order sets, three are alerts or reminders, two are documentation forms or templates, one is for relevant data presentation, and two are for protocol or pathway support. The rating results at this more granular level may be useful for EHR vendors considering what types of CDS interventions practitioners rated highest and viewed as potentially helpful in addressing high-priority performance gaps.

The information contained in Table 4.4 is a subset of the information shown in Table 4.3. Table 4.4 contains only the individual CDS opportunities that were rated with agreement and were rated 7–9 on potential impact and compatibility. These highly rated CDS opportunities may differ from the high-priority gap statement/CDS opportunity sets highlighted in Table 4.3. This occurs when an individual CDS opportunity received a high rating but the overall set of opportunities did not. For example, for gap statements 4, 7, and 10, a single CDS opportunity

among the set of opportunities considered was found to exceed our cutoffs for potential impact and workflow compatibility.

Key Themes Emerging from the Discussion of Clinical Decision Support Opportunities by the Pediatrics Panel

Clinical Decision Support Opportunities Relating to Follow-Up Care Were Not Well Specified

Panelists felt that the CDS opportunities proposed to improve follow-up care for asthma, depression, and ADHD (gaps 2, 3, and 10) did not fully address each gap and would not improve levels of follow-up care. Data displays or tools that generated care plans were felt by panelists to be too indirect to be useful. In particular, panelists thought discharge planning tools (opportunities 3a and 3b) offered limited value because they did not involve the follow-up doctor and it was unclear to panelists how the PCP would get this information. Alerts to warn physicians about missed visits and enhanced communication tools to alert PCPs about utilization (particularly hospital or ED care) were considered to be far superior because they might activate follow-up care processes by the patient's primary care provider. However, these CDS opportunities were not available for rating, and our process did not provide an opportunity for panelists to nominate additional CDS opportunities (although co-chairs did participate in constructing the set of CDS opportunities for rating).

Clinical Decision Support Opportunities Involved the Wrong Provider or Workflow

Panelists thought that longitudinal follow-up planning following an asthma hospitalization should not occur in an ED setting (opportunity 3b) and would be more appropriately handled by the patient's PCP. Panelists also noted that the timing of alerts was critical to their effectiveness and was often underspecified in the description of CDS opportunities. For example, alerts relating to inadequate documentation of DSM-IV criteria for MDD (opportunity 21c) would need to be concurrent with the input of data in order to be effective. Panelists also noted that children are often commonly identified as having developmental delays in the school setting, suggesting that a different set of tools and workflows might be needed to enhance communication between providers and schools.

Health Information Exchange Is Needed for Many Clinical Decision Support Tools

To improve immunization rates, panelists indicated that providers need current information about immunizations received in the past—data that might exist at multiple locations (opportunities 1a–1d). Without health information exchange, CDS opportunities involving alerts (opportunity 1d) would be highly problematic in this context due to the high levels of missing data. Moreover, an alert does not address the most important action, which is the retrieval of data

on the patient's immunization history. One panelist felt that connecting to an electronic registry would be the most effective solution rather than trying to mine data within a provider's EHR. Similarly, alerting of PCPs about a patient's elevated suicide risk (opportunity 11c) was thought to be challenging outside of closed systems because of the need for data exchange. Because risk factors change frequently, displaying suicide risk factors during clinic visits (opportunity 11b) may be misleading if they do not reflect current data. For depression in particular, children may be cared for by psychiatrists or other health professionals, in addition to the child's pediatrician, so communication between providers may be needed to optimize outcomes. Panelists also commented that enhancing communication between a child's PCP about elevated suicide risk could violate Health Insurance Portability and Accountability Act of 1996 (HIPAA) (Pub. L. 104-191) and federal or state regulations (opportunity 11c).

Clinical Decision Support Tools Might Not Be Sensitive to the Unique Characteristics of Individual Patients

Some of the CDS opportunities rated by panelists were thought to allow inadequate tailoring of decisionmaking to a patient's unique circumstances. For example, panelists were unsure whether CDS tools could appropriately automate dose titration of ADHD medications (opportunity 7c). According to one panelist, "many psychosocial factors go into determining stimulant regimens." Panelists also thought that prediction rules may also be inadequately sensitive. Risk factors for suicide, in particular, were described as too general, and panelists said that CDS tools involving suicide risk prediction would produce too many false positives and lead to alert fatigue (opportunities 11a and 11c). On the other hand, some panelists thought that at least some basic information on suicide risk could be successfully elicited without too much noise being introduced.

Panelists Highlighted Incomplete Specification of and Missing Clinical Decision Support Opportunities

Panelists thought that CDS tools to enhance diagnosis of ADHD might be more useful if they "guided clinicians to consider alternative diagnoses" (opportunity 8a). Several CDS opportunities involved providing links to parent educational materials or discharge plans (opportunities 3b and 5b), but the way in which this information would be used was not clearly specified. For example, whether patients were provided with a link to a website or whether providers would download, print, and orient patients to these materials was not clear, and different options might have a significant impact on clinical workflow. Panelists identified a range of other potential CDS opportunities that might have enhanced our original set, including decision support around the selection of selective serotonin reuptake inhibitors (SSRIs) for

children and adolescents (for which only two are U.S. Food and Drug Administration [FDA] approved). Panelists also recommended CDS tools to screen for suicidal thinking when a child has started an SSRI. Panelists also noted that inpatient admissions or ED visits for asthma represented an ideal opportunity to teach patients about asthma, but we did not include CDS opportunities involving patient engagement in this area. Specification of CDS opportunities might have been enhanced by linking opportunities to specific tools that are already on the market and potentially widely used. For example, the Centers for Disease Control and Prevention (CDC) has a vaccine scheduler that is available online (opportunity 1c), and the National Initiative for Children's Healthcare Quality (NICHQ) ADHD toolkit has screening tools and management plans that largely resembled CDS opportunities that we included (e.g., opportunity 7a) and might have simplified the rating task.

Table 4.3. High-Priority Clinical Decision Support Targets for Pediatrics: Important Performance Gaps Rated as Having High-Impact and Highly Compatible Clinical Decision Support Opportunities Overall

Gap	CDS Targets (gap statement with example CDS opportunities)	Potential Impact: Median	Potential Impact: Dev	Potential Impact: Agreement	Compatibility: Median	Compatibility: Dev	Compatibility: Agreement
1[a]	Children and adolescents fail to receive all recommended immunizations. a. Display immunization history and highlight missing immunizations. b. Order set that includes all recommended immunizations c. Tool to facilitate scheduling of immunizations according to recommended sequence and timing d. Alert for missing immunizations, with link to order set.	7.5	1.1	A	8.0	0.4	A
3	Children with asthma treated in inpatient or ED settings may not receive adequate follow-up care or discharge planning. a. Smart form that customizes discharge plan according to patient's asthma-related needs and risks b. Tool that creates longitudinal follow-up plan for adjusting medication therapy and seeing specialists when indicated	7.0	1.6	I	8.0	0.8	A
4[a]	Children with asthma are not routinely monitored for control of their condition. a. Documentation template that includes items needed to assess asthma control b. Display recent health care utilization, symptoms, and medication refill data. c. Asthma order set that prioritizes agents according to effectiveness, safety, and cost d. Pathway to guide dose escalation or medication substitution e. Alert to assess control if too much time has elapsed between assessments.	7.0	0.9	A	7.0	0.8	A
7[a]	Children with ADHD who initiate medications may not receive optimal dose titration. a. Smart form for ADHD encounter that captures changes in symptoms and medication side effects and recommends options for dose titration b. Display office visit utilization data, behavioral symptom history, and medication data during patient encounter. c. Tool that automatically develops a care plan (including dose titration) over multiple visits	7.0	0.8	A	7.0	0.4	A
8	Diagnosis of ADHD is often made without adequate documentation of DSM-IV or DSM-PC criteria. a. Diagnostic assessment template for ADHD that includes all DSM-IV criteria b. Reminder to document DSM criteria triggered by new diagnosis of ADHD	7.0	1.2	I	7.0	1.2	A

Gap	CDS Targets (gap statement with example CDS opportunities)	Potential Impact: Median	Potential Impact: Dev	Potential Impact: Agreement	Compatibility: Median	Compatibility: Dev	Compatibility: Agreement
9	Many sexually active adolescent women do not receive periodic chlamydia screening. a. Smart form that includes sexual history and orders for chlamydia testing, if indicated b. Order form that includes chlamydia test as part of routine screening tests based on patient's age and sexual history c. Reminder to conduct yearly chlamydia screening on patients who report being sexually active	7.0	0.7	I	7.0	0.8	A
10	Children with ADHD who are in the maintenance phase of medication therapy often receive inadequate follow-up care to reassess behavioral symptoms. a. Display office visit utilization data and behavioral symptom history during patient encounter. b. Tool that automatically develops a maintenance therapy care plan over multiple visits c. Alert triggered by drug or office visit utilization patterns that deviate deviation from care plan.	7.0	1.0	I	7.0	0.6	A
2	Children with MDD often receive inadequate follow-up care after receiving initial prescription for antidepressants. a. Display data on current and past history of antidepressant use and adherence. b. Order set that prioritizes medications based on effectiveness, safety, or cost data c. Protocol for antidepressant switching or dose escalation for treatment-resistant depression d. Alert triggered if MDD patient is not on medication and has not been referred for further evaluation.	6.5	1.6	I	7.0	1.1	I
5	Many children presenting with acute respiratory tract infection symptoms are inappropriately diagnosed with bacterial illness. a. Smart form to document signs or symptoms of bacterial infection (or their absence) and to order "cold kit" or antibiotics, if appropriate b. Links to parent education materials relating to antibiotics for URIs	6.5	1.2	I	7.0	0.9	I
11	Children are inadequately assessed for risk of suicide. a. Smart form that elicits suicide risk and alerts provider if symptoms endorsed b. Display suicide risk factors during subsequent clinic visits. c. Alert to PCP about elevated suicide risk if patient is being seen by non-PCP.	6.0	1.1	I	7.0	0.8	I

Gap	CDS Targets (gap statement with example CDS opportunities)	Potential Impact: Median	Potential Impact: Dev	Potential Impact: Agreement	Compatibility: Median	Compatibility: Dev	Compatibility: Agreement
6	Many children receive antibiotics for pharyngitis without first being tested for group A streptococcus.	5.5	1.3	I	7.5	1.1	A
	a. Smart form that prompts for appropriate strep testing based on clinical findings						
	b. Protocol to automate ordering appropriate antibiotics based on strep test results, patient weight, allergies, and other characteristics						
	c. Link to treatment guidelines for pharyngitis						
	d. Alert if pharyngitis is entered as a diagnosis without a strep test being ordered.						

NOTE: URI = upper respiratory infection. A = agreement. I = indeterminate. Dev = mean absolute deviation from median.

[a] Meets criterion for high-priority CDS target by virtue of having the potential for CDS with high impact and high workflow compatibility.

Table 4.4. High-Priority Individual Clinical Decision Support Opportunities for Pediatrics Rated as Having High Impact and Compatibility (Targeting Important Performance Gaps)

CDS Opportunity	Gap Statement with Highly Rated Individual CDS Opportunities	CDS Opportunity Type	Potential Impact: Median	Potential Impact: Dev	Compatibility: Median	Compatibility: Dev
1a	Display immunization history and highlight missing immunizations (addressing gap 1: "Children and adolescents fail to receive all recommended immunizations")	R	8.5	0.7	8.0	0.9
1b	Tool to facilitate scheduling of immunizations according to recommended sequence and timing (addressing gap 1)	P	8.0	0.6	7.5	1.3
1c	Alert for missing immunizations, with link to order set (addressing gap 1)	A	8.0	0.6	8.0	0.9
2	Children with MDD often receive inadequate follow-up care after receiving initial prescription for antidepressants. (No CDS opportunities with agreement)	n/a	n/a	n/a	n/a	n/a
3	Children with asthma treated in inpatient or ED settings may not receive adequate follow-up care or discharge planning. (No CDS opportunities with agreement)	n/a	n/a	n/a	n/a	n/a
4a	Pathway to guide dose escalation or medication substitution (addressing gap 4: "Children with asthma are not routinely monitored for control of their condition")	P	7.0	0.4	7.0	0.8
5	Many children presenting with acute respiratory tract infection symptoms are inappropriately diagnosed with bacterial illness. (No CDS opportunities in agreement)	n/a	n/a	n/a	n/a	n/a
6	Many children receive antibiotics for pharyngitis without first being tested for group A streptococcus. None of the individual CDS opportunities had agreement on both the impact and compatibility rating criteria.[b]	n/a	n/a	n/a	n/a	n/a
7a	Smart form for ADHD encounter that captures changes in symptoms and medication side effects and recommends options for dose titration (addressing gap 7: "Children with ADHD who initiate medications may not receive optimal dose titration")	D	8.0	0.6	7.0	0.8
8a	Diagnostic assessment template for ADHD that includes all DSM-IV criteria (addressing gap 8: "Diagnosis of ADHD is often made without adequate documentation of DSM-IV or DSM-PC criteria")	D	8.0	1.2	7.0	1.3
8b	Reminder to document DSM criteria triggered by new diagnosis of ADHD (addressing gap 8)	A	7.0	0.8	7.0	1.3
9a	Order form that includes chlamydia test as part of routine screening tests based on patient's age and sexual history (addressing gap 9: "Many sexually active adolescent women do not receive periodic chlamydia screening")	O	7.0	0.8	7.0	0.8
9b	Reminder to conduct yearly chlamydia screening on patients who report being sexually active (addressing gap 9)	A	8.0	0.7	7.0	0.9

CDS Opportunity	Gap Statement with Highly Rated Individual CDS Opportunities	CDS Opportunity Type	Potential Impact: Median	Potential Impact: Dev	Compatibility: Median	Compatibility: Dev
10a	Tool that automatically develops a care plan (including dose titration) over multiple visits (addressing gap 10: "Children with ADHD who are in the maintenance phase of medication therapy often receive inadequate follow-up care to reassess behavioral symptoms")	P	7.5	0.7	7.0	1.0
11	Children are inadequately assessed for risk of suicide. None of the individual CDS opportunities had agreement on both the impact and compatibility rating criteria.[a]	n/a	n/a	n/a	n/a	n/a

NOTE: In the "CDS Opportunity Type" column, A = alerts or reminders, D = documentation forms or templates, O = order set or ordering tool, P = protocol or pathway support, R = relevant data presentation, and S = smart links to reference information. Dev = mean absolute deviation from median.

[a] CDS opportunities the panel reviewed for gap 11 were (1) smart form that elicits suicide risk and alerts the provider if symptoms are endorsed, (2) display suicide risk factors during subsequent clinic visits, and (3) alert to PCP about elevated suicide risk if the patient is being seen by a non-PCP.

[b] CDS opportunities the panel reviewed for gap 6 were (1) smart form that prompts for appropriate strep testing based on clinical findings; (2) protocol to automate ordering appropriate antibiotics based on strep test results, patient weight, allergies, and other characteristics; (3) link to treatment guidelines for pharyngitis; and (4) alert if pharyngitis is entered as a diagnosis without a strep test being ordered.

CHAPTER FIVE. PERCUTANEOUS CORONARY INTERVENTION PANEL RESULTS

PANEL COMPOSITION

The PCI panel was constructed, in part, to determine whether condition-specific or procedure-specific panels might also be more useful for eliciting CDS targets than panels defined according to specialty. For this panel, we focused on the management of both ACS and stable CAD. Because this was our only condition-specific panel, we sought input from a wide range of specialties, including interventional and noninterventional cardiologists, as well as internists and electrophysiologists.

At the outset, the panel was made up of 15 physicians, including two panel co-chairs. Thirteen of the panelists completed all ratings. Table 5.1 provides a breakdown of the panelists by specialty.

Table 5.1. Percutaneous Coronary Intervention Panelists by Specialty

Specialty	Panelists
Interventional cardiology	6
Cardiology	4
Internal medicine	1
Electrophysiology	2
Total number of panelists	13

GAP STATEMENT IMPORTANCE RATINGS

Table 5.2 shows the final importance ratings for each performance gap statement. In this table, gaps are sorted by order of agreement, and the median and standard deviation are provided. *Agreement* indicates a narrow range of final ratings, *indeterminate* indicates a wider range, and *disagreement* indicates a very wide range. For the PCI panel, 18 of the 23 performance gaps received ratings of "high importance" (median ≥7). Among these, 11 exhibited statistical agreement. These 11 performance gap statements were considered to be highest priority, and the panel considered CDS opportunities for these gaps. Due to the late submission of performance gap ratings from one panelist, a 12th performance gap that was initially classified as high priority and associated with agreement was subsequently found to have an indeterminate rating but nevertheless moved on for the consideration of CDS opportunities. Thus, a total of 12 CDS opportunity sets were considered. Five of the 23 gaps had a median score of six, thereby classifying these gaps as having "uncertain" importance. No gaps were characterized as having "low importance" or disagreement.

Table 5.2(a). Final Percutaneous Coronary Intervention Gap Statement Ratings: Gap Statements Rated Important with Agreement

Gap	Gap Statement	Median	Dev
1	Nearly half of patients with STEMI receive no reperfusion therapy or receive delayed reperfusion (>12 hours after onset).	9.0	0.8
2	Some patients never fill prescriptions for clopidogrel therapy following DES implantation.	8.0	0.7
3	Many patients undergoing PCI are not prescribed statins at discharge despite having no contraindications.	8.0	0.7
4	Many patients discontinue clopidogrel therapy within six months of DES implantation (12 months of continuous therapy are recommended).	8.0	0.8
5	Many high-risk patients with non-STEMI fail to receive early invasive care, while many low-risk patients receive early invasive care unnecessarily.	8.0	0.9
6	Wide regional variation in rates of elective PCI suggests that some patients may not be appropriate candidates for elective PCI.	8.0	1.4
7	Many STEMI patients who are candidates for primary PCI receive PCI outside of the recommended door-to-balloon time (i.e., 90 minutes).	7.0	0.6
8	Many STEMI patients who are candidates for thrombolysis receive the treatment outside of the recommended door-to-needle time (i.e., 30 minutes).	7.0	0.9
9	The indications for PCI and stent selection (e.g., angina status, prior medical therapy, anatomical findings, flow) are often poorly documented.	7.0	0.9
10	Many patients undergoing PCI have limited understanding about the relative benefits and risks of the procedure.	7.0	0.9
11	Patients sometimes receive DESs despite being at high risk for nonadherence to the long-term antiplatelet therapy required (for financial or other reasons).	7.0	1.1

NOTE: DES = drug-eluting stent. Dev = mean absolute deviation from median.

Table 5.2(b). Final Percutaneous Coronary Intervention Gap Statement Ratings: Gap Statements Rated Important but with Indeterminate Agreement

Gap	Gap Statement	Median	Dev
12	The differential benefits, risks, and follow-up care required for DESs versus bare metal stents are often not discussed with the patient prior to his or her undergoing PCI.	7.0	0.9
13	Antithrombotic therapies prescribed to patients with STEMI or non-STEMI receive dosages in excess of best practice recommendations.	7.0	1.1
14	Patients with chronic kidney disease sometimes receive coronary angiography without having received adequate prehydration for the procedure.	7.0	1.1
15	Some patients experience preventable bleeding complications after PCI due to the cumulative effect of anticoagulants and antiplatelet agents given in the perioperative and interoperative period.	7.0	1.1
16	Few patients with CAD have access to personal health data or tools that can help them manage their condition.	7.0	1.1
17	Many patients referred for coronary CTA for an evaluation of CAD are asymptomatic, and rates of cardiac MRI and cardiac CT procedures vary widely across regions.	7.0	1.2
18	Non-STEMI is often diagnosed based on enzyme markers (e.g., troponin) that have poor specificity, leading to overdiagnosis.	7.0	1.3

NOTE: CTA = computed tomography angiography. MRI = magnetic resonance imagery. CT = computed tomography. Dev = mean absolute deviation from median.

Table 5.2(c). Final Percutaneous Coronary Intervention Gap Statement Ratings: Gap Statements Rated in the Equivocal Range

Gap	Gap Statement	Median	Dev
19	Many STEMI patients are not referred for cardiac rehabilitation despite having no contraindications.	6.0	0.7
20	Not every facility monitors radiation exposure to patients undergoing cardiac procedures.	6.0	1.0
21	Many STEMI patients who receive primary PCI outside of the recommended door-to-balloon time are better candidates for thrombolysis.	6.0	1.1
22	Wide variation exists in the amount of contrast used for coronary angiography.	6.0	1.2
23	Many STEMI patients who are candidates for PCI receive thrombolysis instead.	6.0	1.4

NOTE: Dev = mean absolute deviation from median.

KEY THEMES EMERGING FROM THE DISCUSSION OF CLINICAL PERFORMANCE GAPS BY THE PERCUTANEOUS CORONARY INTERVENTION PANEL

Focus on Decisionmaking Too Far Downstream to Be Clinically Useful or Better Addressed by Other Types of Physicians

Panelists felt that the most important issue regarding appropriate use of PCI (gap 6) was actually the decision to refer patients for angiography and whether patients have had adequate medical therapy or documentation of objective evidence of myocardial ischemia. In order to have a major impact, panelists argued, CDS should focus on "upstream decisions," such as determining "who qualifies for coronary angiography." Similarly, some experts thought that poor documentation of indications for PCI and stent selection (gap 9) were more upstream from interventionalists and that cardiologists should provide informed consent and document relevant information before the patient visits the catheterization lab. The main rationale underlying this perspective was that interventionalists often do not see patients in their offices prior to the intervention—even for elective cases. One panelist thought discontinuation of clopidogrel therapy was a problem that arose "after the interventionalist has finished working with the patient" and thus the responsibility of someone else (gap 4).

Targets for Clinical Decision Support or System Reengineering

Panelists tended to endorse the view that certain gaps were more amenable to the reengineering of systems than to real-time decision support. This theme arose mainly during discussions of two gaps—both involving the delivery of treatment for patients with ACS. For example, one panelist indicated that the failure to deliver thrombolysis within the recommended door-to-needle time (gap 8) might be addressed through retrospective review to identify problems that would allow providers to "figure out what [they would] do better next time." Similarly, one panelist argued that a CDS application to support the decision to recommend thrombolysis to patients for whom PCI is likely to be delayed (gap 21) was less preferable than a "systems"

approach to the problem. This expert indicated that most hospitals have a protocol and "know what they'll do when a patient arrives."

Inadequate Evidence about the Gap

Panelists indicated that performance measures relating to cardiac MRI and cardiac CT imaging were still in development, and there was "not great evidence about which screening test one should get." Thus, there was limited interest by the panel in pursuing performance gaps related to rates of referral for these procedures (gap 17). Moreover, although some panelists felt that "the overuse of imaging and over-interpretation of imaging was driving unnecessary intervention," others felt that CTA was not a potent driver of PCI utilization. Another panelist felt that the much larger problem was inappropriate use of angiography rather than use of CTA itself.

Gaps Relating to Patient Centeredness Were Given High Priority

Several gaps were identified by panelists as being highly patient centered and tended to result in rich discussions. One panelist called discussions about risks, benefits, and follow-up care related to stent selection (gap 12) to be "a marker of how well the interventionalist is engaging the patient." Panelists also emphasized that many physicians do not understand the magnitude of the problem of patients' misconception of the risks and benefits of PCI (gap 10). Panelists discussed success stories in which hospitals have been successful in making linkages with their EHRs to provide this information to patients, particularly examples from physicians at the Mayo Clinic and St. Luke's Mid America Heart Institute.

Some Gaps Involve Political Battles That Are Better Avoided

The political climate surrounding certain issues can be a consideration in whether to select certain performance gaps to represent CDS targets. Panelists indicated that overuse of cardiac CT and MRI were important gaps, but "politically, our ability to deal with it is in its infancy, so it is hard to build consensus and implement [CDS]." In addition, panelists were divided in their opinions about addressing overdiagnosis of non-STEMI (gap 18). Although some felt that troponin serves as a "crutch that ED physicians use instead of taking a good history" and that the condition is often diagnosed, others argued that "the problem is with the definition in our profession of what a non-STEMI is." Although this gap was rated high priority, it also had a fairly large standard deviation.

Some Gaps Were Defined Too Narrowly

Panelists felt that the need to monitor patients' cumulative exposure to radiation (gap 20) was more than an issue relating only to cardiac procedures and one that involved noninvasive

cardiac imaging, as well as noncardiac imaging. Moreover, panelists noted that patients will move across settings and CDS will have to be able to incorporate data from multiple facilities. This gap received an uncertain rating (median 6.0). Another example of a gap with a potentially overly narrow scope was gap 3, which involved underuse of statin prescribing at discharge from the catheterization lab. Two panelists raised questions about whether dosing should be incorporated in the gap statement and, in particular, whether CDS should provide guidance about dosing because there can be much larger benefit for patients who begin therapy at higher doses.

CLINICAL DECISION SUPPORT OPPORTUNITY COMPATIBILITY AND IMPORTANCE RATINGS

Panelists were provided a list of example CDS tools or tool concepts for each highly rated performance gap. The list of candidate CDS opportunities was not exhaustive, and panelists were asked to consider these examples or others they could imagine would be helpful in closing the performance gap. Panelists were then instructed to provide ratings of the CDS opportunities at two levels for each of the 11 performance gaps:

- *Overall for the collection of example candidate CDS opportunities for an individual gap.* Panelists were given examples of possible CDS opportunities for each gap statement and asked to consider whether these examples or other potential CDS opportunities would make the specified performance gap a high-priority target for CDS (see Table 5.3).
- *At the level of the individual candidate CDS opportunities,* presented as example CDS tools or CDS concepts for each gap. Panelists were asked to consider whether this specific CDS opportunity would be rated highly as a means to close the specific performance gap (see Table 5.4).

Table 5.3 shows the *overall* CDS compatibility and impact ratings for the 11 gap statements that made it to the second stage of rating. The potential CDS opportunities for each gap statement are listed under the given gap. The overall gap statement/CDS opportunity sets that were rated with agreement and received a rating of 7–9 on all three criteria (importance of gap statement, compatibility of the CDS opportunity, and impact of CDS opportunities) were considered *high-priority CDS targets*.

Among the *individual CDS opportunities* paired with high-priority performance gaps, 11 of the 34 considered by the panel were highly rated, receiving scores that indicated *both* high *potential impact* and high *compatibility* (median ratings between 7 and 9) and achieved *agreement* (Table 5.4).

The information contained in Table 5.4 is a subset of the information shown in Table 5.3. Table 5.4 contains only the CDS opportunities that were rated with agreement and were rated 7–9 on potential impact and compatibility. These highly rated CDS opportunities may differ from the high-priority gap statement/CDS opportunity sets highlighted in Table 5.3. This occurs when an

individual CDS opportunity received a high rating but the overall set of opportunities did not. For example, for gap statements 4, 5, 8, 9, and 10, a single CDS opportunity among the set of opportunities considered was found to exceed our cutoffs for potential impact and workflow compatibility.

Key Themes Emerging from the Discussion of Clinical Decision Support Opportunities by the Percutaneous Coronary Intervention Panel

Clinical Decision Support Opportunities Focused on the Wrong Physician

One panelist argued that an EHR-based flow sheet that guided ED physicians in the selection of treatment strategies for non-STEMI was not relevant because treatment strategy was not a decision typically made by the ED physician but something that is determined "on the floor" (opportunity 5a). Similarly, there was concern that the decision to triage patients presenting to the ED with possible STEMI might be inappropriate for an ED attending and that this decision is "fairly nuanced" and may not be amenable to being "reduced to a checklist" (opportunity 7a). Ensuring that a CDS tool is focused on the right person who can act is one of the CDS Five Right" identified in the HIMSS CDS tool kit (HIMSS, forthcoming).

Wrong Specification of Workflow

To improve documentation of indications for PCI and the selection of stents, panelists felt that this gap would be better filled through CDS that was implemented during a catheterization procedure rather than in an office setting and that the wording of the CDS opportunities should be changed accordingly. Others felt that the accuracy of documentation would be problematic—particularly for borderline cases. CDS tools relating to the generation of appropriateness ratings of PCI were found by multiple panelists to be incompatible with workflow because information on coronary anatomy would be available only midprocedure (opportunities 18a–18d). The CDS Five Rights also address the issue of inserting CDS at the right point in the workflow as critical to successful implementation of a CDS tool.

Missing Data Limits Feasibility of Clinical Decision Support Tools

Patients may not have a recent lipid profile at the time of PCI to appropriately inform statin prescribing at discharge (gap 3). In fact, even patients undergoing elective PCI are often seen for the first time the morning of the procedure. Another reason for missing data that limits the feasibility of CDS opportunities is information on medication fills—a challenge faced by physicians who practice in "open systems." Our experts were concerned about the technical feasibility of CDS involving medication adherence (opportunity 10c) because of the limited availability of these data. According to panelists, Surescripts is not able to provide complete data

at the present time, and these data are costly. Panelists also emphasized that these data "have to be cleaned up so that they are meaningful." As e-prescribing becomes widely adopted, however, panelists indicated, "potentially 95% of prescriptions will be available for evaluation."

Predictive Algorithms May Have Limited Validity

One panelist argued that factors that predict poor adherence to clopidogrel therapy may not be accurate (opportunity 11b) based on the panelist's own experience trying to develop such models. Also, panelists said that they fear that predictors of benefit relating to the selection of stents might have the unintended consequence of systematically recommending bare metal stents for minority populations. One panelist argued that there was "no good way to predict non-adherence other than talking to the patient and getting a feeling for [him or her]." Others felt that simple risk factors (e.g., lack of insurance, lack of social support) are reasonable enough for predicting adherence.

Some Clinical Decision Support Opportunities Pose Significant Implementation Challenges

CDS opportunities involving the combination of information across multiple sources, such as ECG data and time of symptom onset, were considered by some to be an "integration nightmare" and were "not ready for immediate, high priority use" (opportunities 1a–1c). In other cases, the theoretical basis for the tools was thought to be underdeveloped. For example, portals through which patients might access their personal health data (gap 16) were considered highly desirable, but such tools "would take a very sophisticated EHR," were "some years off," and would require "a lot of work before we know how to implement them." One panelist described this opportunity as "amorphous" and questioned how the technology would specifically enhance patient care. Another panelist questioned the feasibility of implementing such tools on a national scale.

Inadequate Evidence May or May Not Be a Deterrent for Specifying Clinical Decision Support Opportunities

When rating the compatibility and potential impact of links to American College of Cardiology (ACC)/American Heart Association (AHA) recommendations for antithrombotic therapy, as least one panelist indicated, these guidelines were well understood (opportunity 9b). What was most important to this panelist was having information on what regimen a patient was currently on without having to dig through paper charts. However, another panelist argued that, in this area, the science "shifts quickly," so it is hard for CDS to "get this right without being outdated rapidly," suggesting that there might be a role for CDS in providing current recommendations. Another panelist argued that prescribing the right doses of antithrombotic

therapy "appears to be a moving target with not a lot of agreement" and that implementing CDS in this area would be a way to get agreement in this area. Thus, it appears that some panelists viewed the process of specifying CDS targets for MU as a way of bringing attention to unresolved clinical debates. On other clinical topics, such as the overuse of cardiac CT and MRI (gap 17), several panelists indicated that the "indications were evolving," making the gap unsuitable for consideration.

Alerts May Contribute to "Fatigue" and Have Unintended Consequences, but Opinion Is Generally Mixed

The issue of alert fatigue came up several times. One panelist mentioned that a reminder to assess a patient's comprehension of risks and benefits of PCI (opportunity 10c) was an example of a low-value alert. For the treatment of STEMI, some panelists argued, pop-ups might have benefit by pushing the ED staff to get things done in the 90-minute window, while others indicated that pop-ups offered little value for emergency conditions, such as STEMI. One panelist was concerned that alerts that indicate that thrombolysis is being delayed (opportunity 8c) may have little marginal value and may, in fact, have unintended consequences by introducing a "shotgun behavior," especially for patients who have equivocal indications for the treatment.

Clinical Decision Support Opportunities Were Not Always Completely Specified

Panelists indicated that some opportunities they rated did not recommend specific courses of actions to take. For example, an alert that is triggered when door-to-balloon time exceeded 90 minutes (opportunity 7c) did not include specific guidance to inform decisionmaking beyond the alert itself.

Table 5.3. High-Priority Clinical Decision Support Targets for Percutaneous Coronary Intervention: Important Performance Gaps Rated as Having High-Impact and Highly Compatible Clinical Decision Support Opportunities Overall

Gap	CDS Target (gap statement with example CDS opportunities)	Potential Impact: Median	Potential Impact: Dev	Potential Impact: Agreement	Compatibility: Median	Compatibility: Dev	Compatibility: Agreement
1[a]	Nearly half of patients with STEMI receive no reperfusion therapy or receive delayed reperfusion (>12 hours after onset). a. EHR-based flow sheet for suspected STEMI b. Display ECG data, TIMI/GRACE scores, and likely time of symptom onset. c. Alert to inform ED physician and staff of possible ACS diagnosis triggered by abnormal biomarkers.	8.0	0.4	A	7.0	0.5	A
3[a]	Many patients undergoing PCI are not prescribed statins at discharge despite having no contraindications. a. Documentation template for statin history, dose, and side effects b. Order set that includes statins along with other medications commonly prescribed at discharge from the catheterization lab c. Support for appropriate starting doses and appropriate steps for dose escalation based on CVD risk d. Reminder followed by alert to prescribe statin prior to discharge if not yet ordered	7.0	0.6	A	8.0	0.3	A
5[a]	Many high-risk patients with non-STEMI fail to receive early invasive care, while many low-risk patients receive early invasive care unnecessarily. a. EHR-based flow sheet that uses patient data to guide ED physicians into delivering early invasive or selective invasive strategies for non-STEMI b. Display TIMI or GRACE risk scores (or both) and other clinical data that facilitate triage. c. Reminder to calculate TIMI or GRACE scores for patients presenting with suspected ACS	7.0	0.8	A	8.0	0.5	A
6[a]	Wide regional variation in rates of elective PCI suggests that some patients may not be appropriate candidates for elective PCI. a. Display appropriateness rating or elements needed to determine appropriateness rating b. Order tool that requires input of data elements and returns appropriateness rating c. Critical pathway for elective PCI that specifies appropriate escalation of medical therapy and timing of PCI d. Alert if elective PCI is ordered for an inappropriate indication.	7.0	1.0	A	8.0	0.7	A
2	Some patients never fill prescriptions for clopidogrel therapy following DES implantation. a. Template that allows documentation of predischarge counseling about clopidogrel use b. DES discharge order set that includes outpatient clopidogrel prescription c. Alert if prescription not filled within expected window.	7.0	0.7	I	8.0	0.4	A

Gap	CDS Target (gap statement with example CDS opportunities)	Potential Impact: Median	Potential Impact: Dev	Potential Impact: Agreement	Compatibility: Median	Compatibility: Dev	Compatibility: Agreement
4	Many patients discontinue clopidogrel therapy within six months of DES implantation (12 months of continuous therapy are recommended). a. Smart form that displays fill status and allows documentation of counseling about clopidogrel adherence b. Display patient's refill history and factors predictive of adherence (e.g., insurance status). c. Alert if prescriptions not refilled within expected window.	7.0	0.8	I	8.0	0.5	A
9	The indications for PCI and stent selection (e.g., angina status, prior medical therapy, anatomical findings, flow) are often poorly documented. a. Documentation template to record indication for procedure during office visit b. Display lab values, imaging results, and other data needed to assign indication. c. Reminder to document indication for procedure or device prior to the procedure	8.0	1.1	I	8.0	0.5	A
8	Many STEMI patients who are candidates for thrombolysis receive the treatment outside of the recommended door-to-needle time (i.e., 30 minutes). a. EHR-based flow sheet for thrombolysis with target completion times per step and appropriate adjunct therapy b. Thrombolysis order set for STEMI to guide physician through what is needed, how to administer, and what to monitor c. Alert triggered when door-to-needle time has exceeded recommended benchmark	7.0	0.8	I	8.0	0.2	A
10	Many patients undergoing PCI have limited understanding about the relative benefits and risks of the procedure. a. Automated consent form that includes patient-specific benefit/risk data b. Link to educational materials that are archived and readily available to give to patients c. Reminder to assess patients' comprehension of risks and benefits prior to the procedure	7.0	0.8	I	8.0	0.5	A
7	Many STEMI patients who are candidates for primary PCI receive PCI outside of the recommended door-to-balloon time (i.e., 90 minutes). a. Smart form that presents ECG data and key milestone times, and includes a table for diagnosis, including LBBB and posterior MI, and automates catheterization lab activation after STEMI diagnosis if timing is deemed appropriate b. Application that utilizes patient onset of symptoms, known expected response times, and catheterization lab activation times to offer a prediction as to whether timely PCI is possible c. Alert triggered when door-to-balloon time has exceeded recommended benchmark	7.0	0.7	I	7.0	0.7	I

Gap	CDS Target (gap statement with example CDS opportunities)	Potential Impact: Median	Potential Impact: Dev	Potential Impact: Agreement	Compatibility: Median	Compatibility: Dev	Compatibility: Agreement
11	Patients sometimes receive DESs despite being at high risk for nonadherence to long-term antiplatelet therapy required (for financial or other reasons). a. Display risk factors for nonadherence. b. Link to patient education materials relating to risks of poor adherence.	7.0	0.8	I	7.0	0.7	A

NOTE: CVD = cardiovascular disease. LBBB = left bundle branch block. MI = myocardial infarction. Dev = mean absolute deviation from median.

[a] Meets criterion for high-priority CDS target by virtue of having the potential for CDS with high impact and high workflow compatibility.

Table 5.4. High-Priority Individual Clinical Decision Support Opportunities for Percutaneous Coronary Intervention Rated as Having High Impact and Compatibility (Targeting Important Performance Gaps)

Gap	Gap Statements with Highly Rated Individual CDS Opportunities	CDS Opportunity Type	Potential Impact: Median	Potential Impact: Dev	Compatibility: Median	Compatibility: Dev
1b	Display ECG data, TIMI/GRACE scores, and likely time of symptom onset (addressing gap 1)	R	7.0	0.7	7.0	0.8
1c	Alert to inform ED physician and staff of possible ACS diagnosis triggered by abnormal biomarkers (addressing gap 1: "Nearly half of patients with STEMI receive no reperfusion therapy or receive delayed reperfusion [>12 hours after onset]")	A	8.0	0.8	7.0	0.7
2	Some patients never fill prescriptions for clopidogrel therapy following DES implantation. (No CDS opportunities with agreement on both)	n/a	n/a	n/a	n/a	n/a
3b	Order set that includes statins along with other medications commonly prescribed at discharge from the catheterization lab (addressing gap 3: "Many patients undergoing PCI are not prescribed statins at discharge despite having no contraindications")	O	8.0	0.5	8.0	0.5
3d	Reminder followed by alert to prescribe statin prior to discharge if not yet ordered (addressing gap 3)	A	8.0	0.7	8.0	0.4
4c	Alert if prescriptions not refilled within expected window (addressing gap 4: "Many patients discontinue clopidogrel therapy within six months of DES implantation [12 months of continuous therapy are recommended]")	A	8.0	0.9	8.0	0.5
5b	Display TIMI and GRACE risk scores and other clinical data that facilitate triage (addressing gap 5: "Many high-risk patients with non-STEMI fail to receive early invasive care, while many low-risk patients receive early invasive care unnecessarily")	R	8.0	0.8	8.0	0.5
6a	Display appropriateness rating or elements needed to determine appropriateness rating (addressing gap 6)	R	7.0	0.7	8.0	0.5
6b	Order tool that requires input of data elements and returns appropriateness rating (addressing gap 6: "Wide regional variation in rates of elective PCI suggests that some patients may not be appropriate candidates for elective PCI")	O	8.0	1.0	8.0	0.6
7	Many STEMI patients who are candidates for primary PCI receive PCI outside of the recommended door-to-balloon time (i.e., 90 minutes). (No CDS opportunities with agreement on both)	n/a	n/a	n/a	n/a	n/a
8b	Thrombolysis order set for STEMI to guide physician through what is needed, how to administer, and what to monitor (addressing gap 8: "Many STEMI patients who are candidates for thrombolysis receive the treatment outside of the recommended door-to-needle time [i.e., 30 minutes]")	O	8.0	0.7	8.0	0.5

Gap	Gap Statements with Highly Rated Individual CDS Opportunities	CDS Opportunity Type	Potential Impact: Median	Potential Impact: Dev	Compatibility: Median	Compatibility: Dev
9c	Reminder to document indication for procedure or device prior to the procedure (addressing gap 9: "The indications for PCI and stent selection [e.g., angina status, prior medical therapy, anatomical findings, flow] are often poorly documented")	A	7.0	1.0	8.0	0.7
10a	Automated consent form that includes patient-specific benefit/risk data (addressing gap 10: "Many patients undergoing PCI have limited understanding about the relative benefits and risks of the procedure")	D	7.0	0.9	7.0	0.7
11	Patients sometimes receive DESs despite being at high risk for nonadherence to long-term antiplatelet therapy required (for financial or other reasons). (No CDS opportunities with agreement on both)	n/a	n/a	n/a	n/a	n/a

NOTE: In the "CDS Opportunity Type" column, A = alerts or reminders, D = documentation forms or templates, O = order set or ordering tool, P = protocol or pathway support, R = relevant data presentation, and S = smart links to reference information. Dev = mean absolute deviation from median.

CHAPTER SIX. DISCUSSION AND RECOMMENDATIONS

The federal MU incentive program for health information technology (HIT) includes CDS as a central feature for improving health outcomes; however, a process for identifying and selecting the most promising targets for CDS has not been established. To define requirements for CDS to support MU of EHRs, ONC faces a challenging set of demands. ONC is being asked to drive implementation of EHRs on a rapid timeline and to do so in a way that improves both clinical quality and population health outcomes. To accomplish these goals, ONC is being asked to engage health care providers and other stakeholders in a process for identifying CDS MU objectives across an array of specialties and to signal to EHR vendors the types of CDS tools that would support providers in meeting MU requirements. A structured process or framework for identification of high-priority CDS targets to help inform establishment of MU objectives will need to take into account the rapid timetable for advancing the requirements of MU, have methods for engaging health care providers and other relevant stakeholders, and allow for implementation in a feasible and cost-effective fashion.

The purpose of this project was to develop and pilot test a protocol for identifying high-priority CDS targets, which would then serve as a menu of options that ONC and policymaking bodies could use to set MU criteria for the use of CDS among clinical specialists. As detailed in Chapter One, ONC expects that these MU criteria will be *clinically meaningful* to specialists, *implementable* with current EHR technologies**,** and have a *measurable* impact on health. To meet these expectations, the approach to defining specialty-specific MU CDS should include

- a systematic, evidence-based process to prioritize the performance gaps within each specialty that are amenable to CDS
- an evaluation of existing CDS tools or CDS opportunities for tool development to address the prioritized gaps
- a rigorous quantitative process for eliciting expert feedback to prioritize performance gaps and associated CDS opportunities.

In Chapter One, we described the development of a detailed, yet feasible protocol that has these features. Chapters Two through Five provided a summary of the results of tests of this protocol in four specialty panels that were convened to represent a variety of dimensions of potential interest (i.e., clinical conditions, medical treatments, surgical care, nonsurgical invasive procedures, preventive care, and chronic disease management). In this chapter, we discuss key insights from the pilot testing of this protocol to refine the protocol for future applications, which can serve as a general framework for identifying high-priority CDS targets. The discussion of the lessons learned from the pilot test can help guide future stakeholder panel activities and improve

the acceptability and utility of recommendations about CDS to the large variety of stakeholders involved in promoting the MU of EHRs.

Representing Stakeholder Perspectives: Composition of Expert Panels

The composition of expert panels and the scope of their considerations are critical choices, and there are multiple ways in which panels can be configured. Although the results of each panel will be useful to inform policymaking related to defining CDS MU criteria, the results have an even broader utility to physicians, policymakers, payers, patients, and other stakeholders. A key consideration at this juncture is that stakeholders have a variety of goals that may be in tension with one another. The relative weight assigned to a goal may vary among stakeholders, and these trade-offs are important to recognize in the design of the panel process and, in particular, the composition of the panels. Potential and selected panelists could participate even prior to the panel in defining the goals and content that the panel will consider.

Stakeholders must resolve an important trade-off between the objective of achieving broad population health goals on the one hand and maximizing the health outcomes of patients with specific conditions on the other. The purpose of specialization in health care is to focus on patients with specific clinical conditions or those in need of special technical procedures, but CDS tools for specialists should, in the end, influence the quality and costs of care for populations over the full continuum of care (as opposed to fragments of care). Achieving technical excellence in specialized care may influence the health of the population, but these effects may be indirect. The degree of influence on the general population will depend on the prevalence of the condition, the reversibility of the condition based on current clinical science, and the achievable degree of improvement or stabilization of health outcomes.

The trade-off between population health goals and the clinical care goals for patients with specific conditions has implications for the composition of the panels and the clinical topics a panel will consider. The "specialty-focused" approach that we tested included representatives of a specific clinical specialty (or subspecialty) as defined by the specialty boards. This approach tends to emphasize CDS with the potential to provide benefit to patients treated in a specialty setting but may not adequately represent other perspectives related to issues, such as CDS, to support transitions to and from specialty care or a procedure (e.g., referrals and communication), CDS that supports interdisciplinary teams of specialists, and CDS that supports coordination with other types of facilities (such as long-term care). Inclusion of primary care, nonphysician professional stakeholders, patients, and others in panel processes that rate clinical performance gaps may ensure that the performance gaps are relevant and that the focus of specialty CDS opportunities is not overly narrow or applicable to very few patients. Furthermore, broader

inclusion of these other stakeholders at the front end of the process during the gap identification stage may also ensure that the focus for potential CDS applications represents the diverse views of the stakeholders who will be affected by these choices and who will be responsible for providing the full continuum of care.

Although our team initially considered broader perspectives in selecting specialties and clinical topics for the pilot, resource constraints did not allow us to fully test a broadly inclusive approach to panel composition. For example, we convened a multispecialty panel focused on PCI; however, an alternative approach might sought to identify high-priority CDS targets for the management of ACS or even more broadly for the management of chronic and acute CAD. These alternative panels—both in their composition and content focus—might have emphasized CDS to support the choice between PCI and medical therapy. Interestingly, our PCI panel discussion did address this broader context even though the panel did not include payer, patient, or government representatives. Striking the appropriate balance in the clinical conditions that are evaluated and the views that are represented is a key design choice, and one that needs to be carefully considered.

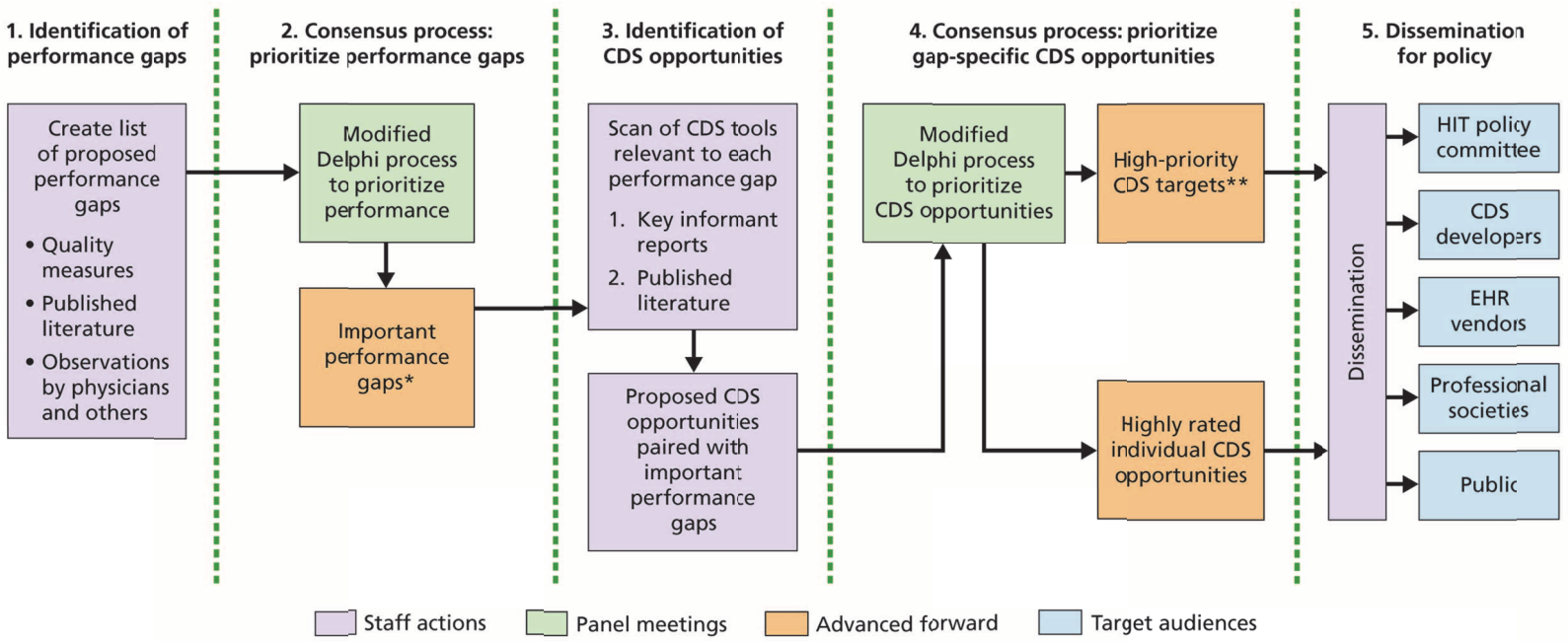
Similarly, the orthopedic panel we composed focused on hip and knee surgery, but, fairly early on in the panel process, the discussion broadened to include the perioperative management of orthopedic surgery patients more generally. We could have convened the panel to consider CDS for hip and knee pain to address a broader set of clinical issues. Our results suggest that a wider set of perspectives is achievable and desirable but that the selection of expert representatives will also need to be broader. In this example, the inclusion of PCPs in both instances and rheumatologists for the panel focused on hip and knee problems would have allowed for a broader set of perspectives on the management of patients and how CDS might enable improved management.

Panel composition must also be influenced by the need to represent relevant care settings and consider differences and challenges in incorporating CDS into the workflow. The combination of specialty, condition, and procedure typically defines specific workflows and locations. Surgical specialists may work in ambulatory offices, ambulatory surgical centers, and hospitals, which have different and potentially incompatible EHR systems that present differing opportunities for CDS. Emergency room physicians rarely venture outside of EDs and often use a single EHR system. Currently, these constraints define the scope of available CDS applications and the potential for new applications.

Insights About the Protocol for Prioritization of Clinical Decision Support Targets

Panel composition and the scope of the panel's focus and content will be resolved through an iterative process, potentially with guidance from other entities. Once those issues have been resolved, the panel moves through a protocol for identification and prioritization of specialty-specific CDS targets. Figure 6.1 outlines the protocol reflecting five phases of work necessary to generate the list of priority CDS targets. We highlight key insights about the five phases that were gained as a result of testing the protocol.

Figure 6.1. Protocol for Selecting High-Priority, Specialty-Specific Clinical Decision Support Targets



* Performance gaps rated with agreement as important targets for CDS; performance gaps not rated as important are dropped and do not move to CDS opportunity consideration.

** High-priority CDS targets are the performance gaps that were rated highly with agreement and that had high impact and compatible CDS opportunities; highly rated gaps without high impact and compatible CDS opportunities were dropped.

NOTE: HIT = health information technology.

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Identification of Performance Gaps (Phase 1 Work)

As the first step in the process, identification of performance gaps has a profound influence on the range of CDS applications that may be considered by a panel. Performance gaps can be conceptualized generally in two major categories—as a set of *suboptimal health outcomes* for a population and as a set of *delivery system failures* that lead to poor reliability of care delivery. Delivery system failures are an important cause of suboptimal health outcomes, although not the only cause because economic conditions, education, and other factors also play a crucial role. CDS applications modify health outcomes through the delivery system actions. Because CDS for specialties is typically embedded in the delivery system, it is tempting to focus on delivery system failures. However, both health outcomes and delivery system factors should be considered when defining performance gaps. Using population health outcomes to define performance gaps may identify areas for which there are few CDS applications. It is rare for CDS applications to map directly to health outcomes. One CDS application may affect many different health outcomes. Conversely, achieving a particular health outcome may require a variety of CDS applications applied across a range of specialties.

Identification of Clinical Decision Support Opportunities (Phase 3 Work)

We demonstrated the feasibility of obtaining ratings of CDS opportunities. Nevertheless, we also learned that there are formidable barriers to this approach that have to be considered carefully in interpreting the ratings. First, many CDS applications and tools are under development, but relatively few are currently used in practice. A focus on existing tools with evidence of effectiveness would create a narrow and highly constrained set of options. On the other hand, there are many futuristic concepts that have not yet been demonstrated in practice or studied for their effectiveness. Including the latter may produce CDS target priorities that are unrealistic and potentially counterproductive if applied in practice.

To strike balance between the constraint of existing tools on the one hand and untested but promising concepts on the other, we defined the "CDS opportunity," which consists of existing or proposed applications that could plausibly affect a performance gap and have either an evidence base (or, in the case of proposed applications, face validity) that support their capacity to improve practice. We defined a cluster of opportunities that could potentially address each clinical performance gap as a CDS target.

We learned that panelists needed to achieve familiarity with a set of CDS tools and the taxonomy of CDS tool types to participate effectively in the panel rating exercise and to understand how the tools could work. However, CDS applications are complex, and few panelists had experience with more than one or two CDS applications. Some had very limited exposure to

CDS applications. Taxonomies of CDS features are available, but they are somewhat unwieldy and not easy to convey to panelists in a short time frame to ensure that all have a common knowledge base for considering the CDS opportunities they are asked to rate.

CDS applications are highly context dependent, and a key consideration is the fit with clinical workflow for that specialty (or the system in which the provider operates). The value of CDS opportunities depends on an understanding of the way in which the CDS application would function in practice. To rate the compatibility and impact of a potential CDS opportunity, panelists must be able to envision the *insertion points in a clinical workflow* that would be amenable to a CDS application and who would be acting on the information at that point in the workflow. Some of these applications would be used by nonphysician members of the team, such as advanced practice nurses or medical assistants. Discussions during the pilot testing of the protocol revealed that physicians are capable of considering the compatibility of proposed CDS alternatives with their specialty-specific workflows. However, clinicians are not engineers (usually), so most are not accustomed to analyzing workflows. Workflow discussions were, for the most, part challenging, suggesting the need for background preparation of panelists with a set of materials that explain workflow and provide examples of workflow within the conditions, episodes, specialties, or procedures that they will consider. Panelists working in different settings (e.g., large integrated delivery systems versus independent practices) may have very different workflows for the same procedure. For example, the referral process for academic center cardiologists may be very different from the referral process for community-based cardiologists.

Last, our test process did not provide an opportunity for panelists to nominate additional CDS opportunities due to the tight scheduling between the second and third meetings. There were situations in which potential CDS opportunities that panelists could envision to address the gap were not available for rating.

Use of Consensus Process to Prioritize Performance Gaps and Clinical Decision Support Opportunities (Phase 2 and 4 Work)

Rating multiple dimensions of an unfamiliar set of constructs is a complex task. To simplify the rating task, we elected to separate it into two stages: (1) the rating of the importance of candidate clinical performance gaps and (2) the rating of the compatibility and potential impact of candidate CDS opportunities. Within each specialty panel, we convened a single panel of experts to accomplish both rating tasks.

There are some important reasons to separate these two rating tasks. One is the efficiency gained by reducing the number of gaps under consideration prior to introducing the CDS opportunities for rating. The process that we tested allowed for a 90-minute call to discuss the

initial ratings of CDS opportunities and then re-rate them; this would have been impossible without limiting the CDS opportunities to those that were applicable to high-priority gaps. Another is the distinct nature of the two rating tasks. For example, rating the importance of performance gaps may require relatively limited EHR or CDS expertise. Furthermore, a broad set of stakeholders might be capable of rating performance gaps but have limited knowledge of how EHRs are used at the point of care and where CDS could be integrated into the workflow; for the latter, physicians and nonphysician members of the care team might be best suited to evaluate the CDS opportunities. Rating the compatibility and impact of CDS opportunities requires a nuanced appreciation of clinical medicine and clinical practice. As noted earlier, different mixes of specialists could be included in each of these two phases to reflect the differing values and expertise required for each task. We found that the single panel for both phases created useful continuity of discussion and that the cumulative, iterative process led to a richer understanding among panelists of the relationship between performance gaps and CDS opportunities. This continuity could still be achieved in the alternative panel process by having a subset of those engaged in the first stage of rating the performance gaps involved in the second stage, when CDS opportunities are rated.

Recommendations for Future Specialty Panels

Although the core expert panel protocol we describe is feasible, robust, and produces quantitative and qualitative results that enhance the transparency of the expert panel process, we recommend additional actions to enhance future specialty panels.

Composition of Expert Panels

- *Convene a multistakeholder "steering committee" with broad representation of potential end users to select the specialties, subspecialties, and clinical content topics to be addressed by future specialty panels.* In the pilot project, the selection of specialties and clinical topics was determined by the research team in consultation with ONC staff. However, this process should be guided by a broader set of perspectives for a variety of reasons. There are potentially hundreds of combinations of specialty and clinical topic combinations that could be used to form panels. Clearly, some of these combinations may yield greater benefit in terms of closing performance gaps than others. If population health improvement and costs of care are prominent considerations, the selection of panels should be informed by inclusion of government, public, and payer representatives, as well as quality measurement and improvement professionals from health care organizations, and not just by specialty representatives. The most promising near-term opportunities for CDS development may be difficult to predict, so the steering committee should include experts with comprehensive knowledge of CDS development. It should also include experts in performance measurement who can assist strategic planning for measurements that will be used both to assess

adherence to ONC or Centers for Medicare and Medicaid Services (CMS) criteria for MU and to assess CDS's impact on performance gaps in the future.

- *Panels should be constituted based on the intersection of four dimensions of interest: (1) specialties, (2) conditions, (3) treatments or procedures, and (4) care delivery settings.* Choosing on one dimension invariably constrains the others. For example, choosing knee pain as a condition could involve primary care, rheumatology, and orthopedic specialists. Choosing orthopedic specialists and knee pain may constrain the panel to consideration of arthroscopy, surgery, and rehabilitation. Each of these configurations will have implications for the types of performance gaps, CDS opportunities, and, ultimately, CDS objectives that can be generated.

Identification of Performance Gaps

- *In identifying the preliminary list of performance gaps, draw on population health gaps and clinical delivery system gaps that may not yet be codified in performance measures.* Once the panel has been constituted and the scope and content of the panel's work has been specified, three important sources can be used to identify candidate performance gaps for the panel to consider: (1) quality measures (either nationally endorsed or locally implemented), (2) published literature (primarily epidemiology and health services research studies), and (3) the observations of practicing clinicians about gaps in care delivery. It seems desirable to ground the identification of performance gaps in the current set of nationally endorsed quality measures. However, the set of nationally endorsed quality measures is highly constrained largely because existing performance measures have been developed to cope with the historical difficulty of gaining access to useful clinical data using billing systems. Important gaps in daily practice may be ideal CDS targets but have not yet been specified as quality measures because of the lack of a suitable data collection mechanism or other issues that make measurement difficult.
- *Develop a method for broadly querying practicing clinicians or their representative societies about performance gaps.* The experiences of practicing clinicians working on the front lines of care delivery are sometimes overlooked as a source of important clinical performance gaps. Astute clinicians can observe directly the processes of care that are prone to break down within a specialty practice, across teams of specialists, and across settings of care. They may also observe directly which processes of care are especially amenable to CDS interventions because of their knowledge of the workflow that produces high-quality services for patients with specific conditions. There is not as yet a straightforward process for obtaining this sort of feedback from clinicians. Not all physicians have the perspective or background to identify these gaps. Professional societies may be able to identify prospectively a cadre of practicing clinicians with experience and interest in identifying these gaps. They may also advance the names of members of expert panels who can provide this feedback. A strategy for querying broadly to professional organizations may also be useful. Additionally, the Association of Medical Directors of Information Systems, a professional organization for physicians who are responsible for health IT, could be a useful vehicle for gaining access to physician informaticists who have frontline clinical expertise and knowledge of the capabilities and limitations of health IT systems. Electronic surveys of practicing clinicians asking them to nominate clinical

performance gaps that might be amenable to CDS may produce ideas for actionable CDS applications.

Identification of Clinical Decision Support Opportunities

- *Develop templates for describing CDS tools in a standardized format so that panelists are fully informed during discussion and rating tasks.* The portrayal of CDS tools may significantly influence panelists' ratings of those tools. CDS applications are complex, and many cannot be easily described in one or two sentences. A standard description of the key features of a CDS application and the evidence base that supports it may help to expedite the work of panelists and increase the validity and reliability of ratings of CDS opportunities. Such a template or standard description could be used to support standardized surveys of clinicians about the applications currently in use and to update a compendium of CDS applications (HIMSS, forthcoming).
- *Enhance panelist knowledge and consideration of clinical workflows before rating CDS opportunities.* The rating of CDS opportunities involves consideration of a variety of workflows and settings. Clinical care is not usually standardized across settings or organizations. The same operation (hip surgery) and its preoperative and postoperative care may be performed through very different workflows in different types of organizations. Panelists should appreciate both the common workflow elements and the variety of potential workflows in which CDS might be embedded. Workflow engineering is not a typical expertise of most clinicians. It may be useful to insert a step in the panel protocol that presents potential high-leverage workflow insertion points for CDS and allows the panelists to explicitly list the range of workflow scenarios they have considered. It may also be useful to include a workflow specialist on each panel. Alternatively, a small group of technical experts could take the output from the expert panels (e.g., the final list of CDS opportunities and targets) and use their knowledge of workflow and its variations to identify those CDS opportunities and targets that are both likely to be implemented in the short term and would be applicable across a reasonably large range of existing organizational workflows.
- *Create opportunities for panelists and outside experts to nominate additional CDS opportunities for the candidate performance gap statements.* This could be done prior to the panel process by consulting with clinicians with expertise in the area of clinical practice and with knowledge of CDS, as well as during the panel process drawing on the panelists' expertise. Building in sufficient time prior to and during the panel process for broader input regarding candidate CDS opportunities for identified performance gaps would expand and strengthen the final set of CDS opportunities that panelists rate.

Use of Consensus Process to Prioritize Performance Gaps and Clinical Decision Support Opportunities

- *Consider convening separate panels to prioritize performance gaps and CDS opportunities.* Each panel we convened considered and rated clinical performance gaps and then considered and rated CDS opportunities associated with the list of high-priority gaps. In some instances, it may be preferable to convene two separate panels—one that prioritizes performance gaps and can include broader specialty or stakeholder representation and a second panel that has technical expertise relevant

to the prioritized subset of performance gaps that emerges from the first panel. This can ensure that relevant expertise is available to address specific conditions, cross-specialty, or setting-specific issues.

- *Allow adequate time within the modified Delphi process to enable thorough discussion of the performance gaps and CDS opportunities between rating tasks.* A methodological approach to rating the appropriateness of care provides a transparent and rigorous basis for rating performance gaps and CDS opportunities. However, there are many nuances for panelists to consider in assessing performance gaps and significant complexity for panelists in assessing dozens of CDS opportunities. Thorough exchange between CDS experts and clinical practitioners appeared to identify CDS opportunities that might have little compatibility or impact in some specialty care settings. Allowing sufficient time for these discussions will undoubtedly enhance the practical applicability (and hence the impact) of CDS. Panelists may also request additional evidence based on these discussions. Allowing more than one discussion period could enable panelists to consider requested evidence and strengthen the validity of subsequent ratings.

In addition, although we established the feasibility of panels convened entirely by teleconference, we considered but did not test an important alternative approach: convening in-person panel meetings. In general, an initial in-person meeting may improve the quality of group dialogue and may allow for better engagement of panelists in the process overall. However, the need to process and analyze the ratings and develop and prepare content for each stage of the protocol based on the prior stage ratings requires more than a single meeting with a minimum of one- to two-week intervals between the meetings. This would imply either multiple in-person meetings or a single in-person meeting with follow-up teleconferences. The latter approach might enhance the quality of the output but at the additional cost of the in-person meeting.

Dissemination of Results

As Figure 6.1 implies, the prioritized CDS targets deriving from the panel process will be of interest to a wide variety of stakeholders. Policy committees may use the identified high-priority CDS targets to specify future MU criteria. The identified CDS targets can serve as a list of priorities for both CDS developers and performance measure developers seeking new areas for performance measure development for specialists. The highly rated individual CDS opportunities can also be used by EHR vendors to prioritize the CDS applications that they will offer or emphasize in their EHR products, including personal health record applications that could be used by patients. Professionals and professional societies can use the performance gap ratings to guide further refinement of guidelines that address performance gaps and to select areas for new quality measure development. Health care organizations are on the front line of having to implement CDS to meet MU criteria, and their engagement could improve the process and provide feedback at the point of implementation. Many other stakeholders may find the results useful to guide

public awareness campaigns, drive organizational quality improvement activities, and set payment incentives. The broad range of stakeholders implies that reporting and dissemination of expert panel results should be carefully calibrated to meet the needs of many different audiences. In some instances, this may require customized reports for specific stakeholder groups.

In summary, the pilot project demonstrates an expert panel process that can feasibly and effectively consider and prioritize specialty-specific CDS targets, based on high-priority performance gaps that can be associated with effective and feasible CDS opportunities. The resulting lists of performance gaps and CDS opportunities have a high degree of face validity. During the discussions that constitute the modified Delphi process, panelists also raise many issues that will inform CDS design and implementation. The process is rigorous, quantitative, and transparent. Our experience with the process also produced recommendations for those who will convene future specialty panels and raises considerations that may guide refinement of the panel protocol over time. We believe that these results point the way toward a national policy process for harnessing CDS to address needs across the full spectrum of health care delivery.

APPENDIX A. ONCOLOGY PANEL MATERIALS

GAP STATEMENT EVIDENCE DOCUMENT WITH PANELISTS' INPUT

Evidence on the Magnitudes and Consequences of Clinical Performance Gaps in Oncology

Table A.1. Estimates of Cancer Incidence and Mortality

Cancer	Number of Incident Cancers: Men	Number of Incident Cancers: Women	Number of Deaths
Breast cancer	n/a	207,090	39,840
Colorectal cancer	72,090	70,480	51,370
Prostate cancer	217,730	n/a	32,050
All cancers	789,620	739,940	569,490

SOURCE: Ledley and Lusted (1959).

Data sources used to estimate the magnitude of performance gaps:

- *Quality Oncology Practice Initiative (QOPI):* QOPI is a practice-based, voluntary, quality improvement program that assesses quality through three types of measures: consensus-derived factors determined by all QOPI participants, evidence-based standards, and items associated with patient/physician interactions generally required by organizations, such as the Joint Commission. Performance data are from the Fall 2010 report and include data submitted from 342 practice sites and up to 25,926 patients per indicator. QOPI granted permission to RAND to use aggregate data from the Fall 2010 report for the purposes of this project but not to include specific data; as a result, we have substituted specific data with x's. (QOPI, 2010).
- *National Initiative on Cancer Care Quality (NICCQ):* The NICCQ is a retrospective cohort study of a sample of patients with incident breast and colorectal cancer drawn from the National Cancer Data Base. Performance data are based on detailed medical record reviews and a patient self-report survey from five different sites across the United States (Malin et al., 2006).

Table A.2. Cancer-Specific Gaps (Breast Cancer and Colorectal Cancer)

Gap	Brief Title	Clinical Performance Gap	Magnitude of Performance Gap	Consequences of Performance Gap
19	Cancer family history documentation	Cancer patients often have poorly documented family histories.	x% of breast cancer patients do not have a documented family history in their medical record (practice range: x% to x%) (QOPI) x% of colorectal cancer patients do not have a documented family history in their medical record (practice range: x% to x%) (QOPI)	Physicians may be more likely to recommend risk reduction strategies for cancer patients with known family histories (Bevers et al., 2009), and physicians may be more likely to use treatment and surveillance protocols tailored to a patient's genotype (Church and Simmang, 2003).
18	Medical/surgical history documentation	Cancer patients often have poorly documented medical and surgical histories.	x% of patients with breast cancer do not have their medical/surgical history documented in their medical record (practice range: x% to x%) (QOPI). x% of patients with colorectal cancer do not have their medical/surgical history documented in their medical record (practice range: x% to x%) (QOPI).	Psychological distress, sexual dysfunction, infertility, impaired organ function, cosmetic changes, and limitations in mobility, communication, and cognition are among the many problems faced by cancer survivors (Hewitt and Ganz, 2006). Optimal patient management requires coordinating care for both cancer and noncancer medical conditions.
13	Pain assessment and pain management plan	The presence of pain and its intensity are inadequately assessed or quantified in cancer patients receiving chemotherapy or radiation therapy, and pain management plans are not routinely documented.	x% of cancer patients do not have their pain assessed by their second office visit (practice range: x% to x%) (QOPI) x% of cancer patients do not have their pain intensity quantified by their second office visit (practice range: x% to x%) (QOPI) x% of cancer patients do not have a plan of care for moderate or severe pain documented in their medical record by their second office visit (practice range: x% to x%) (QOPI)	Cancer pain represents one of the most feared consequences of cancer because of its debilitating symptoms and because patients may associate symptoms with global loss of control and death (Jacox et al., 1994; Greenhalgh and Hurwitz, 1998). An assessment as to whether pain is neuropathic, nociceptive, somatic, or visceral can influence initial selection of drug or nondrug therapy, including surgery or radiation therapy (Goudas et al., 2001). Unless cancer pain intensity is assessed systematically using a validated scale, it is difficult to judge the benefits, or lack of benefit, of any analgesic regimen or to compare one regimen with another (Goudas et al., 2001).

Gap	Brief Title	Clinical Performance Gap	Magnitude of Performance Gap	Consequences of Performance Gap
14	Inadequate pain treatment	Patients started on long-acting opioids do not always receive short-acting opioid formulations for breakthrough pain, and patients receiving chronic opioids do not always receive bowel regimens.	34% of cancer patients who have breakthrough pain report taking no new medication to control their pain (American Pain Foundation, undated). Based on population data from Quebec, 40% of patients who are prescribed chronic opioids and 37% of patients who are prescribed long-term chronic opioids do not receive a concomitant laxative or acid suppressant medication (Williams et al., 2008).	In a meta-analysis of studies on cancer pain, 53% of patients, on average, experienced pain, and, of the patients with pain, more than one-third graded their pain as moderate or severe (Beuken-van Everdingen et al., 2007). 40–80% of patients with advanced cancer experience breakthrough pain that significantly reduces their quality of life (Laverty, 2007). About 40% of patients taking chronic opioids for nonmalignant pain develop bowel dysfunction, including gastric emptying accompanied by increased gastroesophageal reflux and constipation (Thomas, 2008).
2	Documentation of staging	Cancer patients often have poorly documented information on staging.	21% of breast cancer patients have none of the following documented in their medical oncologist's medical record: AJCC stage, TNM stage, tumor size, lymph node status, or hormone receptor status (NICCQ). 63% and 30% of breast cancer patients lack documentation of staging in their surgical oncologist's and radiation oncologist's medical records, respectively (NICCQ).	Doctors at a large teaching hospital found that 7.8% of 340 breast cancer cases had pathology errors that were serious enough to require amended surgery plans (Staradub et al., 2002). A study by Susan G. Komen for the Cure estimates that as many as 2% to 4% of breast cancer diagnoses are inaccurate and may lead to incorrect treatment (Perkins, Balma, and Garcia, 2007).
1	Plan for chemotherapy documented	Patients undergoing chemotherapy often fail to have a current care plan documented.	37% (47%) of breast (colorectal) cancer patients do not have the planned chemotherapy dose documented in their medical record (NICCQ). 75% (81%) of breast (colorectal) cancer patients treated with chemotherapy do not have body surface area documented in their medical record (NICCQ). x% of cancer patients do not have a chemotherapy treatment plan that includes doses, route, and time intervals documented in their medical record (practice range: x% to x%) (QOPI)	Tailored chemotherapy plans that are provided to general practitioners have been shown to improve patients' satisfaction and confidence with their care. General practitioners report that tailored information sheets are more useful and instructive than standard correspondence (Jefford et al., 2008).

Gap	Brief Title	Clinical Performance Gap	Magnitude of Performance Gap	Consequences of Performance Gap
8	Chemotherapy intent discussed with patients	Patients are often unaware of the risks and benefits of chemotherapy, and their understanding of the treatment's intent (palliative versus curative) is often inadequately documented.	x% of patients have no documentation of the intent of chemotherapy in their medical records (practice range: x% to x%) (QOPI) x% of patients have no documentation of a discussion about the intent of chemotherapy in their medical records (practice range: x% to x%) (QOPI) x% of patients do not have either a signed consent form for chemotherapy in their medical record or documentation of consent in a practitioner note (practice range: x% to x%) (QOPI)	A survey of breast cancer patients, found that 60% of women overestimate their chance of being cured with adjuvant therapy (Siminoff, Fetting, and Abeloff, 1989). The majority of patients enrolled in phase I chemotherapy protocols believe that their therapy has a treatment aim as opposed to a research aim despite being given information that contradicted this (Schaeffer et al., 1996). A survey of women with breast cancer found that 68% of women did not achieve their preferred level of control in medical decisionmaking (Degner et al., 1997). Many patients want to receive more information on treatment options, to be given a choice, to have more discussion with their health care team, and to have providers better listen to their needs (Stacey, Paquet, and Samant, 2010).
4	Chemotherapy ordering	Prescribed chemotherapy regimens are not always concordant with standard regimens (as defined by evidence or consensus groups).	42% (32%) of breast (colorectal) cancer patients have planned doses that are inconsistent with published regimens (NICCQ). 17% of patients with stage II or III rectal cancer receive neoadjuvant chemotherapy or adjuvant chemotherapy that is inconsistent with published regimens and are not enrolled in a clinical trial (NICCQ).	Idiosyncratic deviation from predefined regimens may increase the risks of suboptimal care (due to undertreatment, toxicity related to overtreatment, or prescribing errors).
3	Errors in chemotherapy ordering	Many patients receiving chemotherapy are at risk of experiencing adverse events due to errors in chemotherapy ordering.	3% of outpatient chemotherapy orders placed in one cancer center were associated with errors (Gandhi et al., 2005).	A review of medication orders for adult patients undergoing chemotherapy found that 82% of chemotherapy errors had the potential to result in an adverse drug event (Gandhi et al., 2005). A review of oral chemotherapy medication errors found that 20% of errors resulted in adverse drug events (Weingart et al., 2010).
12	Treatment summaries documented and communicated	Chemotherapy and radiotherapy treatment summaries are not always fully documented or provided to patients or physicians providing continuing care.	x% of patients do not have a chemotherapy treatment summary completed within 3 months of chemotherapy cessation (practice range: x% to x%) (QOPI). x% of patients do not receive a copy of their chemotherapy treatment summary within 3 months of chemotherapy cessation (practice range: x% to x%) (QOPI). For x% of cancer patients, chemotherapy treatment summaries are not provided or communicated to their providers within 3 months of chemotherapy cessation (practice range: x% to x%) (QOPI).	Psychological distress, sexual dysfunction, infertility, impaired organ function, cosmetic changes, and limitations in mobility, communication, and cognition are among the many problems faced by cancer survivors (Hewitt and Ganz, 2006). Communication of these outcomes may optimize patient management.

Gap	Brief Title	Clinical Performance Gap	Magnitude of Performance Gap	Consequences of Performance Gap
7	Management of supportive care therapies	Many patients undergoing chemotherapy do not receive supportive care therapies, including potent antiemetic therapy and granulocyte-colony stimulating factor.	34% of patients who receive highly emetogenic chemotherapy fail to receive potent antiemetic therapy (NICCQ). x% of patients treated at practices participating in QOPI fail to receive antiemetics (practice range: x% to x%).	37% of patients with chemotherapy-induced nausea and emesis report reduced daily functioning, and 90% of patients with poorly managed nausea and emesis report a significant negative impact on daily functioning (Haiderali et al., 2010). Inadequately controlled emesis has been shown to be associated with lower adherence to treatment (Hesketh, 2008).
21	Smoking status and counseling	Cigarette smoking status is inadequately documented, and smoking cessation counseling therapy is not routinely provided to cancer patients.	x% of cancer patients do not have cigarette smoking status documented in their medical record by their second office visit (practice range: x% to x%) (QOPI) x% of cancer patients who are smokers do not have smoking cessation counseling offered to them by their second office visit (practice range: x% to x%) (QOPI)	Studies have shown that even brief counseling by health care providers increases smoking cessation rates, yet fewer than 50% of patients who smoke receive cessation counseling and treatment during physician office visits (Prokhorov et al., 2010). A study of smoking cessation interventions found that among patients who were not asked by their physician if they reported smoking, 36% tried quitting in the past year (Kottke et al., 1989). A meta-analysis of smoking cessation interventions found that intensive physician counseling increases the odds of quitting (OR: 2.04) (Lemmens et al., 2008).
5	Infertility risks and options	Among patients of reproductive age, infertility risks and fertility preservation options are inadequately discussed prior to chemotherapy.	In one study of premenopausal women recruited from oncology offices, 68% and 34% reported recalling a discussion with a physician regarding early menopause or fertility, respectively (Duffy, Allen, and Clark, 2005). In a survey of oncology faculty and fellows, 48% of respondents reported informing 10% or fewer of their eligible patients about sperm banking (Schover et al., 2002). In another survey of premenopausal women with breast cancer, 72% discussed fertility with their hematologist/oncologist, but often the topic was brought up by the patient. Only 51% felt that their concerns had been adequately addressed (Partridge et al., 2004). x% of cancer patients of reproductive age did not have discussions about infertility risks prior to initiating chemotherapy (practice range: x% to x%) (QOPI) x% of cancer patients had no discussions about fertility preservation options nor were they referred to specialists (practice range: x% to x%) (QOPI)	Chemotherapy treatment can cause premature menopause and negatively affect fertility. Other side effects of premature menopause may lower patients' quality of life (Duffy, Allen, and Clark, 2005). A review of chemotherapy's impact on fertility found that the average chemotherapy-related amenorrhea rate can be as high as 68% among women with breast cancer but varies by chemotherapy protocol. This review also found that ovarian failure occurred in 38–57% of patients treated for Hodgkin's disease (Meirow and Nugent, 2001). A study of women aged 26–45 diagnosed with cancer found that information received about fertility was insufficient, and patients felt that this information should be provided by a fertility specialist (Thewes et al., 2003).

Gap	Brief Title	Clinical Performance Gap	Magnitude of Performance Gap	Consequences of Performance Gap
17	Dyspnea treatment at end of life	As part of end-of-life care, dyspnea is inadequately assessed and/or treated.	21% to 72% of patients with advanced cancer experience dyspnea (Ripamonti, 1999). x% of patients were not assessed for dyspnea on either of the last two visits before death (practice range: x% to x%) (QOPI) x% of patients did not receive treatment for dyspnea on either of the last two visits before death (practice range: x% to x%) (QOPI)	The frequency and severity of dyspnea increase with the progression of a patient's disease, and a significant proportion of advanced and terminal cancer patients rate their dyspnea as moderate or severe (Ripamonti, 1999). In a study of patients with advanced cancer, dyspnea was associated with significant reductions in quality of life across all major categories of functioning (Gupta, Lis, and Grutsch, 2007).
20	Chemotherapy, palliative care, and hospice enrollment at end of life	Many cancer patients receive chemotherapy within the last 2 weeks of life, and many patients do not have discussions with their providers about hospice or palliative care within the last 2 months of life.	x% of cancer patients receive chemotherapy treatment within the last 2 weeks of life (practice range: x% to x%) (QOPI) x% of patients were not enrolled in hospice, did not receive a palliative care referral, and did not have a discussion about hospice care within the last two months of life (practice range: x% to x%) (QOPI).	In 1998, up to 37% of cancer deaths in the United States occurred in an inpatient setting (Flory et al., 2004). Patients with cancer who die in a hospital or in an intensive care unit have worse quality of life than those who die at home, and their bereaved caregivers are at increased risk for developing psychiatric illness (Wright et al., 2010). A randomized trial of early palliative care versus standard care found that early palliative care improved patients' quality of life and decreased the prevalence of depressive symptoms (Temel et al., 2010).
11	Appropriate treatment with bisphosphonates	Breast cancer patients with bone metastases do not routinely receive treatment with IV bisphosphonates, and, among those who do, renal function is not routinely assessed between the first and second administrations.	x% of patients with breast cancer bone metastases do not receive IV bisphosphonate therapy (QOPI). It is unknown how often patients receiving IV bisphosphonate therapy are monitored for possible safety problems.	Randomized clinical trials have shown that administration of IV bisphosphonates significantly reduces the frequency of skeletal-related events in patients with bone metastases from breast cancer (Lipton, 2010). In patients with renal disease, bisphosphonates can cause nephrotoxicity and can compromise bone quality. However, nephrotoxicity is uncommon and most often clinically insignificant when bisphosphonates are prescribed at recommended doses (Cunningham, 2007).
6	Long-term surveillance and testing	Following curative resection, cancer patients do not always receive adequate surveillance or testing.	30% of breast cancer survivors report no mammography use within the past year, and 28% report no mammography use within the past 2 years (Andersen and Urban, 1998). x% of patients do not receive a carcinoembryonic antigen test within 4 months of curative resection for colorectal cancer (practice range: x% to x%) (QOPI).	30–50% of patients with stage II to III colorectal tumors will have a tumor relapse within 5 years of resection (Rodriguez-Moranta et al., 2006). The five-year relapse risk is 7% for breast cancer patients with stage I disease, 11% for stage II disease, and 13% for stage III disease (Brewster et al., 2008).

Gap	Brief Title	Clinical Performance Gap	Magnitude of Performance Gap	Consequences of Performance Gap
18	Adherence to oral antineoplastic therapies	Many patients who begin treatment with oral anti-neoplastic therapies (e.g., tamoxifen, aromatase inhibitors) do not receive treatment for the recommended duration.	26% of patients with stage I–III breast cancer who initiate treatment with tamoxifen and who do not have evidence of disease progression do not receive tamoxifen for the recommended 5 years (NICCQ).	In a retrospective cohort study, duration of tamoxifen use was associated with greater survival (15% lower hazard ratio). Patients with an adherence index of less than 80% had a 10% higher hazard (McCowan et al., 2008).
10	Appropriate treatment with trastuzumab	Many breast cancer patients who are candidates for trastuzumab do not receive the therapy, and patients who receive the therapy are not always followed for possible safety problems.	x% of patients with AJCC stage I (T1c) to stage III Her-2/neu positive breast cancer do not receive recommendations for trastuzumab therapy (practice range: x% to x%) (QOPI). It is unknown how often patients receiving trastuzumab therapy are monitored for possible safety problems.	Treatment with trastuzumab after adjuvant chemotherapy has been shown to improve disease-free survival by 8.4 percentage points over two years of follow up among women with HER2+ breast cancer (Piccart-Gebhart et al., 2005). Patients with metastatic breast cancer taking Herceptin have a significantly higher risk of cardiotoxicity, including decreases in left ventricular ejection fraction, symptomatic congestive heart failure, and severe CHF (Piccart-Gebhart et al., 2005). Herceptin is also associated with the risk of mild to moderate infusion reactions (Smith, 2001). Other adverse events include fever, chills, rash, and dyspnea (Vogel et al., 2001).
9	Evaluation and follow up for malignant tumors	After surgical excision of a malignant colorectal tumor, many patients do not receive colonoscopy or barium enema to assess for the presence of synchronous tumors or polyps.	x% of patients with colorectal cancer do not receive a colonoscopy before or within 6 months of curative colorectal resection (practice range: x% to x%) (QOPI).	In a large epidemiological study, excision of rectosigmoid adenomas of 1 cm or more, without further intervention, was associated with a 3.6-fold increase in the long-term risk of colon cancer in the general population if a single polyp was present but a 6.6-fold increase if multiple polyps were present (Atkin, Morson, and Cuzick, 1992). In the National Polyp Study, patients with three or more adenomas had a seven-fold greater odds of having adenomas with advanced pathological features at the patient's first follow-up examination (Winawer et al., 1993).
16	KRAS testing for colorectal cancer	Many patients do not undergo KRAS mutation testing before initiating anti-EGFR therapy.	x% of patients with metastatic colorectal cancer do not undergo KRAS testing prior to receiving anti-EGFR therapy (practice range: x% to x%) (QOPI).	For patients with known codon 12 or 13 KRAS mutations, cetuximab or panitumumab (used alone or in combination with other anticancer agents) has no clinical benefit, can be highly toxic, and is costly (Morton and Hammond, 2009).
22	Lymph node removal and examination	Some patients do not have at least 12 regional lymph nodes removed and pathologically examined for resected colon cancer.	x% of patients with colorectal cancer do not have 12 or more lymph nodes examined for resected colon cancer (practice range: x% to x%) (QOPI).	A large systematic review of patients with stage II colon cancer showed that the number of lymph nodes evaluated was associated with survival (Chang et al., 2007).

NOTE: AJCC = American Joint Committee on Cancer. TNM = tumor, node, metastasis. OR = odds ratio.CHF = congestive heart failure.

Table A.3. Clinical Decision Support Opportunity Matrix for Oncology

Gap	Brief Title	Clinical Performance Gap	Action That Can Be Taken to Reduce the Performance Gap	Information Needed by CDS System	Potential Work Flow Insertion Points (relevant personnel)	Potential CDS Opportunity: Documentation Forms/ Templates	Potential CDS Opportunity: Relevant Data Presentation	Potential CDS Opportunity: Order Set or Ordering Tool	Potential CDS Opportunity: Protocol or Pathway Support	Potential CDS Opportunity: Smart Links to Reference Information	Potential CDS Opportunity: Alerts/ Reminders
13	Pain assessment and pain management plan	The presence of pain and its intensity are inadequately assessed or quantified in cancer patients receiving chemotherapy or radiation therapy, and pain management plans are not routinely documented.	Elicit and document pain intensity Develop graded pain management plan to cover full pain spectrum.	Cancer pain history and current symptoms Current and past medications for cancer pain Adverse reactions to previous pain medications	Office visit examination (physician, nurse) Infusion visit intake (nurse) Inpatient exam	Smart form that captures pain intensity and generates pain management plan based on patient preference and particular history.	Display cancer pain history with intensity levels and current/prior treatments for pain.	Order set for cancer pain medication that results in a comprehensive management plan.	Pathway to guide initial selection of pain medication and to guide escalation of therapy when required	n/a	Reminders to assess and to quantify pain at appropriate moments in workflow.
14	Inadequate adjunctive pain treatment	Patients started on long-acting opioids do not always receive short-acting opioid formulations for breakthrough pain, and patients receiving chronic opioids do not always receive bowel regimens.	Order appropriate adjunctive medications along with long-acting or chronic opioid therapy	Current and past medications for cancer pain	Population management (office staff, nurse, physician) Office visit orders (physician) Inpatient exam	n/a	Distinct pain management display accessible by nurses and physicians that highlights missing orders and graphically charts patient's recent pain history.	Order sets long-acting or chronic opioid therapy that include appropriate medications required for breakthrough pain and bowels.	n/a	n/a	Alert when pain management orders have expired with easy automatic renewal.
2	Staging documentation	Cancer patients often have poorly documented information on staging.	Use decision support to improve staging Physician documentation to fixed-value EHRs upon successful staging.	Tumor characteristics from diagnostic examination and surgical findings	At initial assessment and at time of chemotherapy orders (physician)	Cancer-specific documentation template that supports accurate staging for the type of cancer.	n/a	n/a	n/a	Info button to check latest staging criteria at the time that cancer diagnoses are being entered.	Reminder to complete staging information prior to initiation of therapy.

Gap	Brief Title	Clinical Performance Gap	Action That Can Be Taken to Reduce the Performance Gap	Information Needed by CDS System	Potential Work Flow Insertion Points (relevant personnel)	Potential CDS Opportunity: Documentation Forms/ Templates	Potential CDS Opportunity: Relevant Data Presentation	Potential CDS Opportunity: Order Set or Ordering Tool	Potential CDS Opportunity: Protocol or Pathway Support	Potential CDS Opportunity: Smart Links to Reference Information	Potential CDS Opportunity: Alerts/ Reminders
1	Documented chemotherapy plan	Patients undergoing chemotherapy often fail to have a current care plan documented.	Document initial care plan Modify care plan following changes to regimen	Standard cancer-specific chemotherapy regimens Curative versus palliative intent	Office visit orders (physician) Infusion visit orders (physician)	Smart form for chemotherapy that prompts documentation of current care plan and reasons for deviation from previous plan.	Timeline display of prior adverse reactions and therapy adjustments that should inform current care plan.	n/a	Pathway based on standard multicycle regimens with order sets and appropriate refinements for each step.	n/a	n/a
8	Discussion of options, intent, risks, and benefits of chemotherapy treatment	Patients are often unaware of the risks and benefits of chemotherapy, and their understanding of the treatment's intent (palliative versus curative) is often inadequately documented. Furthermore, alternative options are often not provided.	Discuss risks, benefits, and intent of chemotherapy with patient Provided alternative treatment options. Document patient's understanding of risks, benefits, and intent.	Staging, other characteristics from diagnostic exam	Office visit data review (physician, nurse) Office visit education (physician, nurse)	Patient consent form template that includes alternative options, risk/benefit information, and intent of treatment.	Display inputs to and results from predictive models of treatment benefit at time of chemotherapy decisionmaking.	Order set that mandates documentation of palliative versus curative intent and provides appropriate tailoring of regimen.	n/a	Info button at the time of chemotherapy planning linking to reference data on treatment risks and benefits based on stage and treatment history.	n/a
4	Chemotherapy regimen concordance with standards	Prescribed chemotherapy regimens are not always concordant with standard regimens (as defined by evidence or consensus groups).	Implement dosing safeguards on chemotherapy orders Accessible comparison of patient's regimen to known standard.	Locally approved cancer-specific chemotherapy regimens Patient's active chemotherapy orders	Office visit orders (physician, nurse) Infusion visit orders (physician, nurse)	Documentation template for explaining deviation from standard regimen at the time of ordering	n/a	Order tool for cancer-specific chemotherapy regimens (including combinations and specific doses) that are consistent with local standards and that allow overrides.	n/a	n/a	Alert at time of ordering or infusion if chemotherapy plan differs from accepted standards.

Gap	Brief Title	Clinical Performance Gap	Action That Can Be Taken to Reduce the Performance Gap	Information Needed by CDS System	Potential Work Flow Insertion Points (relevant personnel)	Potential CDS Opportunity: Documentation Forms/ Templates	Potential CDS Opportunity: Relevant Data Presentation	Potential CDS Opportunity: Order Set or Ordering Tool	Potential CDS Opportunity: Protocol or Pathway Support	Potential CDS Opportunity: Smart Links to Reference Information	Potential CDS Opportunity: Alerts/ Reminders
3	Errors in chemotherapy ordering	Many patients receiving chemotherapy are at risk of experiencing adverse events due to errors in chemotherapy ordering	Automatic EHR order fidelity surveillance.	Chemotherapy orders and standard order spectrum.	Office visit orders (physician) Infusion visit (physician)	n/a	n/a	Smart ordering forms that help reduce errors.	n/a	n/a	Alert at time of ordering or infusion if chemotherapy orders differ from accepted standards.
12	Treatment summaries documented and communicated	Chemotherapy and radiotherapy treatment summaries are not always fully documented or provided to patients or physicians providing continuing care.	Create comprehensive treatment summary Make summary available to patients and providers	Details of chemo/radiotherapy treatment Contact info for physician providing continuing care	Infusion visit (or radiation therapy visit) documentation (physician, nurse, office staff)	Documentation template for treatment summary that includes content required by CCHIT that can be transmitted electronically (to physicians) or in hard copy (to patients)	n/a	Patient-specific treatment summary automatically generated with order entry.	n/a	n/a	Reminder to generate and submit report to patient and providers triggered by termination of chemotherapy care plan (or as part of radiotherapy visit checklist).
7	Supportive care therapies	Many patients undergoing chemotherapy do not receive supportive care therapies, including potent antiemetic therapy and granulocyte-colony stimulating factor.	Prescribe antiemetic therapy and other supportive therapies concurrently with chemotherapy regimen.	Locally approved cancer-specific supportive therapy regimens	Office visit orders (physician)	n/a	n/a	Order sets for chemotherapy regimens that include recommended antiemetic and other supportive care therapies.	n/a	Info button during ordering to access ASCO, ONS, or NCCN anti- emetic recommendations based on emetogenic potential of chemotherapy.	n/a
5	Infertility risks and options	Among patients of reproductive age, infertility risks and fertility preservation options are inadequately discussed prior to chemotherapy.	Identify men and women who are at risk for infertility Discuss infertility risk and preservation options	Patient age, sex Planned chemotherapy regimen Patients' reproductive plans	Office visit history/examination (physician, nurse, case manager) at time of chemotherapy planning	Fertility preference smart form entry that can be utilized for automated cross-checks.	n/a	Chemotherapy order set that cross-checks patient's reproductive plans.	Treatment plan suggestions in accordance with patient's documented fertility preferences.	n/a	n/a

Gap	Brief Title	Clinical Performance Gap	Action That Can Be Taken to Reduce the Performance Gap	Information Needed by CDS System	Potential Work Flow Insertion Points (relevant personnel)	Potential CDS Opportunity: Documentation Forms/ Templates	Potential CDS Opportunity: Relevant Data Presentation	Potential CDS Opportunity: Order Set or Ordering Tool	Potential CDS Opportunity: Protocol or Pathway Support	Potential CDS Opportunity: Smart Links to Reference Information	Potential CDS Opportunity: Alerts/ Reminders
15	End-of-life management: chemotherapy, palliative care, and hospice	Many cancer patients receive chemotherapy within the last 2 weeks of life, and many patients do not have discussions with their providers about hospice or palliative care within the last 2 months of life.	Identify patients with advanced cancer Include palliative care in discussion of treatment options	Cancer stage Patients' preferences for end-of-life care Performance status assessment	Office visit education (physician, nurse, case manager). Infusion visit (physician, nurse, case manager) Inpatient orders	EHR smart form for patient's end of life preferences and performance status assessment.	n/a	Palliative care order set, including recommended therapies	n/a	n/a	Reminder to assess and document end-of-life care preferences triggered by data on performance status
11	Long-term surveillance and testing	Following curative resection, cancer patients do not always receive adequate surveillance or testing	Identify patients requiring surveillance Develop survivorship care plan	Tests and services recommended for survivorship care plan Specific diagnosis and treatment status	Office visit education (physician, nurse) Population management (office staff, nurse, physician)	n/a	n/a	Automatically generated, diagnosis specific follow-up order sets.	Automated generation of cancer-specific survivorship care plan that includes all necessary tests (and responsible physician) that can be shared with patients.	n/a	Alert if surveillance activities deviate from survivorship care plan
6	Adherence to oral antineoplastic therapies	Many patients who begin treatment with oral antineoplastic therapies (e.g., tamoxifen, aromatase inhibitors) do not receive treatment for the recommended duration.	Assess patient adherence Use techniques to promote adherence	Current medications list Contraindications Side effects Data from pharmacies on refill order rate	Office visit education (physician, nurse, case manager)	Self-administered patient questionnaire regarding compliance and reasons for noncompliance.	n/a	Order set for hormonal therapy that triggers reminder for education regarding compliance.	n/a	n/a	Alert for low adherence based on medication utilization data

Gap	Brief Title	Clinical Performance Gap	Action That Can Be Taken to Reduce the Performance Gap	Information Needed by CDS System	Potential Work Flow Insertion Points (relevant personnel)	Potential CDS Opportunity: Documentation Forms/ Templates	Potential CDS Opportunity: Relevant Data Presentation	Potential CDS Opportunity: Order Set or Ordering Tool	Potential CDS Opportunity: Protocol or Pathway Support	Potential CDS Opportunity: Smart Links to Reference Information	Potential CDS Opportunity: Alerts/ Reminders
10	Appropriate treatment with trastuzumab	Many breast cancer patients who are candidates for trastuzumab do not receive the therapy, and patients who receive the therapy are not always followed for possible safety problems.	Identify candidates for trastuzumab therapy Prescribe treatment Monitor ejection fraction	Eligibility for trastuzumab therapy Date of most recent ejection fraction testing.	Office visit orders (physician) Population management (office staff, nurse, physician)	n/a	n/a	Breast cancer order set that searches for a patient's HER2+ status (or queries provider for it).	n/a	n/a	Alert if EF assessment has not been conducted on schedule or is trending unfavorably for patients receiving trastuzumab.
16	KRAS testing for colorectal cancer	Many patients do not undergo KRAS mutation testing before initiating anti-EGFR therapy.	Administer KRAS test for patients being considered for anti-EGFR therapy Initiate treatment if test is negative	KRAS mutation test result Current medications	Office visit orders (physician)	n/a	n/a	Order set for anti-EGFR therapy that checks KRAS test result or requires input of test result.	n/a	n/a	Reminder to conduct KRAS test triggered by order for anti-EGFR therapy.

Table A.4. Clinical Decision Support Evidence Table: Documentation Forms and Templates for Oncology

Tool	Brief Description	Practice Setting	Impact on Performance Gaps	Impact on Workflow	Citation
Interactive Tailored Patient Assessment Tool	Computerized Interactive Tailored Patient Assessment program allows patients to rank problems according to the need for symptom management. The ranked problem list is given to the clinician during the visit.	Single university oncology practice in Norway	More symptoms and problems were addressed Symptom distress decreased over time Need for symptom management support over time decreased	Tool was used during patient intake No data presented	(Ruland et al., 2010)

Table A.5. Clinical Decision Support Evidence Table: Order Set and Ordering Tool for Oncology

Tool	Brief Description	Practice Setting	Impact on Performance Gaps	Impact on Workflow	Citation
Chemotherapy order sets	Standardized paper-based order sets designed to reduce errors in chemotherapy ordering. Each order set includes patient identifiers, cycle of chemotherapy to be given, criteria necessary to receive chemotherapy, chemotherapy orders with modifications if appropriate, and supportive care orders.	Children's Hospital Boston/Dana-Farber Cancer Institute	Improved completeness of orders Reduction in changes made to orders during order verification	Reduction in time spent verifying orders	(Dinning et al., 2005)
Computerized order entry for chemotherapy	A standardized set of chemotherapy protocols was developed by a multidisciplinary team and incorporated into a computerized order entry system. The system proposes standard doses based on a patient's body surface area. Explanations for dose modification are required. The system issues summaries of chemotherapy protocols and expected side effects to physicians and generates surveillance and treatment sheets for nurses.	Single university hospital in Switzerland	Monthly error rates were reduced from 13% to 0.6% after computerized order entry was introduced	No data presented	(Voeffray et al., 2006)

Table A.6. Clinical Decision Support Evidence Table: Protocol or Pathway Support for Oncology

Tool	Brief Description	Practice Setting	Impact on Performance Gaps	Impact on Workflow	Citation
No evidence found.	n/a	n/a	n/a	n/a	n/a

Table A.7. Clinical Decision Support Evidence Table: Reference Information and Guidance for Oncology

Tool	Brief Description	Practice Setting	Impact on Performance Gaps	Impact on Workflow	Citation
Guidelines for pain therapy and pain assessment	An algorithm following WHO guidelines for cancer pain management was developed and incorporated into a CDS tool. Pain was assessed and other patient characteristics (e.g., diagnoses, comorbidities, pain characteristics) were sent to a pharmacist who was trained in pain therapy. Using the CDS tool along with the patient data, the pharmacist identified deviations from guidelines and submitted recommendations for changes to pain therapy to the oncologist via email.	Radiation oncology ward of a single university hospital in Germany	Number of patients with at least one deviation from guidelines decreased from 74% to 14% Number of patients treated with co-analgesics at discharge increased from 46% to 66% 85% of the 279 recommendations modifications to pain therapy issued by the CDS tool were accepted by physicians	No data presented	(Bertsche et al., 2009)
Breast Cancer Management Guidelines	Breast cancer management program (OncoDoc) based on decision trees. Physicians navigate through decision trees according to patient characteristics and are ultimately provided with a treatment recommendation.	Single outpatient cancer center in France	Physician compliance with guidelines improved from 61% to 85% Physicians modified their prescription in 31% of cases	No data presented	(Bouaud et al., 2001)

NOTE: WHO = World Health Organization.

Table A.8. Clinical Decision Support Evidence Table: Alerts and Reminders for Oncology

Tool	Brief Description	Practice Setting	Impact on Performance Gaps	Impact on Workflow	Citation
Alert for anemia	EHR-based reminder system designed to identify cancer patients with anemia and recommend the prescription of erythropoietin	Two community oncology practices in the United States	Erythropoietin prescriptions increased from 21% to 24%.	No data presented	(Kralj et al., 2003)

Table A.9. Oncology Gap Statements, Round 2

Oncology Gap Survey	Importance
Gap 1: patients undergoing chemotherapy often fail to have a current care plan documented.	1 4 7 1 2 3 4 5 6 7 8 9 **(9.0, 0.5, A)**
Gap 2: cancer patients often have poorly documented information on staging.	2 1 2 7 1 2 3 4 5 6 7 8 9 **(9.0, 0.8, A)**
Gap 3: many patients receiving chemotherapy are at risk of experiencing adverse events due to errors in chemotherapy ordering.	1 2 1 8 1 2 3 4 5 6 7 8 9 **(9.0, 0.8, A)**
Gap 4: prescribed chemotherapy regimens are not always concordant with standard regimens (as defined by evidence or consensus groups).	1 5 6 1 2 3 4 5 6 7 8 9 **(8.5, 0.7, A)**
Gap 5: among patients of reproductive age, infertility risks and fertility preservation options are inadequately discussed prior to chemotherapy.	1 1 4 6 1 2 3 4 5 6 7 8 9 **(8.5, 0.8, A)**
Gap 6: many patients who begin treatment with oral antineoplastic therapies (e.g., tamoxifen, aromatase inhibitors) do not receive treatment for the recommended duration.	2 4 6 1 2 3 4 5 6 7 8 9 **(8.5, 0.8, A)**
Gap 7: many patients undergoing chemotherapy do not receive supportive care therapies, including potent antiemetic therapy and granulocyte-colony stimulating factor.	2 1 3 6 1 2 3 4 5 6 7 8 9 **(8.5, 0.9, A)**
Gap 8: patients are often unaware of the risks and benefits of chemotherapy, and their understanding of the treatment's intent (palliative versus curative) is often inadequately documented.	1 2 1 2 6 1 2 3 4 5 6 7 8 9 **(8.5, 1.2, A)**
Gap 9: after surgical excision of a malignant colorectal tumor, many patients do not receive colonoscopy or barium enema to assess for the presence of synchronous tumors or polyps.	1 4 6 1 1 2 3 4 5 6 7 8 9 **(8.0, 0.6, A)**
Gap 10: many breast cancer patients who are candidates for trastuzumab do not receive the therapy, and patients who receive the therapy are not always followed for possible safety problems.	1 2 6 3 1 2 3 4 5 6 7 8 9 **(8.0, 0.8, A)**
Gap 11: following curative resection, cancer patients do not always receive adequate surveillance or testing.	1 1 2 7 1 1 2 3 4 5 6 7 8 9 **(8.0, 0.7, A)**

Oncology Gap Survey	Importance
Gap 12: chemotherapy and radiotherapy treatment summaries are not always fully documented or provided to patients or physicians providing continuing care.	1 4 3 4 1 2 3 4 5 6 7 8 9 **(8.0, 0.8, A)**
Gap 13: the presence of pain and its intensity are inadequately assessed or quantified in cancer patients receiving chemotherapy or radiation therapy, and pain management plans are not routinely documented.	1 1 2 3 5 1 2 3 4 5 6 7 8 9 **(8.0, 1.0, A)**
Gap 14: patients started on long acting opioids do not always receive short acting opioid formulations for breakthrough pain, and patients receiving chronic opioids do not always receive bowel regimens.	1 1 2 5 3 1 2 3 4 5 6 7 8 9 **(8.0, 1.0, A)**
Gap 15: many cancer patients receive chemotherapy within the last 2 weeks of life, and many patients do not have discussions with their providers about hospice or palliative care within the last 2 months of life.	1 2 1 4 4 1 2 3 4 5 6 7 8 9 **(8.0, 1.0, A)**
Gap 16: many patients do not undergo KRAS mutation testing before initiating anti-EGFR therapy.	3 3 3 3 1 2 3 4 5 6 7 8 9 **(7.5, 1.3, A)**
Gap 17: as part of end-of-life care, dyspnea is inadequately assessed and/or treated.	3 2 1 4 2 1 2 3 4 5 6 7 8 9 **(7.5, 1.3, I)**
Gap 18: cancer patients often have poorly documented medical and surgical histories.	1 1 1 1 1 3 2 2 1 2 3 4 5 6 7 8 9 **(7.0, 1.9, I)**
Gap 19: cancer patients often have poorly documented family histories.	1 1 4 2 3 1 1 2 3 4 5 6 7 8 9 **(6.5, 1.3, I)**
Gap 20: breast cancer patients with bone metastases do not routinely receive treatment with IV bisphosphonates, and, among those who do, renal function is not routinely assessed between the first and second administrations.	3 5 1 3 1 2 3 4 5 6 7 8 9 (6.0, 0.8, I)
Gap 21: cigarette smoking status is inadequately documented, and smoking cessation counseling therapy is not routinely provided to cancer patients.	1 1 2 1 4 2 1 1 2 3 4 5 6 7 8 9 **(6.0, 1.4, I)**
Gap 22: some patients do not have at least 12 regional lymph nodes removed and pathologically examined for resected colon cancer.	1 1 4 2 2 1 1 1 2 3 4 5 6 7 8 9 **(5.5, 1.7, I)**

NOTE: The first row in the "Importance" column shows how many panelists gave each rating. For example, for gap 1, one panelist rated it 7, four rated it 8, and seven rated it 9. The second row shows the ratings that range from 1 to 9 for the importance of the performance gap, with 1 being low importance and 9 being high importance. The third row shows the "median" vote; for gap 1, this gap received a median rating of 9.0 on the importance criterion. The second number (0.5, for gap 1) represents the mean absolute deviation from the median, and the third number represents the statistical assessment of the panelists' ratings (A = agree, D = disagreed, I = indeterminate).

Table A.10. Oncology Gaps and Clinical Decision Support Opportunities, Round 2

Oncology Gap/CDS Opportunity	Compatibility	Potential impact
Gap 1: patients undergoing chemotherapy often fail to have a current care plan documented	**n/a**	**n/a**
Smart form for chemotherapy that prompts documentation of current care plan and reasons for deviation from previous plan.	2 5 5 1 2 3 4 5 6 7 8 9 (8.0, 0.6, A)	1 4 4 3 1 2 3 4 5 6 7 8 9 (8.0, 0.8, A)
Timeline display of prior adverse reactions and therapy adjustments that should inform current care plan.	1 1 1 2 4 3 1 2 3 4 5 6 7 8 9 (8.0, 1.5, A)	1 1 1 3 4 2 1 2 3 4 5 6 7 8 9 (7.5, 1.7, A)
Pathway based on standard multicycle regimens with order sets and appropriate refinements for each step	2 4 6 1 2 3 4 5 6 7 8 9 (8.5, 0.7, A)	2 5 5 1 2 3 4 5 6 7 8 9 (8.0, 0.6, A)
Overall rating	3 5 4 1 2 3 4 5 6 7 8 9 **(8.0, 0.6, A)**	1 3 6 2 1 2 3 4 5 6 7 8 9 **(8.0, 0.6, A)**
Gap 2: cancer patients often have poorly documented information on staging	**n/a**	**n/a**
Cancer-specific documentation template that supports accurate staging for the type of cancer.	1 1 3 7 1 2 3 4 5 6 7 8 9 (9.0, 0.7, A)	1 5 6 1 2 3 4 5 6 7 8 9 (8.5, 0.8, A)
Info button to check latest staging criteria at the time that cancer diagnoses are being entered.	1 4 7 1 2 3 4 5 6 7 8 9 (9.0, 0.8, A)	1 2 2 2 5 1 2 3 4 5 6 7 8 9 (8.0, 1.5, A)
Reminder to complete staging information prior to initiation of therapy.	1 1 3 7 1 2 3 4 5 6 7 8 9 (9.0, 0.8, A)	2 1 2 1 1 5 1 2 3 4 5 6 7 8 9 (7.5, 2.1, I)
Overall rating	1 4 7 1 2 3 4 5 6 7 8 9 **(9.0, 0.8, A)**	1 2 4 5 1 2 3 4 5 6 7 8 9 **(8.0, 1.1, A)**
Gap 3: many patients receiving chemotherapy are at risk of experiencing adverse events due to errors in chemotherapy ordering	**n/a**	**n/a**
Smart ordering forms that help reduce errors.	3 9 1 2 3 4 5 6 7 8 9 (9.0, 0.3, A)	1 3 8 1 2 3 4 5 6 7 8 9 (9.0, 0.4, A)

Oncology Gap/CDS Opportunity	Compatibility	Potential impact
	1 4 7 1 2 3 4 5 6 7 8 9 (9.0, 0.5, A)	4 2 6 1 2 3 4 5 6 7 8 9 (8.5, 0.8, A)
Overall rating	1 2 9 1 2 3 4 5 6 7 8 9 **(9.0, 0.3, A)**	1 3 8 1 2 3 4 5 6 7 8 9 **(9.0, 0.5, A)**
Gap 4: prescribed chemotherapy regimens are not always concordant with standard regimens (as defined by evidence or consensus groups)	**n/a**	**n/a**
Documentation template for explaining deviation from standard regimen at the time of ordering	3 4 5 1 2 3 4 5 6 7 8 9 (8.0, 0.7, A)	4 4 4 1 2 3 4 5 6 7 8 9 (8.0, 0.7, A)
Order tool for cancer-specific chemotherapy regimens (including combinations and specific doses) that are consistent with local standards and that allow overrides.	1 4 7 1 2 3 4 5 6 7 8 9 (9.0, 0.5, A)	2 3 7 1 2 3 4 5 6 7 8 9 (9.0, 0.6, A)
Alert at time of ordering or infusion if chemotherapy plan differs from accepted standards.	1 2 4 5 1 2 3 4 5 6 7 8 9 (8.0, 0.8, A)	2 6 4 1 2 3 4 5 6 7 8 9 (8.0, 0.5, A)
Overall rating	2 6 4 1 2 3 4 5 6 7 8 9 **(8.0, 0.5, A)**	1 8 3 1 2 3 4 5 6 7 8 9 **(8.0, 0.3, A)**
Gap 5: among patients of reproductive age, infertility risks and fertility preservation options are inadequately discussed prior to chemotherapy.	**n/a**	**n/a**
Fertility preference smart form entry that can be utilized for automated cross-checks	1 5 3 3 1 2 3 4 5 6 7 8 9 (7.5, 1.1, A)	1 1 2 3 4 1 1 2 3 4 5 6 7 8 9 (7.0, 1.2, I)
Chemotherapy order set that cross-checks patient's reproductive plans.	1 2 1 1 1 3 3 1 2 3 4 5 6 7 8 9 (7.5, 2.3, I)	2 2 1 2 2 3 1 2 3 4 5 6 7 8 9 (6.0, 2.5, D)
Treatment plan suggestions in accordance with patient's documented fertility preferences	1 1 1 3 4 2 1 2 3 4 5 6 7 8 9 (7.5, 1.3, A)	2 4 3 3 1 2 3 4 5 6 7 8 9 (7.5, 1.4, A)
Overall rating	1 1 1 4 4 1 1 2 3 4 5 6 7 8 9 **(7.0, 1.1, A)**	1 1 6 2 2 1 2 3 4 5 6 7 8 9 **(7.0, 1.1, A)**

Oncology Gap/CDS Opportunity	Compatibility	Potential impact
Gap 6: many patients who begin treatment with oral antineoplastic therapies (e.g., tamoxifen, aromatase inhibitors) do not receive treatment for the recommended duration.	**n/a**	**n/a**
Self-administered patient questionnaire regarding compliance and reasons for noncompliance	1 2 2 3 2 2 1 2 3 4 5 6 7 8 9 (7.0, 1.3, I)	1 3 4 1 1 2 1 2 3 4 5 6 7 8 9 (6.0, 1.2, I)
Order set for hormoral therapy that triggers reminder for education regarding compliance.	1 2 3 1 3 2 1 2 3 4 5 6 7 8 9 (6.0, 2.0, I)	1 3 1 2 2 2 1 1 2 3 4 5 6 7 8 9 (6.0, 1.7, I)
Alert for low adherence based on medication utilization data	2 3 4 3 1 2 3 4 5 6 7 8 9 (8.0, 0.8, A)	1 1 4 2 4 1 2 3 4 5 6 7 8 9 (7.5, 1.1, A)
Overall rating	1 5 4 2 1 2 3 4 5 6 7 8 9 **(7.5, 0.8, A)**	1 1 5 3 2 1 2 3 4 5 6 7 8 9 **(7.0, 0.8, A)**
Gap 7: many patients undergoing chemotherapy do not receive supportive care therapies, including potent antiemetic therapy and granulocyte-colony stimulating factor.	**n/a**	**n/a**
Order sets for chemotherapy regimens that include recommended antiemetic and other supportive care therapies.	4 8 1 2 3 4 5 6 7 8 9 (9.0, 0.3, A)	1 5 6 1 2 3 4 5 6 7 8 9 (8.5, 0.6, A)
Info button during ordering to access ASCO, ONS, or NCCN antiemetic recommendations based on emetogenic potential of chemotherapy.	1 1 3 3 4 1 2 3 4 5 6 7 8 9 (8.0, 1.3, A)	1 1 1 3 1 2 3 1 2 3 4 5 6 7 8 9 (6.5, 1.9, I)
Overall rating	1 5 6 1 2 3 4 5 6 7 8 9 **(8.5, 0.6, A)**	2 6 4 1 2 3 4 5 6 7 8 9 **(8.0, 0.5, A)**
Gap 8: patients are often unaware of the risks and benefits of chemotherapy, and their understanding of the treatment's intent (palliative versus curative) is often inadequately documented. Furthermore, alternative options are often not provided	**n/a**	**n/a**
Patient consent form template that includes alternative options, risk/benefit information, and intent of treatment.	1 3 2 4 2 1 2 3 4 5 6 7 8 9 (7.5, 1.1, I)	1 2 3 3 1 2 1 2 3 4 5 6 7 8 9 (6.5, 1.3, I)
Display inputs to and results from predictive models of treatment benefit at time of chemotherapy decisionmaking.	2 2 5 3 1 2 3 4 5 6 7 8 9 (8.0, 0.8, A)	2 2 2 6 1 2 3 4 5 6 7 8 9 (8.5, 1.0, A)

Oncology Gap/CDS Opportunity	Compatibility	Potential impact
Order set that mandates documentation of palliative versus curative intent and provides appropriate tailoring of regimen.	1 1 3 2 3 2 1 2 3 4 5 6 7 8 9 (7.0, 1.5, I)	1 1 1 1 4 3 1 1 2 3 4 5 6 7 8 9 (6.0, 1.8, I)
Info button at the time of chemotherapy planning linking to reference data on treatment risks and benefits based on stage and treatment history.	1 4 6 1 1 2 3 4 5 6 7 8 9 (8.0, 1.0, I)	1 1 3 2 4 1 1 2 3 4 5 6 7 8 9 (7.0, 1.4, I)
Overall rating	4 1 5 2 1 2 3 4 5 6 7 8 9 **(8.0, 0.9, I)**	1 2 3 5 1 1 2 3 4 5 6 7 8 9 **(7.5, 0.9, A)**
Gap 10: many breast cancer patients who are candidates for trastuzumab do not receive the therapy, and patients who receive the therapy are not always followed for possible safety problems	**n/a**	**n/a**
Breast cancer order set that searches for a patient's HER2+ status (or queries provider for it).	1 1 5 5 1 2 3 4 5 6 7 8 9 (8.0, 1.2, A)	1 1 1 6 3 1 2 3 4 5 6 7 8 9 (8.0, 1.4, A)
Alert if EF assessment has not been conducted on schedule or is trending unfavorably for patients receiving trastuzumab	1 6 5 1 2 3 4 5 6 7 8 9 (8.0, 0.7, A)	1 1 1 5 4 1 2 3 4 5 6 7 8 9 (8.0, 0.9, A)
Overall rating	1 2 5 4 1 2 3 4 5 6 7 8 9 **(8.0, 0.9, A)**	1 1 1 6 3 1 2 3 4 5 6 7 8 9 **(8.0, 1.0, A)**
Gap 11: following curative resection, cancer patients do not always receive adequate surveillance or testing	**n/a**	**n/a**
Automatically generated, diagnosis specific follow-up order sets.	1 8 3 1 2 3 4 5 6 7 8 9 (8.0, 0.3, A)	2 3 4 3 1 2 3 4 5 6 7 8 9 (8.0, 0.8, A)
Automated generation of cancer-specific survivorship care plan that includes all necessary tests (and responsible physician) that can be shared with patients.	7 5 1 2 3 4 5 6 7 8 9 (8.0, 0.4, A)	1 1 7 3 1 2 3 4 5 6 7 8 9 (8.0, 0.5, A)
Alert if surveillance activities deviate from survivorship care plan	1 1 1 3 3 3 1 2 3 4 5 6 7 8 9 (7.5, 1.3, A)	1 2 2 2 4 1 1 2 3 4 5 6 7 8 9 (7.0, 1.3, I)
Overall rating	1 9 2 1 2 3 4 5 6 7 8 9 **(8.0, 0.3, A)**	1 2 8 1 1 2 3 4 5 6 7 8 9 **(8.0, 0.4, A)**

Oncology Gap/CDS Opportunity	Compatibility	Potential impact
Gap 12: chemotherapy and radiotherapy treatment summaries are not always fully documented or provided to patients or physicians providing continuing care.	**n/a**	**n/a**
Documentation template for treatment summary that includes content required by CCHIT that can be transmitted electronically (to physicians) or in hard copy (to patients)	1 1 5 5 1 2 3 4 5 6 7 8 9 (8.0, 0.7, A)	1 1 6 4 1 2 3 4 5 6 7 8 9 (8.0, 0.6, A)
Patient-specific treatment summary automatically generated with order entry.	1 3 4 4 1 2 3 4 5 6 7 8 9 (8.0, 0.8, A)	2 3 5 2 1 2 3 4 5 6 7 8 9 (8.0, 0.8, A)
Reminder to generate and submit report to patient and providers triggered by termination of chemotherapy care plan (or as part of radiotherapy visit checklist).	2 1 5 4 1 2 3 4 5 6 7 8 9 (8.0, 0.8, A)	4 3 4 1 1 2 3 4 5 6 7 8 9 (7.0, 0.8, I)
Overall rating	3 4 5 1 2 3 4 5 6 7 8 9 **(8.0, 0.7, A)**	1 4 5 2 1 2 3 4 5 6 7 8 9 **(8.0, 0.7, A)**
Gap 13: the presence of pain and its intensity are inadequately assessed or quantified in cancer patients receiving chemotherapy or radiation therapy, and pain management plans are not routinely documented	**n/a**	**n/a**
Smart form that captures pain intensity and generates pain management plan based on patient preference and particular history.	1 1 3 6 1 1 2 3 4 5 6 7 8 9 (8.0, 1.1, A)	1 1 1 1 3 5 1 2 3 4 5 6 7 8 9 (7.0, 1.3, I)
Display cancer pain history with intensity levels and current/prior treatments for pain.	1 1 1 8 1 1 2 3 4 5 6 7 8 9 (8.0, 0.7, A)	1 1 6 3 1 1 2 3 4 5 6 7 8 9 (7.0, 0.8, A)
Order set for cancer pain medication that results in a comprehensive management plan.	1 1 2 6 2 1 2 3 4 5 6 7 8 9 (8.0, 0.8, A)	1 1 2 6 2 1 2 3 4 5 6 7 8 9 (8.0, 0.9, A)
Pathway to guide initial selection of pain medication and to guide escalation of therapy when required	1 1 3 5 2 1 2 3 4 5 6 7 8 9 (8.0, 0.9, A)	1 1 8 2 1 2 3 4 5 6 7 8 9 (8.0, 0.8, A)
Reminders to assess and to quantify pain at appropriate moments in workflow.	1 1 2 7 1 1 2 3 4 5 6 7 8 9 (8.0, 0.9, A)	2 1 5 3 1 1 2 3 4 5 6 7 8 9 (7.0, 1.2, A)
Overall rating	1 1 4 5 1 1 2 3 4 5 6 7 8 9 **(7.5, 0.8, A)**	1 2 2 6 1 1 2 3 4 5 6 7 8 9 **(8.0, 1.1, A)**

Oncology Gap/CDS Opportunity	Compatibility	Potential impact
Gap 14: patients started on long-acting opioids do not always receive short-acting opioid formulations for breakthrough pain, and patients receiving chronic opioids do not always receive bowel regimens	**n/a**	**n/a**
Distinct pain management display accessible by nurses and physicians that highlights missing orders and graphically charts patient's recent pain history.	1 5 5 1 1 2 3 4 5 6 7 8 9 (7.5, 0.7, A)	1 1 4 5 1 1 2 3 4 5 6 7 8 9 (7.5, 1.0, A)
Order sets long-acting or chronic opioid therapy that include appropriate medications required for breakthrough pain and bowels.	1 1 9 1 1 2 3 4 5 6 7 8 9 (8.0, 0.3, A)	1 1 9 1 1 2 3 4 5 6 7 8 9 (8.0, 0.5, A)
Alert when pain management orders have expired with easy automatic renewal.	1 1 2 1 5 2 1 2 3 4 5 6 7 8 9 (8.0, 1.3, I)	2 2 4 3 1 1 2 3 4 5 6 7 8 9 (7.0, 0.9, I)
Overall rating	1 3 7 1 1 2 3 4 5 6 7 8 9 **(8.0, 0.5, A)**	1 4 6 1 1 2 3 4 5 6 7 8 9 **(8.0, 0.8, A)**
Gap 15: many cancer patients receive chemotherapy within the last 2 weeks of life, and many patients do not have discussions with their providers about hospice or palliative care within the last 2 months of life	**n/a**	**n/a**
EHRS smart form for patient's end-of-life preferences and performance status assessment.	1 1 1 4 5 1 2 3 4 5 6 7 8 9 (8.0, 0.9, A)	1 1 2 4 4 1 2 3 4 5 6 7 8 9 (8.0, 0.9, A)
Palliative care order set including recommended therapies	1 6 5 1 2 3 4 5 6 7 8 9 (8.0, 0.5, A)	1 4 5 2 1 2 3 4 5 6 7 8 9 (8.0, 0.7, A)
Reminder to assess and document end-of-life care preferences triggered by data on performance status	5 3 4 1 2 3 4 5 6 7 8 9 (8.0, 0.8, A)	1 2 3 2 4 1 2 3 4 5 6 7 8 9 (7.5, 1.2, A)
Overall rating	3 6 3 1 2 3 4 5 6 7 8 9 **(8.0, 0.5, A)**	6 4 2 1 2 3 4 5 6 7 8 9 **(7.5, 0.7, A)**
Gap 16: many patients do not undergo KRAS mutation testing before initiating anti-EGFR therapy.	**n/a**	**n/a**
Order set for anti-EGFR therapy that checks KRAS test result or requires input of test result.	1 5 6 1 2 3 4 5 6 7 8 9 (8.5, 0.6, A)	2 1 5 4 1 2 3 4 5 6 7 8 9 (8.0, 0.8, A)

Oncology Gap/CDS Opportunity	Compatibility	Potential impact
	1 5 6	1 1 6 4
Reminder to conduct KRAS test triggered by order for anti-EGFR therapy.	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
	(8.5, 0.9, A)	(8.0, 0.6, A)
	3 3 6	1 3 4 4
Overall rating	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
	(8.5, 0.8, A)	**(8.0, 0.8, A)**

APPENDIX B. ORTHOPEDICS PANEL MATERIALS

GAP STATEMENT EVIDENCE DOCUMENT WITH PANELISTS' INPUT

Evidence on the Magnitude and Consequences of Clinical Performance Gaps in Total Hip/Knee Replacement Surgery

Table B.1. Annual Utilization Estimates for Total Joint Replacement Surgery

Condition	Utilization Estimate
Total hip replacement surgery	Total hip arthroplasty remains one of the most frequently performed reconstructive procedures in orthopedic surgery (Huo and Brown, 2003). In 2007, more than 33,000 patients in the United States had a revision total hip replacement (HCUPnet, undated).
Total knee replacement surgery	The Medicare program had claims for 430,726 total knee replacement procedures during the years 1998–2000 (Skinner et al., 2003). The total knee replacement procedure is one of the most common performed in the United States, with 380,000 performed in 2003 and a projected 3 million procedures per year by 2030 (Katz et al., 2007).

Table B.2. Magnitude and Consequences of Performance Gaps for Orthopedics

Gap	Gap Category	Gap Statement	Magnitude of Performance Gap	Consequences of Performance Gap
17	Preoperative	Patients are not always informed about the possibility of receiving regional anesthesia before total hip or total knee replacement surgery.	n/a	n/a
9	Preoperative	Reviews of systems conducted prior to total hip or total knee replacement surgery by orthopedic surgeons may be lacking or may not be comprehensive and are often incompletely documented in the medical record.	n/a	In a sample of 238 patients who were screened for total joint replacement surgery, 32% benefited from findings on the preoperative medical evaluation. Four percent of these patients were found to have a condition that warranted the postponement or cancellation of surgery, and others were found to have a condition that was immediately treatable. Some patients required referral to their primary care provider or to a specialist (Clelland et al., 1996).
5	Preoperative	Patients who undergo total hip or total knee replacement surgery may not receive certain necessary preoperative tests, while others may undergo unnecessary testing.	n/a	n/a

Gap	Gap Category	Gap Statement	Magnitude of Performance Gap	Consequences of Performance Gap
14	Preoperative	Prior to undergoing total hip or total knee replacement surgery patients may not receive an appropriate preoperative cardiovascular evaluation, including cardiovascular risk stratification, and may lack documentation of any further cardiac evaluation that was performed.	n/a	n/a
12	Preoperative	Patients undergoing total hip or total knee replacement surgery may not always receive coordinated, multidisciplinary care from the time of operation through discharge and may not receive important tests, consultations, and education.	n/a	n/a
13	Preoperative	Prior to undergoing total hip or total knee replacement surgery, patients may not receive sufficient education about the procedure or about their postdischarge care.	n/a	n/a
23	Preoperative	Patients undergoing total hip or total knee replacement surgery may not have the indication for surgery documented in their medical record.	n/a	n/a
20	Preoperative	Information from diagnostic radiographs is not always fully documented in a patient's medical record prior to total hip or knee replacement surgery.	n/a	n/a
23	Preoperative	Patients undergoing total hip or total knee replacement surgery may not have their history of present illness completely documented in their medical record.	n/a	n/a
19	Preoperative	Patients undergoing total hip or total knee replacement surgery may not have information from physical exams documented completely in their medical record.	n/a	n/a

Gap	Gap Category	Gap Statement	Magnitude of Performance Gap	Consequences of Performance Gap
10	Preoperative	Patients undergoing total hip or total knee replacement surgery may not always have discussions with their surgeons about their preferences, prognosis, or the risks and benefits of surgery, and these discussions may not be documented in their medical record.	n/a	In a qualitative study of patient decisionmaking prior to total knee arthroplasty, many patients expressed concerns about their expected speed of recovery, fear of complications, and fear of anesthesia. Patients may also have financial concerns and be worried about their general health. These findings emphasize the need for open doctor-patient communication around individual experiences to achieve satisfactory shared decisionmaking (Suarez-Almazor et al., 2010).
1	Preoperative	Some patients taking coumadin or Plavix do not always discontinue their therapy or switch to short term anticoagulation therapy in advance of total hip or total knee replacement surgery	n/a	Patients taking coumadin or Plavix have a high probability of perioperative bleeding complications if therapy is not stopped far enough in advance of the surgical procedure. Some patients are at very high risk of clotting and must have short-term anticoagulation while the coumadin is withdrawn. Failing to prescribe treatment for these patients may lead to stroke or pulmonary embolism.
7	Preoperative	Patients are not always assessed preoperatively for noncardiac comorbidities (e.g., hepatitis, HIV) or for the associated risk of morbidity from surgery	n/a	n/a
2	Preoperative	Patients are not always assessed preoperatively for their bleeding and VTE risks, resulting in prophylaxis that does not match the patient's risk	n/a	n/a

Gap	Gap Category	Gap Statement	Magnitude of Performance Gap	Consequences of Performance Gap
8	Infection prevention	Antibiotic prophylaxis recommendations from the National Surgical Infection Prevention Project and AAOS may not be consistently followed for patients undergoing total hip or total knee replacement surgery.	Among Medicare beneficiaries undergoing hip or knee replacement surgery in 2001, 97% received recommended antimicrobial prophylaxis prior to surgery, but only 60% received prophylaxis within one hour prior to surgery (Bratzler et al., 2005).	Infection remains a common cause of failure after total knee arthroplasty and can occur in up to 2% of cases (Ghanem et al., 2009). Among Medicare patients who had elective total hip replacement between 1995 and 1996, 0.2% had a deep infection within three months after a primary total hip replacement, and 1.0% had a deep wound infection within three months after a revision total hip replacement (Phillips et al., 2003). Between 2006 and 2008, surgical site infections were reported nationally in up to 2.4 of every 100 hip prosthesis procedures, and up to 1.6 of every 100 knee prosthesis procedures (Kolbo et al., 2006). Postoperative surgical site infection is one of the most costly complications of orthopedic procedures due to hospital readmissions, extended hospital length of stay, need for additional procedures (often removal and reimplantation of implanted hardware), convalescent or nursing home care between procedures, and significant increases in direct hospital costs (e.g., prolonged antibiotic therapy). Studies have shown an estimated economic impact of one deep wound infection of $100,000 in hospital costs alone after hip arthroplasty and $60,000 after knee arthroplasty (Kolbo et al., 2006).
27	Infection prevention	Patients undergoing total hip or total knee replacement surgery may not have hair removed according to recommended techniques.	n/a	n/a
3	Operative	Patients undergoing total hip or total knee replacement surgery may not receive VTE prophylaxis when it is indicated.	89% and 91% of patients undergoing total hip and total knee arthroplasty, respectively, received thromboprophylaxis consistent with the 2001 ACCP recommendations according to a large registry (Anderson et al., 2003). At discharge, approximately two-thirds of these patients received at least one type of thromboprophylaxis (Anderson et al., 2003).	Without prophylaxis, the incidence of objectively confirmed, hospital-acquired DVT is approximately 40 to 60% following major orthopedic surgery. One-quarter to one-third of these thrombi involve the proximal deep veins and are much more likely to produce symptoms and to result in PE (Geerts et al., 2004).
22	Operative	Patients undergoing total hip or total knee replacement surgery may experience postoperative hemorrhage or postoperative hematoma.	0.2% of 17,784 primary total knee arthroplasties performed at the Mayo Clinic between 1981 and 2004 required a return to the operating room within 30 days of the index arthroplasty for evacuation of a postoperative hematoma (Galat et al., 2008).	Vascular complications of total hip or knee arthroplasty are associated with considerable morbidity, particularly if they are undiagnosed or if treatment is delayed (Barriga et al., 2001). A history of a bleeding disorder was identified as having a significant association with the development of a hematoma requiring surgical evacuation (Galat et al., 2008).

Gap	Gap Category	Gap Statement	Magnitude of Performance Gap	Consequences of Performance Gap
18	Operative	Patients undergoing total hip or total knee replacement surgery may experience physiologic or metabolic derangement.	n/a	Delirium is associated with a longer hospital stay, more complications, poorer outcomes after discharge, and an increased mortality rate (Barsoum et al., 2006).
11	Operative	Patients undergoing total hip or total knee replacement surgery may experience complications requiring readmission.	n/a	n/a
25	Immediate postoperative care	Patients who are recovering from total joint replacement surgery may not be closely monitored for changes in neurological functioning.	n/a	n/a
6	Postoperative care	Patients who undergo total hip or total knee replacement surgery may not receive written discharge instructions, including plans for follow-up, activity restriction, anticoagulation, and dental prophylaxis.	n/a	n/a
21	Postoperative care	Patients may not have a comprehensive radiographic evaluation performed following total hip or total knee replacement surgery.	n/a	Postoperative x-rays are used as a baseline for subsequent comparisons and to identify postoperative complications; however, one study found that only 36% of knee replacement radiographs are of a sufficient quality to provide an accurate baseline for future studies (Glaser and Lotke, 2000).
16	Postoperative care	Patients who have undergone total hip or total knee replacement surgery may not have operative notes in their medical record that document findings from the final examination.	n/a	n/a
26	Postoperative care	Patients who have undergone total hip or total knee replacement surgery may not have follow-up visits at recommended intervals following the operation.	43% of patients undergoing hip and knee replacement surgery had a follow-up visit between one and 3 months following discharge, based on data from a large registry (Anderson et al., 2003).	n/a
24	Postoperative care	Patients who have undergone total hip or total knee replacement surgery may not have radiographs taken at recommended intervals following the operation.	In a study of 622 patients who received total hip replacement in 1995, 15% reported that they had no follow-up radiographs, 43% had only early follow-up radiographs, and 42% had consistent follow-up radiographs over 6 years. Ninety percent of those with consistent follow-up orthopedic visits also had consistent follow-up radiographs over 6 years (Pablo et al., 2006).	In a study of 750 patients undergoing total knee replacement, postoperative radiographs taken routinely before discharge did not alter postoperative management (Glaser and Lotke, 2000). In a study of 209 patients admitted to rehabilitation facilities after total knee replacement, only 1% had abnormal findings on radiographs (A. Lee et al., 2001). There is no published evidence indicating whether early postoperative x-rays following total hip replacement affect early management of patients.

Gap	Gap Category	Gap Statement	Magnitude of Performance Gap	Consequences of Performance Gap
15	Postoperative	VTE prophylaxis is not always maintained for a sufficient time interval postoperatively	n/a	n/a
4	Postoperative care	Many patients who undergo surgery for hip fracture fail to receive follow-up risk assessment and therapy to prevent future osteoporotic fractures	n/a	n/a

NOTE: ACCP = American College of Chest Physicians. PE = pulmonary embolism.

Table B.3. Clinical Decision Support Opportunity Matrix for Orthopedics

Gap	Gap Category	Clinical Performance Gap (brief)	Clinical Performance Gap (full)	Action That Can Be Taken to Reduce the Performance Gap	Information Needed by CDS System	Potential Work Flow Insertion Points (relevant personnel)	Potential CDS Opportunity: Documentation Forms/ Templates	Potential CDS Opportunity: Relevant Data Presentation	Potential CDS Opportunity: Order Set or Ordering Tool	Potential CDS Opportunity: Protocol or Pathway Support	Potential CDS Opportunity: Reference Information	Potential CDS Opportunity: Alerts/ Reminders
9	Preop visit	ROS and documentation	ROS conducted prior to total hip or total knee replacement surgery by orthopedic surgeons may be lacking or may not be comprehensive and is often incompletely documented in the medical record.	Ask patient needed ROS questions Document ROS answers	Results of each review	Preop visit—examination (orthopedist) Preop intake (anesthesia) Population management (nurse, orthopedist, case manager)	Smart form that captures infection-related, cardiovascular and musculoskeletal ROS and generates risk scores or flags high-risk patients.	n/a	n/a	n/a	Link to an expert-defined list of key risk factors to be addressed during ROS.	Reminder to document ROS if not already completed when patient is cleared for surgery.
5	Preop visit	Preoperative tests	Patients who undergo total hip or total knee replacement surgery may not receive certain necessary preoperative tests, while others may undergo unnecessary testing.	Identify tests needed for each patient Order appropriate tests Monitor uncompleted tests	Criteria needed for determining appropriate tests	Preop visit—examination (orthopedist)	n/a	n/a	Preoperative order set that includes recommended preoperative tests based on a patient's medical history and ROS.	n/a	Link to guidelines specifying appropriate preoperative tests.	Alert for incomplete or undocumented test result that is recommended based on patient's medical history and ROS.
10	Preop visit documentation	Documentation of patient preferences, operative risks, and prognosis	Patients undergoing total hip or total knee replacement surgery may not always have discussions with their surgeons about their preferences, prognosis, or the risks and benefits of surgery, and these discussions may not be documented in their medical record.	Estimate and document risks, benefits, and prognosis Elicit patient's preferences Discuss estimates with patient Document outcome of discussion	Risk factors from ROS and medical history Algorithms to compute risk/benefit using patient-level data	Initial exam (orthopedist, nurse) Preop visit—data review (orthopedist)	Preop visit follow-up form assessing patient's understanding that can alert physician to poor understanding or when preference differs from current plan.	Display patient-specific risk factors during preoperative discussion, as well as summary risk and benefit information (calculated automatically).	n/a	n/a	Link to diagnosis- and procedure-specific estimates of benefits and risks overall and stratified by preoperative risk factors.	n/a

Gap	Gap Category	Clinical Performance Gap (brief)	Clinical Performance Gap (full)	Action That Can Be Taken to Reduce the Performance Gap	Information Needed by CDS System	Potential Work Flow Insertion Points (relevant personnel)	Potential CDS Opportunity: Documentation Forms/ Templates	Potential CDS Opportunity: Relevant Data Presentation	Potential CDS Opportunity: Order Set or Ordering Tool	Potential CDS Opportunity: Protocol or Pathway Support	Potential CDS Opportunity: Reference Information	Potential CDS Opportunity: Alerts/ Reminders
1	Preoperative visit	Discontinuation of anticoagulation therapy	Some patients taking coumadin or Plavix do not always discontinue their therapy or switch to short-term anticoagulation therapy in advance of total hip or total knee replacement surgery.	Educate patients about need to hold or switch anticoagulants prior to procedure Remind patients to hold or switch anticoagulants prior to procedure	Patient's medication list Criteria for stopping medications and for switching to short-term anticoagulants	Preop visit—examination (orthopedist) Population management (nurse, orthopedist, case manager)	Preop visit follow-up form that gauges understanding of what patient needs to do prior to surgery.	n/a	n/a	n/a	n/a	Reminder to contact patient at the time when anticoagulation therapy should be discontinued.
7	Preoperative visit	Preoperative noncardiac evaluation	Patients are not always assessed preoperatively for noncardiac comorbidities (e.g., hepatitis, HIV) or for the associated risk of morbidity from surgery.	Conduct noncardiovascular evaluation Order additional tests if necessary Document test results and risk level	Evaluation criteria for noncardiac comorbidities Data elements required for computing risk level	Preop visit—examination (orthopedist)	Preop smart form that scans patient record to populate the form with known noncardiac comorbidities.	n/a	n/a	n/a	Link to published estimates of benefits and risks of surgery for specific noncardiac comorbidities.	n/a
2	Preoperative visit	Bleeding and VTE risk assessment	Patients are not always assessed preoperatively for their bleeding and VTE risks, resulting in prophylaxis that does not match the patient's risk.	Assess and document bleeding and VTE risk Prescribe prophylaxis in accordance with risk	Data elements required to compute risk level	Preop visit—examination (orthopedist, nurse) Preoperative orders (orthopedist)	Smart form that captures bleeding and VTE risk factors and recommends a prophylaxis strategy in accordance with guidelines.	n/a	n/a	n/a	n/a	Alert if prophylaxis plan is inadequate for estimated VTE risk.

Gap	Gap Category	Clinical Performance Gap (brief)	Clinical Performance Gap (full)	Action That Can Be Taken to Reduce the Performance Gap	Information Needed by CDS System	Potential Work Flow Insertion Points (relevant personnel)	Potential CDS Opportunity: Documentation Forms/ Templates	Potential CDS Opportunity: Relevant Data Presentation	Potential CDS Opportunity: Order Set or Ordering Tool	Potential CDS Opportunity: Protocol or Pathway Support	Potential CDS Opportunity: Reference Information	Potential CDS Opportunity: Alerts/ Reminders
8	Infection prevention	Antibiotic prophylaxis	Antibiotic prophylaxis recommendations from the National Surgical Infection Prevention Project and AAOS may not be consistently followed for patients undergoing total hip or total knee replacement surgery.	Assess patient characteristics that affect prophylaxis strategy Administer prophylaxis in accordance with guidelines	Ability to track timing of initiation and cessation of antibiotics Patient characteristics (allergies, MRSA status, weight) Procedure duration	Preoperative assessment (orthopedist, nurse) Preoperative orders (orthopedist)	n/a	n/a	Order set that recommends guideline-based antibiotic treatment customized to patient characteristics.	n/a	n/a	Reminder to stop antibiotic administration at the appropriate time prior to surgery.
3	Operative (process)	VTE prophylaxis	Patients undergoing total hip or total knee replacement surgery may not receive VTE prophylaxis when it is indicated.	Determine patient's risk of VTE and risk of bleeding Prescribe treatment (drug or mechanical) in accordance with risk	Required elements for VTE prophylaxis (ACCP or AAOS) Patient-level bleeding and VTE risk factors.	Preoperative data review (orthopedist, nurse) Preoperative orders (orthopedist)	n/a	Automatically calculate and display estimate of VTE risk based on patient's lab values and medical history.	Order set for VTE prophylaxis that recommends treatment customized to patient's bleeding risk and that conforms to guidelines.	n/a	n/a	Alert if prophylaxis plan is inadequate for estimated VTE risk.
11	Operative	Readmission following elective total hip or knee replacement	Patients undergoing total hip or total knee replacement surgery may experience complications requiring readmission.	Initiate follow-up care through home health Prescribe appropriate DVT prophylaxis. Ensure that patient resumes other meds (e.g., beta blockers). Ensure that patient has adequate home support	Treatment summary for home health agency. Discharge instructions for patients	Orders (orthopedist) Population management (nurse)	n/a	n/a	Discharge order set that includes all relevant medications and post–acute care referrals.	n/a	n/a	Alert if patient deviates from discharge plan based on prescription filling and follow-up visit attendance.

Gap	Gap Category	Clinical Performance Gap (brief)	Clinical Performance Gap (full)	Action That Can Be Taken to Reduce the Performance Gap	Information Needed by CDS System	Potential Work Flow Insertion Points (relevant personnel)	Potential CDS Opportunity: Documentation Forms/ Templates	Potential CDS Opportunity: Relevant Data Presentation	Potential CDS Opportunity: Order Set or Ordering Tool	Potential CDS Opportunity: Protocol or Pathway Support	Potential CDS Opportunity: Reference Information	Potential CDS Opportunity: Alerts/ Reminders
6	Postoperative care	Patient discharge instructions	Patients who undergo total hip or total knee replacement surgery may not receive written discharge instructions, including plans for follow-up, activity restriction, anticoagulation, and dental prophylaxis.	Provide discharge instructions to patient and PCP. Review instructions with patient	Discharge instructions Contact information for PCP	Education (orthopedist, nurse) Discharge (orthopedist, nurse)	n/a	n/a	n/a	Discharge care planning tool covering multiple visits that can be tailored based on patient's needs.	Links to education materials that can be tailored to patient's needs and given to patients.	Reminder to generate and review discharge care plan with patient prior to discharge.
4	Postoperative care	Follow-up risk assessment for hip fracture patients	Many patients who undergo surgery for hip fracture fail to receive follow-up risk assessment and therapy to prevent future osteoporotic fractures.	Identify risk of subsequent fractures Provide therapy to mitigate fracture risk in high-risk patients.	Patient risk factors for additional hip fractures Current medications	Discharge (orthopedist, nurse)	Smart form that captures risk factors for subsequent fractures and recommends orders for tests and/or treatments based on results.	Display fracture history, risk factors, and current fracture-prevention medications.	n/a	n/a	n/a	Alert triggered by delay or inaction on positive finding from follow-up risk assessment.

NOTE: ROS = review of systems. MRSA = methicillin-resistant Staphylococcus aureus.

Table B.4. Clinical Decision Support Evidence Table: Documentation Forms and Templates for Orthopedics

Tool	Brief Description	Practice Setting	Impact on Performance Gaps	Impact on Workflow	Citation
Handheld computer loaded with EHR software	Handheld computer equipped for electronic point-of-care collection of clinical and patient experience data	Orthopedic surgeon practice in Ontario, Canada	n/a	Electronic data collection was more timely, complete, and accurate than paper records 17 of 18 participating surgeons reported agreement that data captured were relevant and that handheld computers were easy to use	(Bourne et al., 2001)
Meditrace electronic documentation with handheld computer	Handheld computer with a software package featuring structured decision trees for examination, obtaining history, and coding	Inpatient orthopedic surgery unit in Germany	Significantly more diagnoses were recorded when physicians used the handheld computer than when using paper documentation (9 versus 4, $p < 0.001$)	The handheld computers significantly decreased time required for documentation ($p < 0.001$)	(Stengel et al., 2004)

NOTE: VA = U.S. Department of Veterans Affairs. CPOE = computerized provider order entry.

Table B.5. Clinical Decision Support Evidence Table: Order Set and Ordering Tool for Orthopedics

Tool	Brief Description	Practice Setting	Impact on Performance Gaps	Impact on Workflow	Citation
Clinical reminders for DVT prophylaxis in admission and transfer orders	Incorporates clinical reminders for DVT prophylaxis into the patient admission and transfer order sections of the paperless medical record system, which includes order sets, reminders, and dosage guidelines. Populates nurse order fields and impatient pharmacy fields simultaneously.	Inpatient surgical unit	Increased use of evidence-based preventive measures for VTE	None discussed	(Rivera and Turner-Biscossi, 2003)
Electronic quick orders for preoperative antibiotic prophylaxis	Electronic ordering system for surgical subspecialties that presented two choices for antibiotic prophylaxis based on procedure type (one recommended type and an alternative for patients with beta-lactam allergy). Order page also included patient assessment and preparation information, including patient status, lab studies, tests, and DVT prophylaxis.	Surgical departments at an academic hospital and a VA hospital	Timely administration of antibiotic prophylaxis increased from 51% to over 95% Increased percentage of patients given appropriate antibiotic prophylaxis from under 80% to over 90% Decreased rate of clean wound infections	None discussed	(Webb, Flagg, and Fink, 2006)
CPOE	Integrated inpatient CPOE into surgery units	Orthopedic/neurosurgery unit at a community hospital and an academic hospital	n/a	Use of CPOE decreased the rate of medication clarifications from 2.8% to 0.40% at the community hospital ($p < 0.001$) and from 2.76% to 0.46% at the academic hospital ($p < 0.001$) Use of CPOE decreased time from provider ordering to pharmacist verification by two hours at the community hospital ($p < 0.001$) and by one hour at the academic hospital ($p < 0.001$) Users complained about the number of alerts presented when using CPOE	(Wess et al., 2007)

Table B.6. Clinical Decision Support Evidence Table: Protocol or Pathway Support for Orthopedics

Tool	Brief Description	Practice Setting	Impact on Performance Gaps	Impact on Workflow	Citation
n/a	n/a	n/a	n/a	n/a	n/a

Table B.7. Clinical Decision Support Evidence Table: Reference Information and Guidance for Orthopedics

Tool	Brief Description	Practice Setting	Impact on Performance Gaps	Impact on Workflow	Citation
CDSS for VTE prophylaxis	Online computer application designed as a tool to provide clinicians with relevant, real-time information pertaining to VTE prevention among surgical patients. The computer system critiques the VTE prophylaxis orders entered after the surgical procedure using patient data and guideline-based criteria. The computer produces an immediate alert if a discrepancy is detected between the prescription and the patient and guideline information.	Orthopedic surgery department in a French, urban hospital	Use of the CDSS improved adherence to guidelines from 83% to 95% When the CDSS was removed, physician adherence to guidelines reverted back to preintervention levels (approximately 83%) When using the CDSS, prescription errors as a percentage of total prescriptions decreased from 17% to 5%.	None discussed	(Durieux et al., 2000)
Kaiser Permanente National Total Joint Replacement Registry	Database to monitor revision, failure, and complication rates; identify the best practices and implant constructs; track implant usage and costs; identify patients at risk for poor clinical outcome; and monitor and support implant recalls from the FDA.	Surgical departments within Kaiser Permanente	Successful identification, monitoring, and notification of a hip implant recall and knee implant advisory Reduced volume of minimally invasive hip and knee procedures, which effectively reduced pain and demonstrated an improvement in subjective patient outcomes Identification of an uncemented total knee technique that was found to be associated with higher revision rates, which allowed surgeons to reduce the usage of this technique	None discussed	(Paxton et al., 2008)
DrugCalc, computer-based warfarin dosing	DrugCalc tool, which relies on Bayesian forecasting model to determine warfarin therapy after total hip replacement	n/a	Use of DrugCalc led to decreased length of hospital stay Average number of days needed to reach therapeutic anticoagulation level decreased	None discussed	(Motykie et al., 1999)

NOTE: CDSS = CDS system.

Table B.8. Clinical Decision Support Evidence Table: Alerts and Reminders for Orthopedics

Tool	Brief Description	Practice Setting	Impact on Performance Gaps	Impact on Workflow	Citation
Computerized reminder for DVT prophylaxis in surgical patients	HELP system searched clinical data to trigger a reminder for DVT prophylaxis in patients scheduled for surgery according to hospital recommendations for surgeries needing DVT prophylaxis.	Inpatient surgical units (including orthopedic surgery) at an academic hospital and a community teaching hospital	In the university hospital, the computer reminder significantly increased the rate of DVT prophylaxis from 85.2% to 99.3% ($p < 0.001$) In the community hospital, the rate of DVT prophylaxis increased from 89.9% to 95.0% ($p < 0.001$) In the community hospital, there was no impact on acquired symptomatic VTE within 90 days after surgery	Not discussed	(Patterson, 1998; Mosen et al., 2004)

NOTE: HELP = Health Evaluation Through Logical Processing.

Table B.9. Orthopedics Gap Statements, Round 2

Orthopedics Gap Survey	Importance
Gap 1: some patients taking coumadin or Plavix do not always discontinue their therapy or switch to short-term anticoagulation therapy in advance of total hip or total knee replacement surgery.	1 11 24A 1 2 3 4 5 6 7 8 9 **(9.0, 1.3, A)**
Gap 2: patients are not always assessed preoperatively for their bleeding and VTE risks resulting in prophylaxis that does not match the patient's risk.	12 A6 1 2 3 4 5 6 7 8 9 **(8.0, 0.7, A)**
Gap 3: patients undergoing total hip or total knee replacement surgery may not receive VTE prophylaxis when it is indicated.	1 495 1 2 3 4 5 6 7 8 9 **(8.0, 0.7, A)**
Gap 4: many patients who undergo surgery for hip fracture fail to receive follow-up risk assessment and therapy to prevent future osteoporotic fractures.	1 3384 1 2 3 4 5 6 7 8 9 **(8.0, 0.0, A)**
Gap 5: patients who undergo total hip or total knee replacement surgery may not receive certain necessary preoperative tests while others may undergo unnecessary testing	2 1871 1 2 3 4 5 6 7 8 9 **(7.0, 0.8, A)**
Gap 6: patients who undergo total hip or total knee replacement surgery may not receive written discharge instructions, including plans for follow-up, activity restriction, anticoagulation, and dental prophylaxis.	1 1944 1 2 3 4 5 6 7 8 9 **(7.0, 0.9, A)**
Gap 7: patients are not always assessed preoperatively for noncardiac comorbidities (e.g., hepatitis, HIV) or for the associated risk of morbidity from surgery.	23464 1 2 3 4 5 6 7 8 9 **(8.0, 1.1, I)**
Gap 8: antibiotic prophylaxis recommendations from the National Surgical Infection Prevention Project and AAOS may not be consistently followed for patients undergoing total hip or total knee replacement surgery.	11 3293 1 2 3 4 5 6 7 8 9 **(8.0, 1.1, I)**
Gap 9: reviews of systems conducted prior to total hip or total knee replacement surgery by orthopedic surgeons may be lacking or may not be comprehensive and are often incompletely documented in the medical record.	2 2273 1 2 3 4 5 6 7 8 9 **(8.0, 1.5, I)**
Gap 10: patients undergoing total hip or total knee replacement surgery may not always have discussions with their surgeons about their preferences, prognosis, or the risks and benefits of surgery, and these discussions may not be documented in their medical record.	1112671 1 2 3 4 5 6 7 8 9 **(7.0, 1.1, I)**
Gap 11: patients undergoing total hip or total knee replacement surgery may experience complications requiring readmission.	142561 1 2 3 4 5 6 7 8 9 **(7.0, 1.1, I)**
Gap 12: patients undergoing total hip or total knee replacement surgery may not always receive coordinated, multidisciplinary care from the time of operation through discharge and may not receive important tests, consultations, and education.	114454 1 2 3 4 5 6 7 8 9 **(7.0, 1.2, I)**

Orthopedics Gap Survey	Importance
Gap 13: prior to undergoing total hip or total knee replacement surgery, patients may not receive sufficient education about the procedure or about their post-discharge care.	1 2 1 2 7 3 3 1 2 3 4 5 6 7 8 9 **(7.0, 1.2, I)**
Gap 14: prior to undergoing total hip or total knee replacement surgery, patients may not receive an appropriate pre-operative cardiovascular evaluation, including cardiovascular risk stratification, and may lack documentation of any further cardiac evaluation that was performed.	1 2 1 2 7 4 2 1 2 3 4 5 6 7 8 9 **(7.0, 1.3, I)**
Gap 15: VTE prophylaxis is not always maintained for a sufficient time interval postoperatively.	2 3 2 3 6 3 1 2 3 4 5 6 7 8 9 (7.0, 1.5, I)
Gap 16: patients who have undergone total hip or total knee replacement surgery may not have operative notes in their medical record that document findings from the final examination.	1 2 2 1 4 7 2 1 2 3 4 5 6 7 8 9 **(7.0, 1.6, I)**
Gap 17: patients are not always informed about the possibility of receiving regional anesthesia before total hip or total knee replacement surgery.	3 2 7 3 3 1 1 2 3 4 5 6 7 8 9 **(5.0, 1.1, I)**
Gap 18: patients undergoing total hip or total knee replacement surgery may experience physiologic or metabolic derangement.	1 2 4 4 5 1 2 1 2 3 4 5 6 7 8 9 **(6.0, 1.3, I)**
Gap 19: patients undergoing total hip or total knee replacement surgery may not have information from physical exams documented completely in their medical record.	1 1 1 4 4 4 3 1 1 2 3 4 5 6 7 8 9 **(6.0, 1.4, I)**
Gap 20: information from diagnostic radiographs is not always fully documented in a patient's medical record prior to total hip or knee replacement surgery.	2 1 2 1 6 4 3 1 2 3 4 5 6 7 8 9 **(6.0, 1.5, I)**
Gap 21: patients may not have a comprehensive radiographic evaluation performed following total hip or total knee replacement surgery.	2 1 3 2 5 3 2 1 1 2 3 4 5 6 7 8 9 **(6.0, 1.5, I)**
Gap 22: patients undergoing total hip or total knee replacement surgery may experience postoperative hemorrhage or postoperative hematoma.	4 2 3 2 2 3 3 1 2 3 4 5 6 7 8 9 **(6.0, 1.9, I)**
Gap 23: patients undergoing total hip or total knee replacement surgery may not have the indication for surgery documented in their medical record.	1 2 6 1 1 2 6 1 2 3 4 5 6 7 8 9 **(6.0, 2.1, I)**
Gap 24: patients who have undergone total hip or total knee replacement surgery may not have radiographs taken at recommended intervals following the operation.	2 3 7 3 1 2 1 1 2 3 4 5 6 7 8 9 **(5.0, 1.4, I)**

Orthopedics Gap Survey	Importance
Gap 25: patients who are recovering from total joint replacement surgery may not be closely monitored for changes in neurological functioning.	2 2 4 3 3 3 1 1 1 2 3 4 5 6 7 8 9 **(5.0, 1.6, I)**
Gap 26: patients who have undergone total hip or total knee replacement surgery may not have follow-up visits at recommended intervals following the operation	2 2 2 5 3 2 1 2 1 2 3 4 5 6 7 8 9 **(5.0, 1.7, I)**
Gap 27: patients undergoing total hip or total knee replacement surgery may not have hair removed according to recommended techniques.	2 4 3 2 3 4 1 1 2 3 4 5 6 7 8 9 **(4.0, 1.7, I)**
Gap 28: patients undergoing total hip or total knee replacement surgery may not have their history of present illness completely documented in their medical record.	1 4 4 1 3 5 1 1 2 3 4 5 6 7 8 9 **(5.0, 1.6, D)**

Table B.10. Orthopedics Gap and Clinical Decision Support Opportunities, Round 2

Orthopedics Gap/CDS Opportunity	Compatibility	Potential Impact
Gap 1: some patients taking coumadin or Plavix do not always discontinue their therapy or switch to short-term anticoagulation therapy in advance of total hip or total knee replacement surgery.	**n/a**	**n/a**
Opportunity a: preoperative visit follow-up form that gauges understanding of what patient needs to do prior to surgery.	2 5 3 5 2 1 2 3 4 5 6 7 8 9 (7.0, 1.1, I)	1 1 3 3 2 6 1 1 2 3 4 5 6 7 8 9 (7.0, 1.5, I)
Opportunity b: reminder to contact patient at the time when anticoagulation therapy should be discontinued.	2 2 4 7 2 1 2 3 4 5 6 7 8 9 (8.0, 0.9, A)	1 2 1 1 4 6 2 1 2 3 4 5 6 7 8 9 (7.0, 1.4, I)
Overall rating	2 3 3 6 3 1 2 3 4 5 6 7 8 9 **(8.0, 1.1, I)**	1 1 1 1 5 5 3 1 2 3 4 5 6 7 8 9 **(7.0, 1.2, A)**
Gap 2: patients are not always assessed preoperatively for their bleeding and VTE risks, resulting in prophylaxis that does not match the patient's risk.	**n/a**	**n/a**
Opportunity a: smart form that captures bleeding and VTE risk factors and recommends a prophylaxis strategy in accordance with guidelines.	1 1 1 8 5 1 2 3 4 5 6 7 8 9 (8.0, 0.7, A)	2 1 A 4 1 2 3 4 5 6 7 8 9 (8.0, 1.1, I)
Opportunity b: alert if prophylaxis plan is inadequate for estimated VTE risk.	2 2 2 7 4 1 2 3 4 5 6 7 8 9 (8.0, 0.9, A)	1 1 4 1 7 3 1 2 3 4 5 6 7 8 9 (8.0, 1.1, I)
Overall rating	2 3 9 3 1 2 3 4 5 6 7 8 9 **(8.0, 0.7, A)**	1 1 2 B 2 1 2 3 4 5 6 7 8 9 **(8.0, 0.6, A)**
Gap 3: patients undergoing total hip or total knee replacement surgery may not receive VTE prophylaxis when it is indicated.	**n/a**	**n/a**
Opportunity a: automatically calculate and display estimate of VTE risk based on patient's lab values and medical history.	1 1 3 3 3 5 1 2 3 4 5 6 7 8 9 (8.0, 0.8, A)	1 5 2 3 6 1 2 3 4 5 6 7 8 9 (8.0, 1.1, A)
Opportunity b: order set for VTE prophylaxis that recommends treatment customized to patient's bleeding risk and that conforms to guidelines.	1 1 1 3 4 7 1 2 3 4 5 6 7 8 9 (8.0, 1.1, A)	1 2 3 2 9 1 2 3 4 5 6 7 8 9 (9.0, 1.1, A)
Opportunity c: alert if prophylaxis plan is inadequate for estimated VTE risk.	1 4 2 6 4 1 2 3 4 5 6 7 8 9 (8.0, 1.1, I)	1 1 4 3 4 4 1 2 3 4 5 6 7 8 9 (7.0, 1.3, I)

Orthopedics Gap/CDS Opportunity	Compatibility	Potential Impact
Overall rating	1 1465 1 2 3 4 5 6 7 8 9 **(8.0, 0.9, A)**	1 1267 1 2 3 4 5 6 7 8 9 **(8.0, 0.9, A)**
Gap4: many patients who undergo surgery for hip fracture fail to receive follow-up risk assessment and therapy to prevent future osteoporotic fractures.	**n/a**	**n/a**
Opportunity a: smart form that captures risk factors for subsequent fractures and recommends orders for tests and/or treatments based on results.	1 2293 1 2 3 4 5 6 7 8 9 (8.0, 0.8, A)	1 1 2 3 6 4 1 2 3 4 5 6 7 8 9 (8.0, 1.1, A)
Opportunity b: display fracture history, risk factors, and current fracture prevention medications.	2 2364 1 2 3 4 5 6 7 8 9 (8.0, 1.1, A)	2 1 3 3 5 3 1 2 3 4 5 6 7 8 9 (7.0, 1.3, I)
Opportunity c: alert triggered by delay or inaction on positive finding from follow-up risk assessment.	1 1 1 2 2 2 4 4 1 2 3 4 5 6 7 8 9 (7.0, 1.8, I)	2 1 1 3 3 3 4 1 2 3 4 5 6 7 8 9 (7.0, 2.0, I)
Overall rating	2 2544 1 2 3 4 5 6 7 8 9 **(7.0, 1.3, A)**	2 3444 1 2 3 4 5 6 7 8 9 **(7.0, 1.4, I)**
Gap 5: patients who undergo total hip or total knee replacement surgery may not receive certain necessary preoperative tests, while others may undergo unnecessary testing.	**n/a**	**n/a**
Opportunity a: preoperative order set that includes recommended preoperative tests based on a patient's medical history and review of systems.	1 4B1 1 2 3 4 5 6 7 8 9 (8.0, 0.5, A)	1 3 1 9 3 1 2 3 4 5 6 7 8 9 (8.0, 0.8, A)
Opportunity b: link to guidelines specifying appropriate preoperative tests.	1 3 6 4 2 1 1 2 3 4 5 6 7 8 9 (6.0, 0.9, I)	2 1 2 4 4 2 1 1 1 2 3 4 5 6 7 8 9 (5.0, 1.5, I)
Opportunity c: alert for incomplete or undocumented test result that is recommended based on patient's medical history and review of systems.	2 2 4 5 4 1 2 3 4 5 6 7 8 9 (8.0, 1.1, A)	1 2 3 4 4 3 1 2 3 4 5 6 7 8 9 (7.0, 1.2, I)
Overall rating	2681 1 2 3 4 5 6 7 8 9 **(8.0, 0.6, A)**	1 2761 1 2 3 4 5 6 7 8 9 **(7.0, 0.8, A)**
Gap 6: patients who undergo total hip or total knee replacement surgery may not receive written discharge instructions, including plans for follow-up, activity restriction, anticoagulation, and dental prophylaxis.	**n/a**	**n/a**

Orthopedics Gap/CDS Opportunity	Compatibility	Potential Impact
Opportunity a: discharge care planning tool covering multiple visits that can be tailored based on patient's needs.	2 5 6 4 1 2 3 4 5 6 7 8 9 (8.0, 0.8, A)	2 4 2 6 3 1 2 3 4 5 6 7 8 9 (8.0, 1.1, I)
Opportunity b: links to educational materials that can be tailored to patient's needs and given to patients.	1 4 2 5 3 2 1 2 3 4 5 6 7 8 9 (7.0, 1.2, I)	1 2 4 5 2 2 1 1 2 3 4 5 6 7 8 9 (6.0, 1.3, I)
Opportunity c: reminder to generate and review discharge care plan with patient prior to discharge.	2 2 2 1 5 3 2 1 2 3 4 5 6 7 8 9 (7.0, 1.5, I)	1 2 3 2 2 5 2 1 2 3 4 5 6 7 8 9 (6.0, 1.5, I)
Overall rating	1 1 4 7 2 2 1 2 3 4 5 6 7 8 9 **(7.0, 0.9, I)**	1 2 5 5 3 1 1 2 3 4 5 6 7 8 9 **(7.0, 1.0, I)**
Gap 7: patients are not always assessed preoperatively for noncardiac comorbidities (e.g., hepatitis, HIV) or for the associated risk of morbidity from surgery	**n/a**	**n/a**
Opportunity a: preoperative smart form that scans patient record to populate the form with known noncardiac comorbidities.	1 3 1 6 2 4 1 2 3 4 5 6 7 8 9 (7.0, 1.2, I)	1 3 1 2 4 5 1 1 2 3 4 5 6 7 8 9 (7.0, 1.4, I)
Opportunity b: link to published estimates of benefits and risks of surgery for specific noncardiac comorbidities.	1 1 1 4 6 2 2 1 2 3 4 5 6 7 8 9 (6.0, 1.1, I)	2 2 1 2 3 5 1 1 1 2 3 4 5 6 7 8 9 (6.0, 1.2, I)
Overall rating	1 2 1 6 5 2 1 2 3 4 5 6 7 8 9 **(8.0, 1.1, I)**	3 2 6 4 2 1 2 3 4 5 6 7 8 9 **(8.0, 0.5, A)**
Gap 8: antibiotic prophylaxis recommendations from the National Surgical Infection Prevention Project and AAOS may not be consistently followed for patients undergoing total hip or total knee replacement surgery.	**n/a**	**n/a**
Opportunity a: order set that recommends guideline-based antibiotic treatment customized to patient characteristics	1 2 6 8 1 2 3 4 5 6 7 8 9 (8.0, 0.8, A)	1 1 1 1 6 7 1 2 3 4 5 6 7 8 9 (8.0, 1.1, A)
Opportunity b: reminder to stop antibiotic administration at the appropriate time prior to surgery.	1 1 3 7 5 1 2 3 4 5 6 7 8 9 (8.0, 0.9, A)	1 1 2 4 4 5 1 2 3 4 5 6 7 8 9 (8.0, 1.4, A)

Orthopedics Gap/CDS Opportunity	Compatibility	Potential Impact
Overall rating	1 1 2 6 7 1 2 3 4 5 6 7 8 9 **(8.0, 0.9, A)**	1 1 1 3 4 7 1 2 3 4 5 6 7 8 9 **(8.0, 1.2, A)**
Gap 9: ROSs conducted prior to total hip or total knee replacement surgery by orthopedic surgeons may be lacking or may not be comprehensive and are often incompletely documented in the medical record.	**n/a**	**n/a**
Opportunity a: smart form that captures infection-related, cardiovascular, and musculoskeletal ROS and generates risk scores or flags high-risk patients.	4 7 3 3 1 2 3 4 5 6 7 8 9 (7.0, 0.8, A)	5 7 4 1 1 2 3 4 5 6 7 8 9 (7.0, 0.6, I)
Opportunity b: link to an expert-defined list of key risk factors to be addressed during ROS	2 5 5 5 1 2 3 4 5 6 7 8 9 (6.0, 0.9, I)	1 2 1 3 6 3 1 1 2 3 4 5 6 7 8 9 (6.0, 1.2, I)
Opportunity c: reminder to document ROS if not already completed when patient is cleared for surgery.	1 1 5 5 2 2 1 2 3 4 5 6 7 8 9 (6.0, 1.0, I)	1 1 3 5 3 3 1 1 2 3 4 5 6 7 8 9 (5.0, 1.5, D)
Overall rating	2 6 7 2 1 2 3 4 5 6 7 8 9 **(7.0, 0.7, I)**	4 5 5 3 1 2 3 4 5 6 7 8 9 **(6.0, 0.9, I)**
Gap 10: patients undergoing total hip or total knee replacement surgery may not always have discussions with their surgeons about their preferences, prognosis, or the risks and benefits of surgery, and these discussions may not be documented in their medical record.	**n/a**	**n/a**
Opportunity a: preoperative visit follow-up form assessing patient's understanding that can alert physician to poor understanding or when preference differs from current plan.	3 1 4 3 3 2 1 1 2 3 4 5 6 7 8 9 (6.0, 1.5, I)	1 2 2 4 3 4 1 1 2 3 4 5 6 7 8 9 (5.0, 1.4, I)
Opportunity b: display patient-specific risk factors during preoperative discussion, as well as summary risk and benefit information (calculated automatically).	2 1 2 8 2 2 1 2 3 4 5 6 7 8 9 (6.0, 0.9, I)	2 1 3 6 3 2 1 2 3 4 5 6 7 8 9 (6.0, 1.1, I)
Opportunity c: link to diagnosis- and procedure-specific estimates of benefits and risks overall and stratified by preoperative risk factors.	1 2 2 5 3 3 1 1 2 3 4 5 6 7 8 9 (5.0, 1.3, I)	1 1 2 3 3 3 3 1 1 2 3 4 5 6 7 8 9 (5.0, 1.5, D)
Overall rating	2 2 6 3 2 2 1 2 3 4 5 6 7 8 9 **(5.0, 1.1, I)**	3 3 5 2 2 2 1 2 3 4 5 6 7 8 9 **(5.0, 1.2, I)**

Orthopedics Gap/CDS Opportunity	Compatibility	Potential Impact
Gap 11: patients undergoing total hip or total knee replacement surgery may experience complications requiring readmission	**n/a**	**n/a**
Opportunity a: discharge order set that includes all relevant medications and post–acute care referrals	1 2 5 3 5 1 2 3 4 5 6 7 8 9 (8.0, 1.1, A)	3 4 4 2 4 1 2 3 4 5 6 7 8 9 (7.0, 1.2, I)
Opportunity b: alert if patient deviates from discharge plan based on prescription filling and follow-up visit attendance.	1 1 2 4 2 4 3 1 2 3 4 5 6 7 8 9 (6.0, 1.5, I)	1 2 3 2 2 2 4 1 1 2 3 4 5 6 7 8 9 (6.0, 1.9, I)
Overall rating	1 3 1 7 4 1 1 2 3 4 5 6 7 8 9 **(7.0, 0.9, I)**	2 5 1 5 3 1 1 2 3 4 5 6 7 8 9 **(7.0, 1.3, I)**

APPENDIX C. PEDIATRICS PANEL MATERIALS

GAP STATEMENT EVIDENCE DOCUMENT WITH PANELISTS' INPUT

Evidence on the Magnitudes and Consequences of Pediatric Clinical Performance Gaps

Table C.1. Estimated Prevalence of Childhood Conditions

Condition	Prevalence or Incidence of Condition
URIs	According to CDC, 22 million school days are lost annually in the United States due to the common cold. Children have about six to ten colds per year (Wenger et al., 2003).
Acute pharyngitis	In the United States, children typically average five sore throats per year. The incidence of pharyngitis and strep throat is highest in children between the ages of 5 and 18. Sore throat is rare in children younger than age 3 (Wennberg and Gittelsohn, 1973).
Overweight	Prevalence of overweight is 10.4% for children age 2 to 5 years (1.76 million), 19.6% for children aged 6 to 11 years (4.76 million), and 18.1% for children age 12 to 19 years (6.09 million) (Kann, Kinchen, et al., 1998b).
Lead poisoning	In 2007, 1% of children under age 6 who were tested for elevated blood levels had a positive result (32,000 children) (Wennberg, 1990). African American children and children in low-income families have the highest risk of exposure (Felt-Lisk, Barrett, and Nyman, 2007).
Mental health disorders	About 20% of children (14 million) are estimated to have mental health disorders with at least mild functional impairment (Felt-Lisk, Gimm, and Peterson, 2007). 13.1% of children age 8–15 (4.23 million) meet criteria for at least one of the following: ADHD, mood disorder, conduct disorder, generalized anxiety disorder, panic disorder, or eating disorder (Merikangas et al., 2010).
Depression	An estimated 5% of children ages 9–17 (1.83 million) have a diagnosis of MDD, while, at any one time, between 10% and 15% of the child and adolescent population (7.04 million to 10.5 million) has some symptoms of depression (Felt-Lisk, Gimm, and Peterson, 2007).
ADHD	In 2007, approximately 9.5% of children age 4–17 (5.4 million children) were diagnosed with ADHD (Raimer and Stobo, 2004).
Diabetes	About 186,300 children and adolescents, or 0.2% of children under age 20, have type 1 or type 2 diabetes (Way et al., 2007). Each year, more than 13,000 young people are diagnosed with type 1 diabetes (Baillargeon et al., 2000).
Asthma	An estimated 13.1% of children under the age of 18 (9.6 million children) have been diagnosed with asthma (American College of Physicians, National Commission on Correctional Health Care, and American Correctional Health Services Association, 1992).
Tobacco use	Approximately 20% of high school students in 2007 reported smoking in the past 30 days, and 11.7% of middle school students in 2004 reported using tobacco products (Shekelle, Chassin, and Park, 1998).
Chlamydia	In 2007, 3% of girls and women aged 15 to 19 (315,000) and 0.6% of boys and men aged 15 to 19 (66,300) were diagnosed with chlamydia (Donabedian, 1966).
Anemia	In the 2003 CDC Pediatric and Pregnancy Nutrition Surveillance System report, 16.2% of infants age 6–11 months had Hgb <110 g/L, and 15% of children age 12–17 months had Hgb <110 g/L. The prevalence of anemia in PedNSS children was 12.8% in 2003. The highest prevalence of anemia was among black infants (19.0%).
Developmental delays	16.7% of children under age 18 (12.4 million) have developmental delays (Boyle, Decouflé, and Yeargin-Allsopp, 1994). 12% of children have developmental delays at 9 months, and 13.8% of children have developmental delays at 24 months (Rosenberg, Zhang, and Robinson, 2008).
Autism	Most recent reviews of epidemiology estimate a prevalence of one to two cases of autism per 1,000 people and about six per 1,000 for ASD (Newschaffer et al., 2007).
Fluoride deficiency	Data could not be found.

Condition	Prevalence or Incidence of Condition
Vitamin D deficiency	12.1% of healthy infants and toddlers are vitamin D deficient (Gordon, Feldman, et al., 2008). 24.1% of healthy adolescents are vitamin D deficient (Gordon, DePeter, et al., 2004). More than half of children are vitamin D insufficient (Kumar et al., 2009).
Suicide	In 2007, suicide was the third leading cause of death for young people ages 15 to 24. Rates by age group were 0.9 per 100,000 (children age 10–14), 6.9 per 100,000 (adolescents age 15–19), and 12.7 per 100,000 (young adults age 20–24) (Kann, Warren, Harris, Collins, Douglas, et al., 1995a).

NOTE: PedNSS = Pediatric Nutrition Surveillance System. Hgb = hemoglobin. g = gram. L = liter. ASD = autism spectrum disorder.

Table C.2. Magnitude and Consequences of Performance Gaps for Pediatrics

Gap	Gap Category	Gap Statement	Magnitude of Performance Gap	Consequences of Performance Gap
5	Antibiotics	Many children presenting with acute respiratory tract infection symptoms are inappropriately diagnosed with bacterial illness.	According to NAMCS data, 55% of antibiotics prescribed for acute respiratory infections are used for infections that do not have bacterial etiology (Gonzales et al., 2001).	Limiting the inappropriate use of antibiotics for URIs will reduce the incidence of antibiotic-related complications, which range from fevers and rashes to drug allergies, prolonged hospital stays, and even death (Gonzales et al., 2001). It is estimated that $726 million is spent on use of antibiotics for acute respiratory infections that do not have bacterial etiology (Gonzales et al., 2001).
6	Antibiotics	Many children receive antibiotics for pharyngitis without first being tested for group A streptococcus.	Only about half of sore throat cases in children are caused by group A streptococcus, more commonly referred to as "strep throat" (Grunbaum et al., 1999). One study found that, in 36% of cases in which a patient received antibiotics and underwent a test for strep throat, the test came back negative (Grunbaum et al., 1999). In a recent nationwide survey, 42 percent of physicians reported that they would start antibiotic treatment for children with pharyngitis before knowing the results and would continue with treatment despite a negative strep test (Park et al., 2006). A study conducted in 2005 found that guidelines for clinical evaluation were not followed for 25 percent of children who were diagnosed with pharyngitis and consequently prescribed antibiotics (Tanz et al., 2009).	Inappropriate treatment of the common cold with antibiotics increases drug resistance and increases the likelihood of infections for which current antibiotics are ineffective. Limiting the inappropriate use of antibiotics will reduce the incidence of antibiotic-related complications, which range from fevers and rashes to drug allergies, prolonged hospital stays, and even death (Gonzales et al., 2001).
18	Antibiotics	Many children treated for bacterial URIs receive second-line antibiotics rather than first-line antibiotics.	A study of NAMCS data found that pediatricians inappropriately used second-line antibiotics to treat 13% of patients with otitis media or sinusitis and 34% of patients with URTIs or bronchitis (Nash et al., 2002).	Data not available

Gap	Gap Category	Gap Statement	Magnitude of Performance Gap	Consequences of Performance Gap
27	Obesity	Children often have poor documentation of their BMI and the corresponding percentile of the population distribution.	In a longitudinal study of 632 overweight and obese children and adolescents, it was found that documentation of BMI dropped from 96% at the first clinic visit to 27% by the fifth visit; additionally, documentation of individual risk behaviors for obesity fell from 72% at the first visit to 23% at the fifth visit. Despite initial adoption of screening and assessment practices, clinicians' attention to weight management diminished over time (Dorsey et al., 2010). In 2009, NCQA reported that only 30–35% of children had documentation of their BMI percentile by their PCP or OB/GYN (NCQA, 2010).	One study found that approximately 80 percent of children who were overweight at age 10–15 years were obese adults at age 25 (Kann, Kinchen, et al., 1998b). Another study found that 25 percent of obese adults were overweight as children and that, if overweight begins before 8 years of age, obesity in adulthood is likely to be more severe (Kann, Kinchen, et al., 1998b).
24	Obesity	Children often fail to receive nutrition and/or physical activity counseling.	Pediatricians and geriatricians counsel fewer patients about aerobic exercise than do family practitioners and internists. Counseling regarding strength training is less common in all physician groups surveyed and lowest among pediatricians, of whom 50% did not advise these exercises for any of their patients (Abramson et al., 2000). In 2009, NCQA reported that only 41% of children and adolescents received counseling for nutrition and only 33–37% received counseling for physical activity (NCQA, 2010).	One study found that approximately 80 percent of children who were overweight at age 10–15 years were obese adults at age 25 (Kann, Kinchen, et al., 1998b). Another study found that 25 percent of obese adults were overweight as children and that, if overweight begins before 8 years of age, obesity in adulthood is likely to be more severe (Kann, Kinchen, et al., 1998b).
1	Immunization	Children and adolescents fail to receive all recommended immunizations.	In 2007, nearly one-quarter of children aged 19 to 35 months had not received recommended immunizations (Kann, Kinchen, et al., 1998a). Adolescent immunization rates have historically lagged behind early childhood immunization rates in the United States. In 2000, the AAP reported that 3 million adolescents failed to receive at least one recommended vaccination (Everett, Kann, and McReynolds, 1997).	Childhood immunizations help prevent serious illnesses, such as polio, tetanus, and hepatitis. Vaccines are a proven way to help a child stay healthy and avoid the potentially harmful effects of childhood diseases, such as mumps and measles. Even preventing "mild" diseases saves hundreds of lost school days and workdays and millions of dollars. Low immunization rates have the potential to cause outbreaks of preventable diseases and to establish reservoirs of disease that can affect vulnerable populations, including infants, the elderly, and individuals with chronic conditions (Everett, Kann, and McReynolds, 1997).

Gap	Gap Category	Gap Statement	Magnitude of Performance Gap	Consequences of Performance Gap
28	Lead screening	Children fail to receive recommended levels of lead screening.	In 2009, NCQA reported that 66% of children on Medicaid had at least one venous lead blood test for lead poisoning by their second birthday (NCQA, 2010). A 1998 GAO report estimated that only 19 percent of children enrolled in Medicaid had been screened for lead exposure and that, in 1999, only eight of 42 states reported a Medicaid lead-screening rate above 20 percent for one- and two-year-olds. These low rates suggest that the vast majority of lead-poisoned children served by Medicaid are never identified or treated and that the lead hazards in their environments are likely left uncontrolled (Felt-Lisk, Barrett, and Nyman, 2007).	Lead poisoning in childhood affects primarily the central nervous system, the kidneys, and the blood-forming organs. Adverse effects in young children have been noted at levels as low as 10 micrograms/dL and include impairment in cognitive function and initiation of various behavioral disorders. Recent studies have noted effects of lead on cognitive ability at levels even below the level of concern of 10 micrograms/dL ("Youth Risk Behavior Surveillance," 1997).
20	MDD	Diagnoses of MDD are often made without the use of patient interviews.	The prevalence of the use of patient interviews to diagnosis MDD is unknown.	Data not available
21	MDD	DSM-IV criteria are often poorly documented among patients with MDD.	The prevalence of poor documentation is unknown. Depression in children and adolescents is often underdiagnosed; one-quarter to one-half of all cases of MDDs are estimated to be properly recognized by primary care and nonpsychiatric practitioners (Kann, Warren, Harris, Collins, Williams, et al., 1996).	Data not available
2	MDD	Children with MDD often receive inadequate follow-up care after receiving initial prescription for antidepressants.	Among a sample of Medicaid-covered adolescents, 28.1% of youth with an SSRI prescription fill had three or more follow-up visits in the subsequent three months, and 29.2% had no further provider visits (Richardson et al., 2004). Among a sample of clinicians treating pediatric patients in Nebraska, 31.9% reported seeing patients more frequently upon initiation of antidepressants, and 7.5% reported weekly visits for the first month of treatment, as recommended by the FDA (Bhatia et al., 2008).	Among the Medicaid sample, SSRIs were continued by 46.6% of treated youth at 3 months and by 26.3% at 6 months (Richardson et al., 2004).

Gap	Gap Category	Gap Statement	Magnitude of Performance Gap	Consequences of Performance Gap
11	Mental health	Children are inadequately assessed for risk of suicide.	Among a sample of pediatricians and family physicians in Maryland, only 23% reported frequently or always screening adolescent patients for suicide risk factors (Frankenfield et al., 2000).	One recent study found that the decreased use of antidepressants was associated with an increase in suicide rates by 14% between 2003 and 2004, which is the largest year-to-year change in suicide rates in this population since CDC began systematically collecting suicide data in 1979 (Gibbons et al., 2007). A meta-analysis of literature on suicide prevention programs found that physician education in depression recognition and treatment and restricting access to lethal methods reduce suicide rates (Mann et al., 2005).
14	Mental health	Many children are not screened for depression.	17% of pediatricians in one HMO reported screening all adolescent patients for depression (Halpern-Felsher et al., 2000).	Untreated depression may lead to failure to achieve full academic potential, disruption of key relationships within and outside the family, poor physical health, loss of self esteem, and self-harmful behaviors which may include drug use, risk-taking behaviors, and suicide (Kann, Warren, Harris, Collins, Douglas, et al., 1995b; "Appendix II," 1993).
8	ADHD	Diagnosis of ADHD is often made without adequate documentation of DSM-IV or DSM-PC criteria.	Among a sample of PCPs in Michigan, only 44% reported using DSM criteria to diagnosis ADHD in pediatric patients (Rushton, Fant, and Clark, 2004).	Many patients never receive an accurate diagnosis that would afford them appropriate therapeutic intervention. If left untreated, ADHD can cause significant personal, social, and economic burdens that can have a negative impact on overall quality of life (Goodman, 2007). Misdiagnosis of ADHD and subsequent treatment expose children to unnecessary risks and are costly. Medications used to treat ADHD result in elevated pulse rates and blood pressure and reductions in growth rate (Elder, 2010). Stimulant treatments for ADHD cost $1.6 billion to 2.5 billion annually in the United States (Elder, 2010).

Gap	Gap Category	Gap Statement	Magnitude of Performance Gap	Consequences of Performance Gap
7	ADHD	Children with ADHD who initiate medications may not receive optimal dose titration.	In 2009, NCQA reported that only 36% of children age 6–12 diagnosed with ADHD had one follow-up visit with a practitioner within a month of the first prescription of ADHD medication (NCQA, 2010). Among a sample of PCPs in Michigan, 34% reported not routinely following pharmacotherapy recommendations for ADHD medications, and 18.7% reported not following recommendations for titration in the first month when prescribed to pediatric patients (Rushton, Fant, and Clark, 2004).	The AAP recommends medication management of stimulants using systematic titration and intensive monitoring for a 1-year period. Reevaluation of a child's response after a drug holiday is essential to see whether drugs are still appropriate and necessary (Valente, 2001). Possible side effects of medications used to treat ADHD include sleep problems, decreased appetite, stomachaches, headaches, repetitive tics, and personality changes. Though the problems are rare, ADHD medications have also been associated with slightly higher risk of strokes, heart attacks, and sudden death. Psychiatric problems, including hearing voices, having hallucinations, becoming paranoid, and becoming manic, are rare as well. Many of these side effects can be attenuated or eliminated through reductions in medication dosage. The abuse potential of stimulants is also a concern because high doses can damage the cardiac and central nervous systems (Valente, 2001).
10	ADHD	Children with ADHD who are in the maintenance phase of medication therapy often receive inadequate follow-up care to reassess behavioral symptoms.	In 2009, NCQA reported that 42% of children age 6–12 with a prescription for ADHD medication remained on the medication for at least 210 days and had at least two follow-up visits in the 9 months following initiation (NCQA, 2010). Among a sample of PCPs in Michigan, only 53% reported routine follow-up visits (3–4 times per year) for children who have ADHD and are taking medications (Rushton, Fant, and Clark, 2004).	A review of literature on ADHD adherence found that, in clinical trial populations of adults and children, mean nonadherence rates ranged between 13% and 64% (Adler and Nierenberg, 2010). Poor adherence to stimulants in children is associated with an increased degree of maternal psychological distress, indifferent parenting, maternal overprotection/control, poor family support, decreased interaction with parents, and increased problems at home (Gau et al., 2006).
3	Asthma	Children with asthma treated in inpatient or ED settings may not receive adequate follow-up care or discharge planning.	60% of patients reported not having a written asthma action plan. Only 20% of patients completed a visit with their asthma care provider within one week of their last ED visit (Reeves et al., 2006).	For children, uncontrolled asthma is one of the most frequent reasons for admission to hospitals (McCormick et al., 2000). There are approximately 200,000 admissions for childhood asthma in the United States annually, representing more than $3 billion in expenditures. Undertreatment and inappropriate treatment of asthma are recognized as major contributors to asthma morbidity and mortality (Silber et al., 2003).
23	Asthma	Environmental risks are not routinely assessed for children with asthma, and parents are not always advised on risk mitigation.	A 2002 study reported that, although more than half of practicing pediatricians surveyed had seen a patient with health issues related to environmental exposures, fewer than 20% were trained in taking an environmental history (Kilpatrick et al., 2002).	Environmental exposure to pollutants and allergens, including molds, dust, environmental tobacco smoke, irritant chemicals and fumes, and expellants from combustion devices, are known to affect the prevalence and severity of asthma (Weiner et al., 2006).

Gap	Gap Category	Gap Statement	Magnitude of Performance Gap	Consequences of Performance Gap
4	Asthma	Children with asthma are not routinely monitored for control of their condition.	In 2000, about 60% of children age 5–9 and 59% of adolescents age 10–17 in HEDIS-participating managed care plans received appropriate asthma medication, compared with about 65% of adults age 18 to 56 years (Ochroch et al., 2006). Among a sample of pediatric asthma patients treated in three Michigan hospitals, less than half of patients reported attending two scheduled asthma appointments with their asthma care provider in the past year. 30% of patients reported going to directly to the ED when in need of urgent asthma care. 40% of patients reported not having a spacer or peak-flow meter, and 60% of patients reported not having a written asthma action plan. Only 20% of patients completed a visit with their asthma care provider within one week of their last ED visit (Reeves et al., 2006).	For children, uncontrolled asthma is one of the most frequent reasons for admission to hospitals (McCormick et al., 2000). There are approximately 200,000 admissions for childhood asthma in the United States annually, representing more than $3 billion in expenditures. Undertreatment and inappropriate treatment of asthma are recognized as major contributors to asthma morbidity and mortality (Silber et al., 2003). In a school-based survey of 3,109 teenagers, 50% of students who self-reported a diagnosis of asthma reported problems with wheezing in the past 28 days. These students also reported lower perceived well-being, more physical and emotional symptoms, greater limitations in activity, more comorbidities, and more negative behaviors that threaten social development than students without asthma (Forrest et al., 1997).
17	Asthma	Many children with asthma fail to have spirometry performed to assess asthma control and severity as outlined in national guidelines, resulting in undertreatment with controller medications.	Among a random national sample of pediatricians and family practitioners, 48% did not use spirometry in clinical practice. Among the group who reported using spirometry, 21% reported using it in all guideline-recommended clinical situations (Dombkowski et al., 2010).	A comparison of asthma severity rating based on symptoms alone and severity rating based on pulmonary function testing found that one-third of patients were moved to a higher severity category when pulmonary function testing in addition to symptom severity (Stout et al., 2006).

Gap	Gap Category	Gap Statement	Magnitude of Performance Gap	Consequences of Performance Gap
15	Tobacco	Children and their parents are not routinely screened for tobacco use, and, among children and their parents who smoke, providers often fail to ask about their interest in quitting, to give advice to quit, or to offer tobacco cessation interventions.	23% of adults in the United States are smokers, and more than 2,000 adolescents become regular tobacco users daily. Nearly 90% of smokers start by age 18, and 25% of teen smokers remain addicted as adults. Because 70% of smokers see a physician each year, clinicians have a unique opportunity to intervene (Gottesman, Fojo, and Bates, 2002).	The adverse health effects from cigarette smoking account for an estimated 443,000 deaths, or nearly one of every five deaths, each year in the United States (Amarasingham et al., 2009). Compared with nonsmokers, smokers are estimated to have increased risk of coronary heart disease (by 2 to 4 times), stroke (by 2 to 4 times), lung cancer (by 23 times in men and by 13 times in women), and dying from chronic obstructive lung diseases, such as chronic bronchitis and emphysema (by 12 to 13 times) (Amarasingham et al., 2009). Studies have shown that even brief counseling by health care providers increases smoking cessation rates, yet fewer than 50% of patients who smoke receive cessation counseling and treatment during physician office visits (Prokhorov et al., 2010). A study of smoking cessation interventions found that, among patients who were not asked by their physician if they reported smoking, 36% tried quitting in the past year (Kottke et al., 1989). A meta-analysis of smoking cessation interventions found that intensive physician counseling increases the odds of quitting (Lemmens et al., 2008).
9	Sexual health	Many sexually active adolescent women do not receive periodic chlamydia screening.	In 2009, NCQA reported that chlamydia screening rates ranged between 38 and 54% among young adults age 16–20 (NCQA, 2010). Among sexually active female enrollees age 16–25 years in commercial and Medicaid health plans in the United States, the annual chlamydia screening rate was 41.6% in 2007. In 2007, Hawaii had the highest chlamydia screening rate (57.8%), and Utah had the lowest (20.8%) ("Chlamydia Screening Among Sexually Active Young Female Enrollees of Health Plans," 2009).	In women, untreated infection can spread into the uterus or fallopian tubes and cause PID. This happens in about 10 to 15 percent of women with untreated chlamydia. Chlamydia can also cause fallopian tube infection without any symptoms. PID and "silent" infection in the upper genital tract can cause permanent damage to the fallopian tubes, uterus, and surrounding tissues. The damage can lead to chronic pelvic pain, infertility, and potentially fatal ectopic pregnancy (pregnancy outside the uterus). Chlamydia may also increase the chances of becoming infected with HIV, if exposed (Fischer et al., 2008). In pregnant women, there is some evidence that untreated chlamydial infections can lead to premature delivery. Babies who are born to infected mothers can get chlamydial infections in their eyes and respiratory tracts. Chlamydia is a leading cause of early infant pneumonia and conjunctivitis in newborns (Fischer et al., 2008).

Gap	Gap Category	Gap Statement	Magnitude of Performance Gap	Consequences of Performance Gap
19	Anemia	Infants and children are inadequately screened and/or treated for iron deficiency anemia.	As many as 55% to 60% of children between 1 and 2 years of age are not getting the 1989 recommended daily allowance for iron (Kohli-Kumar, 2001). Premature and low-birth-weight babies are at high risk for iron-deficiency anemia (Ledley and Lusted, 1959).	Several cross-sectional and case-control studies have demonstrated an association between IDA and psychomotor and cognitive abnormalities and poor school performance in children. For example, in a recent cross-sectional analysis of NHANES III data, 71% of iron-deficient children had below-average math scores, versus 49% of children who had normal iron status. Scores of tests on reading, block design, and digit span did not differ. The effect was strongest among girls age 12–16 (Halterman et al., 2001).
12	Development	Children do not always undergo developmental and behavioral screening using standardized assessments.	A study of 17 pediatric primary care practices from 15 states found that, on average, practices screened 85% of patients at recommended screening ages, but no practices were found to implement developmental screening as recommended by the AAP (King et al., 2010).	Data not available
22	Development	Many children at risk for developmental delays do not receive adequate follow-up care.	A study of 17 pediatric primary care practices from 15 states found that monthly referral rates among children with failed screens ranged from 48 to 78% (King et al., 2010).	Data not available
13	Autism	Many children with ASDs are not diagnosed in a timely manner.	One study of Medicaid-eligible white and black children found that black children were, on average, diagnosed with autistic disorders 1.6 years later than white children (Mandell et al., 2002).	The advantages of early diagnosis of autism include earlier educational planning and treatment, provision for family supports and education, reduction of family stress, and delivery of appropriate medical care to the child (Filipek et al., 1999). Intensive early intervention in optimal educational settings results in improved outcomes in most young children with autism, including speech and significant increases in rates of developmental progress and intellectual performance (Filipek et al., 1999).
25	Oral health	Children under the age of 6 are not routinely monitored for fluoride intake.	In 2008, only 32 percent of children who were eligible to receive preventive dental services under EPSDT received them (Agency for Healthcare Research and Quality, 2009).	Children with low fluoride intake are more likely to develop cavities, while children with excess fluoride intake are more likely to develop fluorosis (Warren et al., 2009). During 1999–2002, 41% of children age 2–11 and 42% of children and adolescents age 6–19 had dental caries in their primary teeth (Beltran-Aguilar et al., 2005).
26	Inpatient care	Many children hospitalized with a diagnosis of bronchiolitis inappropriately receive systemic corticosteroid therapy.	A study of infants in the Pediatric Health Information System found that 25% of infants under 1 year hospitalized for bronchiolitis received system corticosteroids (Christakis, Cowan, et al., 2005).	Treatment of children with acute viral bronchiolitis with glucocorticoids does not reduce length of hospitalization, readmission rate, respiratory rate, or hemoglobin oxygen saturation (Fernandes et al., 2010).

Gap	Gap Category	Gap Statement	Magnitude of Performance Gap	Consequences of Performance Gap
16	Inpatient care	Not all noncritically ill hospitalized children receiving nephrotoxic medications are monitored for nephrotoxic medication associated AKI.	Data not available	A study of hospitalized children receiving nephrotoxic medications found that 33.8% of the children developed AKI. AKI was associated with greater length of hospitalization and increased hospital cost (Moffett and Goldstein, 2011). A study of hospitalized children treated with aminoglycosides found that 33% of children were categorized as having pRIFLE AKI and 20% were categorized as having AKIN AKI (Zappitelli et al., 2011).

NOTE: NAMCS = National Ambulatory Medical Care Survey. URTI = upper respiratory tract infection. NCQA = National Committee for Quality Assurance. OB/GYN = obstetrician/gynecologist. AAP = American Academy of Pediatrics. GAO = U.S. Government Accountability Office. dL = deciliter. HMO = health maintenance organization. HEDIS = Healthcare Effectiveness Data and Information Set. PID = pelvic inflammatory disease. IDA = iron-deficiency anemia. NHANES III = National Health and Nutrition Examination Survey (third). EPSDT = Early Periodic Screening, Diagnosis, and Treatment. AKI = acute kidney injury. pRIFLE = pediatric Risk, Injury, Failure, Loss, End-Stage Kidney Disease. AKIN = Acute Kidney Injury Network. SSRI = selective serotonin reuptake inhibitor.

Table C.3. Clinical Decision Support Opportunity Matrix for Pediatrics

Gap	Gap Category	Clinical Performance Gap	Action That Can Be Taken to Reduce the Performance Gap	Information Needed by CDS System	Potential Work Flow Insertion Points (relevant personnel)	Potential CDS Opportunities to Reduce Performance Gaps: Documentation Forms/ Templates	Potential CDS Opportunities to Reduce Performance Gaps: Relevant Data Presentation	Potential CDS Opportunities to Reduce Performance Gaps: Order Set or Ordering Tool	Potential CDS Opportunities to Reduce Performance Gaps: Protocol or Pathway Support	Potential CDS Opportunities to Reduce Performance Gaps: Smart Links to Reference Information	Potential CDS Opportunities to Reduce Performance Gaps: Alerts/ Reminders
1	Antibiotics	Many children presenting with acute respiratory tract infection symptoms are inappropriately diagnosed with bacterial illness.	For children age 3 months to 18 years: Avoid prescribing or dispensing an antibiotic. Educate parents about appropriate antibiotic use.	Presenting signs and symptoms Antibiotic order	Orders (physician, nurse practitioner)	Smart form to document signs or symptoms of bacterial infection (or their absence) and to order "cold kit" or antibiotics, if appropriate	n/a	n/a	n/a	Links to parent education materials relating to antibiotics for URIs.	n/a
2	Antibiotics	Many children receive antibiotics for pharyngitis without first being tested for group A streptococcus.	For children age 2 through 18 years with symptoms of streptococcus pharyngitis: Test for group A streptococcus pharyngitis Dispense antibiotic when strep test is positive	Strep test result Antibiotic order	Orders (physician, nurse practitioner)	Smart form that prompts for appropriate strep testing based on clinical findings.	n/a	n/a	Protocol to automate ordering appropriate antibiotics based on strep test results, patient weight, allergies, and other factors.	Link to treatment guidelines for pharyngitis.	Alert if pharyngitis is entered as a diagnosis without a strep test being ordered.

Gap	Gap Category	Clinical Performance Gap	Action That Can Be Taken to Reduce the Performance Gap	Information Needed by CDS System	Potential Work Flow Insertion Points (relevant personnel)	Potential CDS Opportunities to Reduce Performance Gaps: Documentation Forms/ Templates	Potential CDS Opportunities to Reduce Performance Gaps: Relevant Data Presentation	Potential CDS Opportunities to Reduce Performance Gaps: Order Set or Ordering Tool	Potential CDS Opportunities to Reduce Performance Gaps: Protocol or Pathway Support	Potential CDS Opportunities to Reduce Performance Gaps: Smart Links to Reference Information	Potential CDS Opportunities to Reduce Performance Gaps: Alerts/ Reminders
6	Immunization	Children and adolescents fail to receive all recommended immunizations.	For children or adolescents with immunizations that are out of date: Administer immunizations Establish immunization schedule	Immunization history Patient preferences relating to immunizations	Intake (nurse, case manager) Orders (physician, nurse practitioner)	n/a	Display immunization history and highlight missing immunizations.	Order set that includes all recommended immunizations.	Tool to facilitate scheduling of immunizations according to recommended sequence and timing.	n/a	Alert for missing immunizations, with link to order set.
9	MDD	DSM-IV criteria are often poorly documented among patients with MDD.	For children with depression symptoms: Document DSM-IV criteria for MDD	DSM-IV criteria met by patient	History/exam (physician) Documentation (physician, nurse)	Diagnostic interview template for MDD that includes DSM-IV criteria.	Display DSM-IV criteria met by patient during subsequent clinic visits.	n/a	n/a	n/a	Reminder to specify DSM-IV criteria in a note triggered by new diagnosis of MDD.
10	MDD	Children with MDD often receive inadequate follow-up care after receiving initial prescription for antidepressants.	For children with MDD: Develop follow-up care plan. Monitor adherence to care plan.	Patient's MDD treatment history (including effectiveness, side effects) Treatment adherence data	History/ exam (physician) Medication management (physician, nurse) Orders (physician, nurse practitioner)	n/a	Display data on current and past history of antidepressant use and adherence.	Order set that prioritizes medications based on effectiveness, safety, or cost data.	Protocol for antidepressant switching or dose escalation for treatment-resistant depression.	n/a	Alert triggered if MDD patient is not on medication and has not been referred for further evaluation.

Gap	Gap Category	Clinical Performance Gap	Action That Can Be Taken to Reduce the Performance Gap	Information Needed by CDS System	Potential Work Flow Insertion Points (relevant personnel)	Potential CDS Opportunities to Reduce Performance Gaps: Documentation Forms/ Templates	Potential CDS Opportunities to Reduce Performance Gaps: Relevant Data Presentation	Potential CDS Opportunities to Reduce Performance Gaps: Order Set or Ordering Tool	Potential CDS Opportunities to Reduce Performance Gaps: Protocol or Pathway Support	Potential CDS Opportunities to Reduce Performance Gaps: Smart Links to Reference Information	Potential CDS Opportunities to Reduce Performance Gaps: Alerts/ Reminders
11	Mental health	Children are inadequately assessed for risk of suicide.	For pediatric patients (age 6–17 years): Assess suicide risk Counsel patients at risk for suicide Refer to specialist when indicated	History of MDD symptoms History of suicidality Risk factors for suicide	Intake (nurse, office staff) Data review (physician, nurse) Population management (nurse, office staff) Referral (physician)	Smart self-assessment form that elicits suicide risk and alerts provider if symptoms endorsed.	Display suicide risk factors during subsequent clinic visits.	n/a	n/a	n/a	Alert to PCP about elevated suicide risk if patient is being seen by non-PCP.
13	ADHD	Diagnosis of ADHD is often made without adequate documentation of DSM-IV or DSM-PC criteria.	For children newly diagnosed with ADHD, document DSM-IV or DSM-PC criteria	ADHD diagnostic criteria	History/examination (physician, nurse practitioner) Data review (physician, nurse) Discharge (physician)	Diagnostic assessment template for ADHD that includes all DSM-IV criteria.	n/a	n/a	n/a	n/a	Reminder to document DSM criteria triggered by new diagnosis of ADHD.
14	ADHD	Children with ADHD who initiate medications may not receive optimal dose titration.	For children with ADHD, Develop care plan for initiation phase Ensure patients adhere to care plan	ADHD symptoms Medication refill data Office visit utilization data	History/ exam (physician, nurse practitioner) Medication management (physician, nurse)	Smart form for ADHD encounter that captures changes in symptoms and medication side effects and recommends options for dose titration.	Display office visit utilization data, behavioral symptom history, medication data during patient encounter	n/a	Tool that automatically develops a care plan (including dose titration) over multiple visits.	n/a	n/a

Gap	Gap Category	Clinical Performance Gap	Action That Can Be Taken to Reduce the Performance Gap	Information Needed by CDS System	Potential Work Flow Insertion Points (relevant personnel)	Potential CDS Opportunities to Reduce Performance Gaps: Documentation Forms/ Templates	Potential CDS Opportunities to Reduce Performance Gaps: Relevant Data Presentation	Potential CDS Opportunities to Reduce Performance Gaps: Order Set or Ordering Tool	Potential CDS Opportunities to Reduce Performance Gaps: Protocol or Pathway Support	Potential CDS Opportunities to Reduce Performance Gaps: Smart Links to Reference Information	Potential CDS Opportunities to Reduce Performance Gaps: Alerts/ Reminders
15	ADHD	Children with ADHD who are in the maintenance phase of medication therapy often receive inadequate follow-up care to reassess behavioral symptoms.	For children with ADHD, Develop care plan for maintenance phase Ensure that patients adhere to care plan Assess changes in behavioral symptoms Refer to specialist when indicated	ADHD symptoms Medication refill data Office visit utilization data	History/ exam (physician, nurse practitioner) Medication management (physician, nurse) Referral (physician)	n/a	Display office visit utilization data and behavioral symptom history during patient encounter.	n/a	Tool that automatically develops a maintenance therapy care plan over multiple visits.	n/a	Alert triggered by drug or office visit utilization patterns that deviate deviation from care plan.
16	Asthma	Children with asthma treated in inpatient or ED settings may not receive adequate follow-up care or discharge planning.	For children 5 years and older treated in an inpatient setting: provide patient with asthma discharge plan coordinate with PCP Refer to specialist when indicated	PCP info Asthma severity Medication history Environmental triggers	Hospital discharge (physician, nurse) Referral (physician)	Smart form that customizes discharge plan according to patient's asthma-related needs and risks.	n/a	n/a	Tool that creates longitudinal follow-up plan for adjusting medication therapy and seeing specialists when indicated.	n/a	n/a

Gap	Gap Category	Clinical Performance Gap	Action That Can Be Taken to Reduce the Performance Gap	Information Needed by CDS System	Potential Work Flow Insertion Points (relevant personnel)	Potential CDS Opportunities to Reduce Performance Gaps: Documentation Forms/ Templates	Potential CDS Opportunities to Reduce Performance Gaps: Relevant Data Presentation	Potential CDS Opportunities to Reduce Performance Gaps: Order Set or Ordering Tool	Potential CDS Opportunities to Reduce Performance Gaps: Protocol or Pathway Support	Potential CDS Opportunities to Reduce Performance Gaps: Smart Links to Reference Information	Potential CDS Opportunities to Reduce Performance Gaps: Alerts/ Reminders
18	Asthma	Children with asthma are not routinely monitored for control of their condition.	For children 5 years and older: Evaluate and document asthma impairment and asthma risk Prescribe appropriate control medication for persistent asthma Adjust controller/reliever medication ratio if indicated	Asthma control history Medication history (including side effects and adverse events) Office visit/ED utilization data	Population management (nurse, office staff) Medication management (physician, nurse practitioner) Orders (physician, nurse practitioner)	Documentation template that includes items needed to assess asthma control.	Display recent health care utilization, symptoms, and medication refill data.	Asthma order set that prioritizes agents according to effectiveness, safety, and/or cost.	Pathway to guide dose escalation or medication substitution.	n/a	Alert to assess control if too much time has elapsed between assessments.
19	Asthma	Many children with asthma fail to have spirometry performed to assess asthma control and severity as outlined in national guidelines (resulting in undertreatment with controller medications).	For children with asthma: Assess asthma control and severity using spirometry in accordance with national guidelines Treat with controller medications when indicated by spirometry results	Asthma control and severity history	Intake (nurse) Population management (nurse, office staff) Data review (physician, nurse) Orders (physician, nurse practitioner)	n/a	Display patient's historical spirometry data along with current medications.	Asthma order set that includes spirometry	n/a	n/a	Alert to conduct spirometry test if too much time has elapsed between assessments.

Gap	Gap Category	Clinical Performance Gap	Action That Can Be Taken to Reduce the Performance Gap	Information Needed by CDS System	Potential Work Flow Insertion Points (relevant personnel)	Potential CDS Opportunities to Reduce Performance Gaps: Documentation Forms/ Templates	Potential CDS Opportunities to Reduce Performance Gaps: Relevant Data Presentation	Potential CDS Opportunities to Reduce Performance Gaps: Order Set or Ordering Tool	Potential CDS Opportunities to Reduce Performance Gaps: Protocol or Pathway Support	Potential CDS Opportunities to Reduce Performance Gaps: Smart Links to Reference Information	Potential CDS Opportunities to Reduce Performance Gaps: Alerts/ Reminders
21	Sexual health	Many sexually active adolescent women do not receive periodic chlamydia screening.	For women age 15 and older: Determine sexual activity status Test for chlamydia	Sexual activity status Chlamydia testing history (with test results)	Intake (nurse, office staff) Orders (physician, nurse practitioner) Population management (nurse, office staff)	Smart form that includes sexual history and orders for chlamydia testing, if indicated.	n/a	Order form that includes chlamydia test as part of routine screening tests based on patient's age and/or sexual history	n/a	n/a	Reminder to conduct yearly chlamydia screening on patients who report being sexually active.
28	Inpatient care	Not all noncritically ill hospitalized children receiving nephrotoxic medications are monitored for nephrotoxic medication-associated AKI.	For noncritically ill, hospitalized children taking nephrotoxic medications: Monitor for nephrotoxic medication associated acute kidney illness	Medication list Prior lab test results	Orders (physician, nurse practitioner) Medication management (physician, nurse practitioner)	n/a	n/a	Order set for nephrotoxic medications that includes lab tests for monitoring kidney function and, when appropriate, drug levels	n/a	n/a	Alert if lab result for patient on nephrotoxic medication is suggestive of AKI.

Table C.4. Clinical Decision Support Evidence Table: Documentation Forms and Templates for Pediatrics

Tool	Description	Practice Setting	Impact on Performance	Impact on Workflow	Citation
ADHD documentation form with reminder to assess ADHD symptoms	Reminder to assess ADHD symptoms every 3 to 6 months and ADHD structured note template based on AAP guidelines.	Outpatient clinic at community health centers and private practices	More patients in the intervention group than in the control had an ADHD visit (71% versus 54%, $p = 0.04$). Notes in which the template was used were more likely to document any assessment of symptoms (100% versus 61%, $p < 0.001$), treatment effectiveness (97% versus 55%, $p < 0.001$), and treatment adverse effects (97% versus 40%, $p < 0.001$). The number of times a reminder appeared for a patient during the study period was not associated with an increased likelihood of having a visit at which ADHD symptoms and treatment were discussed.	Physicians who had access to the ADHD reminder and template were more satisfied with their patient management than were physicians in the control group, $p = 0.01$).	(Co et al., 2010)
Computerized clinical documentation system	Used the Eclipsys Continuum 2000 clinical documentation system in the PICU.	PICU	No data on impact on clinical performance.	No significant difference in nursing time devoted to direct patient care or charting. There was no significant difference in time for nursing shift change. Nursing reports of satisfaction with reporting when using the computerized clinical documentation were significantly higher than before the CDS system was implemented, $p < 0.01$. There was a significantly longer delay in medication delivery when using the computerized clinical documentation system (16.9 minutes versus 12.8 minutes, $p < 0.01$). Improved accessibility to patients' records	(Menke et al., 2001)

Tool	Description	Practice Setting	Impact on Performance	Impact on Workflow	Citation
Electronic clinical information system	Integrated an electronic clinical information system, CLINFOSYS, into a PICU. CLINFOSYS accepts structured and unstructured data, including diagnoses, procedures, events, medications, and physical exam. Allows generation of a printable record of the encounter, calculates personalized formulations of parenteral and enteral supplements, and generates clinical summaries.	Inpatient ICU	Electronically documented encounters contained significantly more descriptors of physical exams (17.8 versus 11.6, $p < 0.01$). Nutrition formulations were more likely to be recorded for encounters documented using the system ($p < 0.001$).	The system had no significant effect on the amount of time required to document an encounter. PCPs who referred patients to the ICU received correspondence electronically, including records of their patients' hospitalizations. These PCPs found the correspondences to be very useful.	(Apkon and Singhaviranon, 2001)
Electronic structured reporting tool for documentation of patient encounters	Clictate is a reporting tool that allows electronic entry of patient history, patient encounter, screening results, immunization records, diagnoses, and treatment plans.	Outpatient setting	70% of surveyed physicians felt that the tool helped teach new residents about well-child care. 33% of surveyed physicians felt that the tool made their care more thorough. 85% of surveyed physicians agreed or strongly agreed that the tool helped them comply with guidelines for development assessment and anticipatory guidance.	Respondents believed that the tool increased the time it took to document the visit.	(Johnson and Cowan, 2002)
Diagnostic decision tool	Tool that captures details of the patient in the provider's own words, as well as his or her diagnostic workup and clinical plans and provides diagnostic suggestions based on the input, giving the provider an option to revise his or her original diagnostic plan or to keep the original plan.	Pediatric ambulatory units in UK hospitals	The diagnostic tool significantly decreased the percent of "unsafe" workups (instances in which all clinically significant diagnoses were not considered) (45% versus 33%, $p < 0.001$). There was no significant increase in diagnostic quality score.	Feedback from physicians indicated that the trial website was cumbersome to use in real time because it forced them to record all their decisions prior to advice.	(Ramnarayan et al., 2006)

NOTE: PICU = pediatric intensive care unit. ICU = intensive care unit.

Table C.5. Clinical Decision Support Evidence Table: Order Set and Ordering Tool for Pediatrics

Tool	Description	Practice Setting	Impact on Performance	Impact on Workflow	Citation
ARI-IT	The ARI-IT automatically generates a clinic note based on items checked off by physicians. Physicians then edit the drafted note. The ARI-IT generates guideline-compatible, diagnosis-specific management suggestions. Management support included guidelines for appropriate antibiotic prescriptions, testing recommendations, and patient handouts (including excuse forms).	Outpatient pediatric practice	Clinicians who had access to the ARI-IT were more likely to prescribe antibiotics for diagnoses of streptococcal pharyngitis (81% versus 66%, $p < 0.001$). Clinicians were less likely to prescribe antibiotics at visits when the ARI-IT was used (32% versus 40%, $p = 0.02$). Clinicians using the ARI-IT were less likely to prescribe macrolides for bacterial illness (6.2% versus 9.5%, $p = 0.02$). Clinicians using the ARI-IT were less likely to dispense prescriptions for suppurative otitis media.	Access to the ARI-IT did not always ensure use of the ARI-IT. Clinicians indicated benefit of the note creation feature, automatic generation of weight-based printable prescriptions, patient handouts, and excuse forms.	(Bourgeois et al., 2010)
Smart lab order form	The LUMPS allows for lab ordering rules to be defined based on clinical classification. The system suggests a lab schedule that can be modified by the physician. The system then prints lab request forms and tube labels.	Inpatient pediatric liver disease unit at a UK hospital	There was a13% increase in total number of tests requested per patient. Among transplant patients, there was a 27% decrease in number of tests requested. The number of STAT requests decreased by 44%. 78% compliance with proposed testing protocol 45% compliance of proposed testing in transplant patients No data on changes in the appropriateness of orders	None discussed	(Boon-Falleur et al., 1995)

Tool	Description	Practice Setting	Impact on Performance	Impact on Workflow	Citation
Anti-infective management tool	Integrated a pediatric anti-infective management tool into the HELP hospital information system.	PICU	Patients admitted while the management tool was implemented where more likely to receive antimicrobials (65% versus 60%, $p < 0.05$). Increased likelihood of appropriate orders. There was no significant difference in length of stay, mortality, or hospital cost. Decreased the number of orders placed per anti-infective course	None discussed	(Mullet et al., 2001)
Asthma order sets	Evaluated an asthma order set that was incorporated into a CPOE (Sunrise Clinical Manager). The order set included orders for prescriptions, monitoring of vital signs, respiratory care, and other general care orders.	Inpatient setting	When the asthma order set was used, patients were significantly more likely to receive PulseOx, systemic corticosteroids, and metered-dose inhalers ($p < 0.05$).	None discussed	(Chisolm et al., 2006)
Medication quicklist incorporated into CPOE that provides dosing recommendation and allergy and interaction alerts	CPOE (IBEX) with a pediatric medication quicklist of commonly used medications. The quicklist suggests a dose, unit, route, and frequency for the selected medication. The system also includes drug allergy and interaction alerts.	Pediatric ED	Overall errors per 100 visits were significantly reduced from 24 to 13 ($p < 0.0001$). Overall errors per 100 orders were significantly reduced from 31 to 14 ($p < 0.001$). Reduced the number of incorrect frequency errors (12 versus 1, $p = 0.01$), incorrect route errors (8 versus 2, $p = 0.04$), and wrong formulation (9 versus 0, $p = 0.03$). There was no significant impact on drug allergy and drug interaction errors.	None discussed	(Sard et al., 2008)
Vaccine history and order entry system with reminders for overdue vaccinations	Application integrated into the electronic patient record that included a clinical help file containing information about vaccines, a rule database, patient historical information, vaccine ordering, and charting administration of a vaccine. Also contained reports on patients with recommendations or warnings.	Outpatient setting	Significant increase in the number of patients who had all vaccinations recommended by national guidelines (17% versus 14%, $p < 0.0001$).	None discussed	(Flanagan and Walker, 1999)

NOTE: ARI-IT = Acute Respiratory Illness Interactive Template. LUMPS = Liver Unit Management Protocol System.

Table C.6. Clinical Decision Support Evidence Table: Protocol and Pathway Support for Pediatrics

Tool	Description	Practice Setting	Impact on Performance	Impact on Workflow	Citation
Bedside, computerized insulin protocol guidelines and support	eProtocol-insulin recommends an insulin infusion rate based on the patient's blood glucose level. If the suggested infusion protocol is accepted, the tool starts a countdown to the next blood glucose measurement	Adult and pediatric ICUs	When eProtocol-insulin recommendations were followed, 48% of blood-glucose levels fell within normal range.	More than half of surveyed nurses found eProtocol-insulin at least as time-intensive as managing mechanical ventilation or a single vasoactive infusion.	(Thompson et al., 2008)

Table C.7. Clinical Decision Support Evidence Table: Reference Information and Guidance for Pediatrics

Tool	Description	Practice Setting	Impact on Performance	Impact on Workflow	Citation
Handheld computer with recommendations for management of acute asthma exacerbation	Handheld computer with AsthMonitor software. The clinician documents the encounter on the computer, and the system generates recommendations for acute asthma exacerbation management based on the AAP guidelines, including dosage calculations. The clinician can also print encounter summaries and prescriptions.	Outpatient practice	Significantly increased adherence to guidelines for oxygen saturation measurement (56% versus 29%, $p < 0.01$) and for systemic corticosteroid prescriptions ($p = 0.055$). There was no significant impact on adherence to guidelines for PEFR measurements, metered dose inhaler treatments, or oxygen treatments. There was no significant impact on immediate patient disposition. In 27 out of 30 cases, providers disagreed with the tool's recommendation to give oxygen treatment.	The average duration of clinic visits was significantly longer when the AsthMonitor was used ($p < 0.001$).	(Shiffman et al., 2000)
Differential diagnostic aid	ISABEL is a differential diagnostic aid delivered via the Internet. The system pulls information from standard pediatric textbooks and generates a list of 10–15 possible diagnoses based on patient manifestation.	Simulation of critically ill children	In 20% of cases, the final diagnosis was absent from the system-generated list. The system's sensitivity was 80% for the three most common groups of diseases in the simulation—infectious, cardiovascular, and nervous system. Decreased average diagnostic errors of omission per clinician from 9/1,000 to 8/1,000 ($p < 0.0001$). There was no significant impact on the average number of irrelevant diagnoses per clinician.	Length of diagnostic workup increased without a significant increase in quality.	(Bavdekar and Pawar, 2005; Ramnarayan et al., 2006)
Parenteral nutrition order system	A computerized parenteral nutrition order system with alerts for clinical safety limits. The system does not allow authentication of orders that exceed insolubility constraints or other clinical safety limits.	PICU	Eliminated errors involving calcium-phosphorus precipitation, calcium or phosphorus concentrations exceeding guidelines, and missing information.	There was no significant impact on requests for clarification when a parenteral nutrition order differed markedly from the prior order.	(Peverini et al., 2000)

Tool	Description	Practice Setting	Impact on Performance	Impact on Workflow	Citation
Point-of-care evidence-based message system for antibiotics	Evidence-based system that provides pop-ups based on the clinician's antibiotic selection. The pop-ups summarize evidence about appropriate durations of antibiotic prescribing for otitis media.	Outpatient setting	Physicians using the tool had 44% increase in frequency of antibiotic prescriptions for <10 days, while physicians not using the tool had a 10% increase ($p < 0.001$).	None discussed	(Christakis, Zimmerman, et al., 2001)

NOTE: PEFR = peak expiratory flow rate.

Table C.8. Clinical Decision Support Evidence Table: Alerts and Reminders for Pediatrics

Tool	Description	Practice Setting	Impact on Performance	Impact on Workflow	Citation
Patient-specific alerts and reminders for asthma patients	Patient-specific alerts/reminders to use various CDS tools for practitioners treating asthma patients. The alerts and reminders were determined based on the patient's diagnosis and medication history. The CDS tools included (1) Pediatric Asthma Control Test data entry tool for capturing asthma symptom frequency, (2) standardized documentation templates to facilitate severity classifications, (3) order sets to facilitate ordering controller meds/spirometry, and (4) asthma care plan that can be provided to families.	Urban teaching outpatient clinics and suburban nonteaching outpatient clinics	The alerts/reminders increased the number of controller medication prescriptions at urban practices ($p < 0.01$) but not at suburban practices. Alerts/reminders increased the use of asthma action plans at suburban practices ($p = 0.03$) but not at urban practices. Increased use of spriometry at suburban practices ($p = 0.04$) but not at urban practices.	None discussed	(Bell et al., 2010)
Vaccination reminders	Vaccination reminders popped up within EHR (EpicCare) when a patient encounter was opened for a child under 24 months of age with overdue vaccinations.	Outpatient setting	Up-to-date immunization rates at 24 months of age increased from 82% to 90%. Among well-child visits in which the patient had overdue vaccinations, the rate of at least one vaccination increased from 78% to 90%, and the rate of all overdue vaccinations provided increased from 47% to 81%. Among sick visits in which the patient had overdue vaccinations, the rate of at least one vaccination given increased from 11% to 32%, and the rate of all overdue vaccinations given increased from 6% to 28%	None discussed	(Fiks, Grundmeier, et al., 2007)
Influenza vaccine alerts	Influenza vaccination reminders popped up within EHR (EpicCare) when a patient encounter was opened for a child with asthma between ages 5 and 19 who was due for influenza vaccine.	Outpatient setting	There was no significant difference in rate of captured opportunities for vaccination between control and intervention practices. There was no significant difference in rate of up-to-date influenza vaccination between intervention and control sites.	None discussed	(Fiks, Hunter et al., 2009)

Tool	Description	Practice Setting	Impact on Performance	Impact on Workflow	Citation
CPOE with medication shortage alerts	Implemented medication shortage alerts within an ICIS that included CPOE, documentation, electronic medication administration record, CDS, and data storage. Program produced a pop-up alert on the screen anytime a medication was entered into the ICIS that was on the hospital shortage alert list. The program would also recommend alternative medications with dosage information.	Inpatient setting	During a methylprednisolone shortage, there was a 55% relative reduction in the number of orders. During the shortage, there was a significant increase in ordering of dexamethasone (12% increase) and hydrocortisone (49%).	None discussed	(Bogucki, Jacobs, and Hingle, 2004)
Internet-based ASP	The Internet-based antimicrobial restriction program included automated decision support, facilitated approval, and enhanced real-time communication among providers. The program included inpatient census, lists of restricted and unrestricted antimicrobials, notification email reminders about requests, and automatic approval generation for specific drug indication combinations with the goal of reducing inappropriate hospital microbial use.	Inpatient setting	The number of doses of restricted antimicrobials decreased by 11%. The number of doses of unrestricted antimicrobials decreased by 12%. Based on provider report, there was a 21% reduction in number of missed antimicrobial doses. Annual cost of antimicrobials decreased by 22% from projected costs in the year after the ASP was implemented.	Based on provider report, there was a 32% reduction in number of delays of antimicrobial doses. Based on pharmacist report, there was a 40% decrease in the number of telephone calls related to restricted antimicrobial use. Based on pharmacist report, there was a 37% decrease in number of delayed approval of restricted antimicrobials. There was no significant impact on average dispensing time for restricted microbials. Average dispensing time for unrestricted microbials decreased from 2.97 minutes to 1.93 minutes ($p < 0.001$).	(Agwu et al., 2008)

NOTE: ICIS = Integrating Clinical Information System. ASP = antimicrobial stewardship program.

Table C.9. Pediatrics Gap Statements, Round 2

Pediatrics Gap Survey	Importance
Gap 1: children and adolescents fail to receive all recommended immunizations.	1 2 2 9 1 2 3 4 5 6 7 8 9 **(9.0, 0.6, A)**
Gap 2: children with MDD often receive inadequate follow-up care after receiving initial prescription for antidepressants.	2 1 3 8 1 2 3 4 5 6 7 8 9 **(9.0, 0.9, A)**
Gap 3: children with asthma treated in inpatient or ED settings may not receive adequate follow-up care or discharge planning.	4 3 7 1 2 3 4 5 6 7 8 9 **(8.5, 0.8, A)**
Gap 4: children with asthma are not routinely monitored for control of their condition.	1 7 6 1 2 3 4 5 6 7 8 9 **(8.0, 0.5, A)**
Gap 5: many children presenting with acute respiratory tract infection symptoms are inappropriately diagnosed with bacterial illness.	1 4 7 2 1 2 3 4 5 6 7 8 9 **(8.0, 0.6, A)**
Gap 6: many children receive antibiotics for pharyngitis without first being tested for group A streptococcus.	1 1 2 8 2 1 2 3 4 5 6 7 8 9 **(8.0, 0.6, A)**
Gap 7: children with ADHD who initiate medications may not receive optimal dose titration.	6 5 3 1 2 3 4 5 6 7 8 9 **(8.0, 0.6, A)**
Gap 8: diagnosis of ADHD is often made without adequate documentation of DSM-IV or DSM-PC criteria.	1 5 6 2 1 2 3 4 5 6 7 8 9 **(8.0, 0.7, A)**
Gap 9: many sexually active adolescent women do not receive periodic chlamydia screening.	1 4 5 4 1 2 3 4 5 6 7 8 9 **(8.0, 0.8, A)**
Gap 10: children with ADHD who are in the maintenance phase of medication therapy often receive inadequate follow-up care to reassess behavioral symptoms.	1 4 3 6 1 2 3 4 5 6 7 8 9 **(8.0, 0.9, A)**
Gap 11: children are inadequately assessed for risk of suicide.	1 1 4 3 5 1 2 3 4 5 6 7 8 9 **(8.0, 1.0, A)**

Pediatrics Gap Survey	Importance
Gap 12: children do not always undergo developmental and behavioral screening using standardized assessments.	1 1 1 4 4 3 1 2 3 4 5 6 7 8 9 **(7.5, 1.3, A)**
Gap 13: many children with autism disorders are not diagnosed in a timely manner.	1 7 3 3 1 2 3 4 5 6 7 8 9 **(7.0, 0.7, A)**
Gap 14: many children are not screened for depression.	1 1 6 3 3 1 2 3 4 5 6 7 8 9 **(7.0, 0.9, A)**
Gap 15: children and their parents are not routinely screened for tobacco use, and, among children and their parents who smoke, providers often fail to ask about their interest in quitting, to give advice to quit, or to offer tobacco cessation interventions.	1 1 7 2 3 1 2 3 4 5 6 7 8 9 **(7.0, 1.1, A)**
Gap 16: not all noncritically ill hospitalized children receiving nephrotoxic medications are monitored for nephrotoxic medication associated kidney injury.	1 1 2 2 7 1 1 2 3 4 5 6 7 8 9 **(8.0, 1.2, I)**
Gap 17: many children with asthma fail to have spirometry performed to assess asthma control and severity as outlined in national guidelines, resulting in undertreatment with controller medications.	1 1 2 2 5 3 1 2 3 4 5 6 7 8 9 **(8.0, 1.4, A)**
Gap 18: many children treated for bacterial URIs receive second-line antibiotics rather than first-line antibiotics.	4 5 4 1 1 2 3 4 5 6 7 8 9 **(7.0, 0.7, I)**
Gap 19: infants and children are inadequately screened and/or treated for IDA.	1 1 2 5 5 1 2 3 4 5 6 7 8 9 **(7.0, 0.9, I)**
Gap 20: diagnoses of MDD are often made without the use of patient interviews.	1 3 2 4 3 1 1 2 3 4 5 6 7 8 9 **(7.0, 1.1, I)**
Gap 21: DSM-IV criteria are often poorly documented among patients with MDD.	1 2 1 4 5 1 1 2 3 4 5 6 7 8 9 **(7.0, 1.1, I)**
Gap 22: many children at risk for developmental delays do not receive adequate follow-up care.	1 3 1 3 4 2 1 2 3 4 5 6 7 8 9 **(7.0, 1.3, I)**

Pediatrics Gap Survey	Importance
Gap 23: environmental risks are not routinely assessed for children with asthma, and parents are not always advised on risk mitigation.	1 1 3 3 3 3 1 2 3 4 5 6 7 8 9 **(7.0, 1.4, I)**
Gap 24. children often fail to receive nutrition and/or physical activity counseling.	1 1 1 1 1 4 3 2 1 2 3 4 5 6 7 8 9 **(7.0, 1.6, I)**
Gap 25: children under the age of 6 are not routinely monitored for fluoride intake.	1 2 1 6 1 3 1 2 3 4 5 6 7 8 9 **(6.0, 1.1, I)**
Gap 27: children often have poor documentation of their BMI and the corresponding percentile of the population distribution.	1 1 2 3 1 3 2 1 1 2 3 4 5 6 7 8 9 **(5.5, 1.8, I)**
Gap 26: many children hospitalized with a diagnosis of bronchiolitis inappropriately receive systemic corticosteroid therapy.	3 1 4 3 3 1 2 3 4 5 6 7 8 9 **(6.0, 1.1, I)**
Gap 28: children fail to receive recommended levels of lead screening.	2 2 3 3 4 1 2 3 4 5 6 7 8 9 **(4.5, 1.8, D)**

Table C.10. Pediatrics Gap and Clinical Decision Support Opportunities, Round 2

Pediatrics Gap/CDS Opportunity	Compatibility	Potential impact
Gap 1: children and adolescents fail to receive all recommended immunizations.	**n/a**	**n/a**
Opportunity a: display immunization history and highlight missing immunizations	2 4 6 1 2 3 4 5 6 7 8 9 (8.5, 0.7, A)	1 1 3 4 3 1 2 3 4 5 6 7 8 9 (8.0, 0.9, A)
Opportunity b: order set that includes all recommended immunizations	1 1 1 1 6 2 1 2 3 4 5 6 7 8 9 (8.0, 1.5, A)	1 1 2 2 3 3 1 2 3 4 5 6 7 8 9 (7.5, 1.9, I)
Opportunity c: tool to facilitate scheduling of immunizations according to recommended sequence and timing.	2 5 5 1 2 3 4 5 6 7 8 9 (8.0, 0.6, A)	1 1 4 3 3 1 2 3 4 5 6 7 8 9 (7.5, 1.3, A)
Opportunity d: alert for missing immunizations, with link to order set.	2 5 5 1 2 3 4 5 6 7 8 9 (8.0, 0.6, A)	2 1 5 4 1 2 3 4 5 6 7 8 9 (8.0, 0.9, A)
Overall rating	2 7 3 1 2 3 4 5 6 7 8 9 **(8.0, 0.4, A)**	1 1 4 4 2 1 2 3 4 5 6 7 8 9 **(7.5, 1.1, A)**
Gap 2: children with MDD often receive inadequate follow-up care after receiving initial prescription for antidepressants.	**n/a**	**n/a**
Opportunity a: display data on current and past history of antidepressant use and adherence.	1 1 4 3 3 1 2 3 4 5 6 7 8 9 (6.5, 1.3, I)	1 1 2 3 2 3 1 2 3 4 5 6 7 8 9 (5.0, 1.3, I)
Opportunity b: order set that prioritizes medications based on effectiveness, safety, or cost data.	1 1 4 3 3 1 2 3 4 5 6 7 8 9 (6.0, 1.8, I)	1 1 2 1 2 2 1 2 1 2 3 4 5 6 7 8 9 (5.0, 1.8, I)
Opportunity c: protocol for antidepressant switching or dose escalation for treatment-resistant depression.	1 1 2 4 3 1 1 2 3 4 5 6 7 8 9 (7.0, 1.3, I)	1 1 3 2 4 1 1 2 3 4 5 6 7 8 9 (6.0, 1.4, I)
Opportunity d: alert triggered if MDD patient is not on medication and has not been referred for further evaluation.	1 1 2 3 4 1 1 2 3 4 5 6 7 8 9 (7.0, 1.4, I)	1 1 3 1 5 1 1 2 3 4 5 6 7 8 9 (6.5, 1.5, I)
Overall rating	1 3 5 2 1 1 2 3 4 5 6 7 8 9 **(7.0, 1.01 I)**	1 1 1 2 1 5 1 1 2 3 4 5 6 7 8 9 **(6.5, 1.6, I)**

Pediatrics Gap/CDS Opportunity	Compatibility	Potential impact
Gap 3: children with asthma treated in inpatient or ED settings may not receive adequate follow-up care or discharge planning.	**n/a**	**n/a**
Opportunity a: smart form that customizes discharge plan according to patient's asthma-related needs and risks	1 8 3 1 2 3 4 5 6 7 8 9 (8.0, 0.3, A)	1 2 1 2 3 3 1 2 3 4 5 6 7 8 9 (7.5, 1.4, I)
Opportunity b: tool that creates longitudinal follow-up plan for adjusting medication therapy and seeing specialists when indicated.	1 1 1 3 4 2 1 2 3 4 5 6 7 8 9 (7.4, 1.2, A)	1 1 2 1 1 3 1 2 1 2 3 4 5 6 7 8 9 (6.5, 1.9, I)
Overall rating	1 2 7 2 1 2 3 4 5 6 7 8 9 **(8.0, 0.8, A)**	1 2 1 3 3 2 1 2 3 4 5 6 7 8 9 **(7.0, 1.6, I)**
Gap 4: children with asthma are not routinely monitored for control of their condition.	**n/a**	**n/a**
Opportunity a: documentation template that includes items needed to assess asthma control.	1 4 4 3 1 2 3 4 5 6 7 8 9 (8.0, 0.8, A)	1 1 2 3 2 3 1 2 3 4 5 6 7 8 9 (8.0, 1.1, I)
Opportunity b: display recent health care utilization, symptoms, and medication refill data.	5 4 3 1 2 3 4 5 6 7 8 9 (8.0, 0.7, A)	5 2 4 1 1 2 3 4 5 6 7 8 9 (7.0, 0.8, I)
Opportunity c: asthma order set that prioritizes agents according to effectiveness, safety, and/or cost.	1 1 1 4 5 1 2 3 4 5 6 7 8 9 (7.0, 1.5, A)	1 1 1 3 1 2 3 1 2 3 4 5 6 7 8 9 (5.5, 1.9, I)
Opportunity d: pathway to guide dose escalation or medication substitution	7 5 1 2 3 4 5 6 7 8 9 (7.0, 1.5, A)	1 2 6 3 1 2 3 4 5 6 7 8 9 (7.0, 0.8, A)
Opportunity e: alert to assess control if too much time has elapsed between assessments	1 5 4 2 1 2 3 4 5 6 7 8 9 (7.5, 0.8, A)	1 1 5 3 1 1 1 2 3 4 5 6 7 8 9 (6.0, 0.9, I)
Overall rating	1 6 4 1 1 2 3 4 5 6 7 8 9 **(7.0, 0.8, A)**	1 1 6 4 1 2 3 4 5 6 7 8 9 **(7.0, 0.9, A)**
Gap 5: many children presenting with acute respiratory tract infection symptoms are inappropriately diagnosed with bacterial illness.	**n/a**	**n/a**

Pediatrics Gap/CDS Opportunity	Compatibility	Potential impact
Opportunity a: smart form to document signs or symptoms of bacterial infection (or their absence) and to order "cold kit" or antibiotics, if appropriate	2 1 4 3 2 1 2 3 4 5 6 7 8 9 (7.0, 1.0, A)	1 1 4 4 1 1 1 2 3 4 5 6 7 8 9 (6.5, 1.0, I)
Opportunity b: links to parent education materials relating to antibiotics for URIs.	1 1 7 2 1 1 2 3 4 5 6 7 8 9 (7.0, 0.7, A)	1 1 2 2 5 1 1 2 3 4 5 6 7 8 9 (6.5, 1.3, I)
Overall rating	1 1 3 4 3 1 2 3 4 5 6 7 8 9 **(7.0, 0.9, I)**	1 1 1 3 4 2 1 2 3 4 5 6 7 8 9 **(6.5, 1.2, I)**
Gap 6: many children receive antibiotics for pharyngitis *without* first being tested for group A streptococcus.	**n/a**	**n/a**
Opportunity a: smart form that prompts for appropriate strep testing based on clinical findings	1 2 1 5 3 1 2 3 4 5 6 7 8 9 (8.0, 0.9, A)	2 1 2 2 3 1 1 1 2 3 4 5 6 7 8 9 (6.0, 1.5, I)
Opportunity b: protocol to automate ordering appropriate antibiotics based on strep test results, patient weight, allergies, and other characteristics.	1 1 3 1 1 3 2 1 2 3 4 5 6 7 8 9 (6.5, 1.9, I)	2 2 2 3 2 1 1 2 3 4 5 6 7 8 9 (6.0, 1.8, I)
Opportunity c: link to treatment guidelines for pharyngitis.	4 1 1 6 1 2 3 4 5 6 7 8 9 (7.5, 1.3, I)	1 1 2 3 1 2 2 1 2 3 4 5 6 7 8 9 (5.0, 1.5, I)
Opportunity d: alert if pharyngitis is entered as a diagnosis without a strep test being ordered.	3 4 4 1 1 2 3 4 5 6 7 8 9 (7.0, 1.3, A)	1 2 1 1 2 4 1 1 2 3 4 5 6 7 8 9 (6.0, 1.6, I)
Overall rating	1 2 3 5 1 1 2 3 4 5 6 7 8 9 **(7.5, 1.1, A)**	1 2 3 2 2 2 1 2 3 4 5 6 7 8 9 **(5.5, 1.3, I)**
Gap 7: children with ADHD who initiate medications may not receive optimal dose titration.	**n/a**	**n/a**
Opportunity a: smart form for ADHD encounter that captures changes in symptoms and medication side effects and recommends options for dose titration.	5 5 2 1 2 3 4 5 6 7 8 9 (8.0, 0.6, A)	1 6 3 2 1 2 3 4 5 6 7 8 9 (7.0, 0.8, A)
Opportunity b: display office visit utilization data, behavioral symptom history, and medication data during patient encounter	1 7 4 1 2 3 4 5 6 7 8 9 (7.0, 0.5, A)	2 3 6 1 1 2 3 4 5 6 7 8 9 (7.0, 0.7, I)

Pediatrics Gap/CDS Opportunity	Compatibility	Potential impact
Opportunity c: tool that automatically develops a care plan (including dose titration) over multiple visits.	1 1 5 4 1 1 2 3 4 5 6 7 8 9 (7.0, 0.8, A)	1 3 1 4 2 1 1 2 3 4 5 6 7 8 9 (7.0, 1.3, I)
Overall rating	8 3 1 1 2 3 4 5 6 7 8 9 **(7.0, 0.4, A)**	2 1 6 2 1 1 2 3 4 5 6 7 8 9 **(7.0, 0.8, A)**
Gap 8: diagnosis of ADHD is often made without adequate documentation of DSM-IV or DSM-PC criteria.	**n/a**	**n/a**
Opportunity a: diagnostic assessment template for ADHD that includes all DSM-IV criteria	2 1 2 3 4 1 2 3 4 5 6 7 8 9 (8.0, 1.2, A)	2 1 4 3 2 1 2 3 4 5 6 7 8 9 (7.0, 1.3, A)
Opportunity b: reminder to document DSM criteria triggered by new diagnosis of ADHD.	1 1 6 2 2 1 2 3 4 5 6 7 8 9 (7.0, 0.8, A)	1 2 5 2 2 1 2 3 4 5 6 7 8 9 (7.0, 1.3, A)
Overall rating	1 1 1 5 3 1 1 2 3 4 5 6 7 8 9 **(7.0, 1.2, A)**	1 1 2 6 1 1 1 2 3 4 5 6 7 8 9 **(7.0, 1.2, I)**
Gap 9: many sexually active adolescent women do not receive periodic chlamydia screening.	**n/a**	**n/a**
Opportunity a: smart form that includes sexual history and orders for chlamydia testing, if indicated.	1 5 1 5 1 2 3 4 5 6 7 8 9 (6.5, 1.0, I)	1 5 3 3 1 2 3 4 5 6 7 8 9 (6.5, 0.9, I)
Opportunity b: order form that includes chlamydia test as part of routine screening tests based on patient's age and/or sexual history	1 1 5 3 2 1 2 3 4 5 6 7 8 9 (7.0, 0.8, A)	1 1 5 4 1 1 2 3 4 5 6 7 8 9 (7.0, 0.8, A)
Opportunity c: reminder to conduct yearly chlamydia screening on patients who report being sexually active	1 1 2 7 1 1 2 3 4 5 6 7 8 9 (8.0, 0.7, A)	1 1 1 5 4 1 2 3 4 5 6 7 8 9 (7.0, 0.9, A)
Overall rating	2 5 3 2 1 2 3 4 5 6 7 8 9 **(7.0, 0.8, A)**	1 3 6 2 1 2 3 4 5 6 7 8 9 **(7.0, 0.7, I)**
Gap 10: children with ADHD who are in the maintenance phase of medication therapy often receive inadequate follow-up care to reassess behavioral symptoms.	**n/a**	**n/a**

Pediatrics Gap/CDS Opportunity	Compatibility	Potential impact
Opportunity a: display office visit utilization data and behavioral symptom history during patient encounter.	3 3 5 1 1 2 3 4 5 6 7 8 9 (7.5, 0.8, A)	1 : 2 3 3 2 1 2 3 4 5 6 7 8 9 (6.0, 1.3, I)
Opportunity b: tool that automatically develops a maintenance therapy care plan over multiple visits	3 3 5 1 1 2 3 4 5 6 7 8 9 (7.5, 0.8, A)	1 4 2 2 2 1 1 2 3 4 5 6 7 8 9 (6.0, 1.3, I)
Opportunity c: alert triggered by drug or office visit utilization patterns that deviate deviation from care plan.	1 5 5 1 1 2 3 4 5 6 7 8 9 (7.5, 0.7, A)	1 2 5 3 1 1 2 3 4 5 6 7 8 9 (7.0, 1.0, A)
Overall rating	2 5 5 1 2 3 4 5 6 7 8 9 **(7.0, 0.6, A)**	1 2 2 4 2 1 2 3 4 5 6 7 8 9 **(7.0, 1.0, I)**
Gap 11: children are inadequately assessed for risk of suicide.	**n/a**	**n/a**
Opportunity a: smart form that elicits suicide risk and alerts provider if symptoms endorsed	2 2 4 4 1 2 3 4 5 6 7 8 9 (8.0, 0.8, A)	2 3 1 5 1 1 2 3 4 5 6 7 8 9 (7.5, 1.2, I)
Opportunity b: display suicide risk factors during subsequent clinic visits.	1 1 3 1 2 4 1 2 3 4 5 6 7 8 9 (6.5, 1.5, I)	2 1 5 3 1 1 2 3 4 5 6 7 8 9 (5.0, 1.2, I)
Opportunity c: alert to PCP about elevated suicide risk if patient is being seen by non-PCP.	2 2 2 3 3 1 2 3 4 5 6 7 8 9 (6.5, 1.3, I)	: 1 3 4 1 2 1 2 3 4 5 6 7 8 9 (6.0, 1.1, I)
Overall rating	1 3 3 5 1 2 3 4 5 6 7 8 9 **(7.0, 0.8, I)**	1 3 3 2 3 1 2 3 4 5 6 7 8 9 **(6.0, 1.1, I)**
Gap 16: not all noncritically ill hospitalized children receiving nephrotoxic medications are monitored for nephrotoxic medication-associated AKI.	**n/a**	**n/a**
Opportunity a: order set for nephrotoxic medications that includes lab tests for monitoring kidney function and, when appropriate, drug levels	2 8 2 1 2 3 4 5 6 7 8 9 (8.0, 0.3, A)	1 1 2 2 3 3 1 2 3 4 5 6 7 8 9 (7.5, 1.3, I)
Opportunity b: alert if lab result for patient on nephrotoxic medication is suggestive of AKI.	7 5 1 2 3 4 5 6 7 8 9 (8.0, 0.4, A)	1 1 5 5 1 2 3 4 5 6 7 8 9 (8.0, 0.8, A)

Pediatrics Gap/CDS Opportunity	Compatibility	Potential impact
Overall rating	1 9 2 1 2 3 4 5 6 7 8 9 **(8.0, 0.4, A)**	1 2 2 5 2 1 2 3 4 5 6 7 8 9 **(8.0, 1.0, A)**
Gap 17: many children with asthma fail to have spirometry performed to assess asthma control and severity as outlined in national guidelines (resulting in undertreatment with controller medications).	**n/a**	**n/a**
Opportunity a: display patient's historical spirometry data along with current medications.	1 1 3 2 5 1 2 3 4 5 6 7 8 9 (7.0, 1.3, I)	1 2 1 3 2 1 2 1 2 3 4 5 6 7 8 9 (5.0, 1.6, A)
Opportunity b: asthma order set that includes spirometry	1 1 1 5 4 1 2 3 4 5 6 7 8 9 (7.0, 1.3, A)	1 1 2 3 2 1 2 1 2 3 4 5 6 7 8 9 (5.0, 1.5, I)
Opportunity c: alert to conduct spirometry test if too much time has elapsed between assessments.	1 1 1 3 6 1 2 3 4 5 6 7 8 9 (7.5, 1.4, A)	1 1 3 2 2 3 1 2 3 4 5 6 7 8 9 (5.0, 1.8, I)
Overall rating	1 2 2 3 4 1 2 3 4 5 6 7 8 9 **(7.0, 1.3, I)**	1 1 1 4 1 2 2 1 2 3 4 5 6 7 8 9 **(5.0, 1.5, I)**
Gap 21: DSM-IV criteria are often poorly documented among patients with MDD.	**n/a**	**n/a**
Opportunity a: diagnostic interview template for MDD that includes DSM-IV criteria.	1 3 5 3 1 2 3 4 5 6 7 8 9 (8.0, 0.8, A)	1 1 7 1 2 1 2 3 4 5 6 7 8 9 (7.0, 0.7, A)
Opportunity b: display DSM-IV criteria met by patient during subsequent clinic visits.	3 4 4 1 1 2 3 4 5 6 7 8 9 (7.0, 0.8, A)	1 2 1 5 3 1 2 3 4 5 6 7 8 9 (7.0, 0.9, I)
Opportunity c: reminder to specify DSM-IV criteria in a note triggered by new diagnosis of MDD.	1 2 2 4 3 1 2 3 4 5 6 7 8 9 (8.0, 1.0, A)	2 4 3 1 2 1 2 3 4 5 6 7 8 9 (6.5, 1.1, I)
Overall rating	1 3 3 4 1 1 2 3 4 5 6 7 8 9 **(7.0, 0.9, I)**	1 3 6 2 1 2 3 4 5 6 7 8 9 **(7.0, 0.6, I)**

APPENDIX D. PERCUTANEOUS CORONARY INTERVENTION PANELIST MATERIALS

GAP STATEMENT EVIDENCE DOCUMENT WITH PANELISTS' INPUT

Evidence on the Magnitudes and Consequences of Clinical Performance Gaps for PCI

Estimates of the Incidence of Coronary Heart Disease (CHD) and CHD-Related Hospitalizations. Based on the NHANES survey, approximately 17.6 million people have CHD in the United States.

Each year, there are an estimated 610,000 new episodes of MI and 185,000 episodes of recurrent MI (Lloyd-Jones et al., 2010). An estimated 330,000 of these events will involve STEMI (Califf and Roe, 2010).

Each year in the United States, there are 1.5 million hospitalizations for ACS, including STEMI, non-STEMI, and unstable angina (Hochman et al., 1999).

Estimates of PCI Utilization and Utilization of PCI-Related Procedures. There were more than 1 million inpatient PCI procedures in 2006.

Contrast angiography remains the dominant diagnostic tool used to stratify patients before intervention (Hirsch et al., 2006).

The volume of cardiac diagnostic procedures involving the use of ionizing radiation has increased rapidly in recent years. Whereas, in 1990, fewer than 3 million nuclear cardiology studies were performed in the United States, by 2002, this figure more than tripled to 9.9 million. Cardiac CT volume doubled between 2002 and 2003, to 485,000 cases, and has continued to grow since then. The volume of procedures performed in cardiac catheterization labs increased from 2.45 million in 1993 to 3.85 million in 2002 (Einstein et al., 2007).

Data sources used to estimate the magnitude of performance gaps:

- National Registry of Myocardial Infarction (NRMI): The studies presented here use the third and fourth waves of the NRMI, including more than 100,000 patients with STEMI from approximately 1,500 U.S. hospitals between 1999 and 2002.
- Can Rapid Risk Stratification of Unstable Angina Patients Suppress Adverse Outcomes with Early Implementation of the ACC/AHA Guidelines (CRUSADE) National Quality Improvement Registry: This registry included more than 30,000 patients with non-STEMI ACS with chest pain and either positive ECGs or cardiac biomarkers. Patients were treated in one of 387 participating U.S. hospitals between January and September 2004.
- Acute Coronary Syndromes (ACS) Registry: This registry included 4,547 patients from 155 German hospitals with STEMI or non-STEMI between June and December 2002.
- Treatment with Enoxaparin and Tirofiban in Acute Myocardial Infarction (TETAMI) Registry: An international, multicenter trial, including both randomization and registry components. The registry enrolled patients between

1999 and 2002 and compared patients who received reperfusion therapy with those who did not. The study presented here included 1,654 registry patients, of whom 72 percent received reperfusion therapy.

- National Cardiovascular Data Registry (NCDR) CathPCI Registry: This registry included 1,522,935 patients undergoing PCI at 955 U.S. hospitals from January 1, 2004, through September 30, 2008.

Table D.1. Magnitude and Consequences of Performance Gaps for Percutaneous Coronary Intervention

Gap	Gap Category	Clinical Performance Gap	Magnitude of Performance Gap	Consequences of Performance Gap
7	STEMI	Many STEMI patients who are candidates for primary PCI receive PCI outside of the recommended door-to-balloon time (e.g., 90 minutes).	40% of patients with STEMI who receive primary PCI meet the ACC/AHA goal of PCI within 90 minutes of presentation (McNamara et al., 2006).	For patients with STEMI, the risk of 1-year mortality is increased by 7.5% for each 30-minute delay in reperfusion (Luca et al., 2004).
21	STEMI	Many STEMI patients who receive primary PCI outside of the recommended door-to-balloon time are better candidates for thrombolysis.	Unknown. The performance gap is likely to be higher for facilities without 24-hour staffing and for low-volume facilities.	PCI procedure volume (but not fibrinolysis volume) is inversely associated with mortality for patients with STEMI (Canto et al., 2000). Although, in hospitals with intermediate and high PCI volumes, PCI is associated with lower mortality than thrombolysis is, there was no significant difference between PCI and thrombolysis in low-volume facilities (Magid et al., 2000).
8	STEMI	Many STEMI patients who are candidates for thrombolysis receive the treatment outside of the recommended door-to-needle time (e.g., 30 minutes).	Fewer than 50% of patients receive treatment within the recommended 30-minute door-to-needle time (McNamara et al., 2006).	For patients with STEMI, the risk of 1-year mortality is increased by 7.5% for each 30-minute delay in reperfusion (Luca et al., 2004). Compared with patients with door-to-needle times of 30 minutes or less, the adjusted OR of in-hospital mortality in the NRMI was 1.17 for door-to-needle times of 31–45 minutes and 1.37 for times greater than 45 minutes (McNamara et al., 2006).
23	STEMI	Many STEMI patients who are candidates for PCI receive thrombolysis instead.	Only 15% of STEMI patients are treated with primary PCI, whereas the majority are treated with thrombolytics (O'Neill, 2003).	Compared with thrombolysis, primary PCI reduces short- and long-term mortality and reinfarction rates by 30% to 40%, shortens hospital stay, and reduces the need for subsequent hospital care (Stenestrand, Lindbäck, and Wallentin, 2006). In addition to lower short-term mortality and nonfatal reinfarction rates, PCI-treated patients have a lower risk of hemorrhagic stroke than those treated by fibrinolysis but have an increased risk for major bleeding (Hirsch et al., 2006).
1	STEMI	Nearly half of patients with STEMI receive no reperfusion therapy or receive delayed reperfusion (>12 hours after onset).	24% of eligible patients in NRMI received no reperfusion therapy (French, 2000), and, in the TETAMI registry, 55% of patients did not receive reperfusion therapy within 12 hours (Cohen et al., 2003).	Rapid initiation of reperfusion therapy for STEMI with either full-dose fibrinolytic therapy or primary PCI limits infarct size and improves survival (Hirsch et al., 2006).

Gap	Gap Category	Clinical Performance Gap	Magnitude of Performance Gap	Consequences of Performance Gap
19	STEMI	Many STEMI patients are not referred for cardiac rehabilitation despite having no contraindications.	Only 10–20% of patients who experience MI or undergo cardiac revascularization procedures in the United States participate in cardiac rehabilitation programs (Spronk et al., 2008).	A meta-analysis of randomized trials of cardiac rehabilitation after MI found that cardiac rehabilitation reduced cardiac mortality during a 3-year follow-up period by 20% to 25% (O'Connor et al., 1989). Among patients with STEMI participating in the ACS registry, cardiac rehabilitation was associated with a significant reduction in all-cause mortality (OR: 0.41), and major cardiac and cerebrovascular events (OR: 0.66) during a 1-year follow-up period (Jünger et al., 2010).
18	Non-STEMI	Non-STEMI is often diagnosed based on enzyme markers (e.g., troponin) that have poor specificity, leading to overdiagnosis.	The use of cardiac troponin to diagnose MI can cause as many as 41% more patients to be diagnosed with MI than the use of CK-MB alone (Roger et al., 2006).	Studies have reported that multimarker measurements at baseline and 90 minutes have a sensitivity for MI of approximately 95% with a high negative predictive value, thus allowing for the early exclusion of MI when combined with clinical judgment. However, because of the low specificity of the multimarker strategy (mainly due to the lower specificity of myoglobin), a positive multimarker test is inadequate to diagnose MI and requires confirmation with a later-appearing definitive marker (O'Neill, 2003). These patients may then receive treatments carrying risks that outweigh the benefits.
5	Non-STEMI	Many high-risk patients with non-STEMI fail to receive early invasive care, while many low-risk patients receive early invasive care unnecessarily.	Less than half of high-risk patients with non-STEMI are managed with an early invasive strategy (CRUSADE) (Bhatt et al., 2004). Patients undergoing invasive management are more likely to be younger and lower-risk (Bhatt et al., 2004).	Randomized trials comparing early invasive with conservative strategies in non-STEMI patients demonstrated mixed survival results but improved cardiac morbidity. Evidence suggests that invasive management strategies benefit primarily elderly or high-risk patients and may not be warranted in lower-risk patients because of the smaller benefit they receive (Spronk et al., 2008). In the CRUSADE registry, an early invasive management strategy was associated with a significantly lower risk of in-hospital mortality in high-risk patients with non-STEMI (Bhatt et al., 2004).
13	STEMI and non-STEMI	Antithrombotic therapies prescribed to patients with STEMI or non-STEMI receive dosages in excess of best practice recommendations.	42% of patients who were administered an antithrombotic agent received at least 1 initial dose outside the recommended range (CRUSADE) (Michael et al., 2010). 46% of women receiving glycoprotein IIb/IIIa inhibitors were more likely to receive excessive doses than were 17% of men (CRUSADE) (Alexander, Chen, Roe, et al., 2005).	Up to one-fourth of the bleeding-risk difference observed in women is avoidable and attributed to excessive dosing in women (Alexander, Chen, Newby, 2006). In the CRUSADE registry, 15% of all major bleeding was attributable to excessive dosing (Alexander, Chen, Roe, et al., 2005).

Gap	Gap Category	Clinical Performance Gap	Magnitude of Performance Gap	Consequences of Performance Gap
2	Discharge medications	Some patients never fill prescriptions for clopidogrel therapy following DES implantation.	7% of patients in a study of more than 5,000 patients who underwent DES implantation at medical centers in Ontario between 2003 and 2006 never filled prescriptions for clopidogrel (Ko et al., 2009). 2.3% of patients in a study of more than 7,000 patients who received a DES in one of three integrated health care delivery systems in California, Colorado, and Minnesota between 2004 and 2007 never filled prescriptions for clopidogrel (Ho et al., 2010).	Patients who do not initiate antiplatelet therapy risk complications, including restenosis and stent thrombosis (Jeremias et al., 2004; Iakovou et al., 2005). In a study of more than 18,000 patients who were covered by a prescription drug insurance plan in Quebec, those who did not fill a prescription for clopidogrel after coronary stenting (involving either DES or bare metal stents) had a significantly higher mortality risk (6.9% versus 2.9%) (Sheehy, LeLorier, and Rinfret, 2008).
4	Discharge medications	Many patients discontinue clopidogrel therapy within 6 months of DES implantation (12 months of continuous therapy are recommended).	More than 25% of patients in a study of more than 5,000 patients age >65 years who received a DES at medical centers in Ontario between 2003 and 2006 discontinued clopidogrel therapy within 6 months of DES implantation (Ko et al., 2009).	Discontinuation of antiplatelet therapy is a major predictor of stent thrombosis (Jeremias et al., 2004; Iakovou et al., 2005). Discontinuing clopidogrel therapy within 6 months has been associated with increased mortality (adjusted HR: 2.64) (Ko et al., 2009).
11	Discharge medications	Patients sometimes receive DESs despite being at high risk for nonadherence to the long-term antiplatelet therapy required (for financial or other reasons).	Among a group of patients receiving DES, 20% of patients reported having no insurance coverage for medications (Pallares et al., 2009). Among nonadherent patients, 42% cited financial reasons as the reason for discontinuing their antiplatelet medication Pallares et al., 2009).	Discontinuation of antiplatelet therapy is a major predictor of stent thrombosis (Jeremias et al., 2004; Iakovou et al., 2005). Discontinuing clopidogrel therapy within 6 months has been associated with increased mortality (adjusted HR: 2.64) (Ko et al., 2009).
3	Discharge medications	Many patients undergoing PCI are not prescribed statins at discharge despite having no contraindications.	Only 35% of patients undergoing revascularization or receiving treatment for ACS in a German study received statins at discharge (Schömig et al., 2002). 47% of patients diagnosed with ACS had not filled a prescription for a statin within 3 months of discharge (H. Lee, Cooke, and Robertson, 2008).	In a study of more than 4,500 patients under age 80 who underwent coronary artery stenting, patients who received statins had a 49% lower relative risk of mortality than those patients who were not treated with statins (Schömig et al., 2002).
22	Angiography	Wide variation exists in the amount of contrast used for coronary angiography.	Unknown	Contrast agents are associated with a small but important risk of nephrotoxicity (McCullough et al., 1997). Patients who are at increased risk of contrast nephropathy include those with severe baseline renal dysfunction, diabetes, low cardiac output state, or dehydration. Any combination of these is more problematic than an individual risk factor.

Gap	Gap Category	Clinical Performance Gap	Magnitude of Performance Gap	Consequences of Performance Gap
20	Angiography	Not every facility monitors radiation exposure to patients undergoing cardiac procedures.	Unknown	A significant association between radiation dose and mortality from cancer has been shown in many epidemiological studies (Brenner and Hall, 2007). Ionizing radiation causes numerous types of DNA damage, and it is hypothesized that multiply damaged sites, such as double-strand breaks, are oncogenic (Einstein et al., 2007).
14	Angiography	Patients with chronic kidney disease sometimes receive coronary angiography without having received adequate prehydration for the procedure.	Unknown	A randomized trial of saline hydration among patients undergoing nonemergency cardiac catheterization found that saline hydration decreased the risk of acute renal insufficiency (4% versus 35%) (Trivedi et al., 2003).
15	Angiography	Some patients experience preventable bleeding complications after PCI due to the cumulative effect of anticoagulants and antiplatelet agents given in the perioperative and interoperative period.	Only 14% of patients with a high pre-PCI bleeding risk received prophylaxis that included a vascular closure device and bivalirudin (NCDR CathPCI registry) (Marso et al., 2010).	Among patients in the NCDR CathPCI registry treated with a vascular closure device and bivalirudin, patients with the highest pre-PCI bleeding risk had fewer bleeding events per 1,000 patients than intermediate or low-risk patients (Marso et al., 2010). Major bleeding events result in an average 4- to 6-day increase in length of stay (Aronow et al., 2001; Kinnaird et al., 2003) and, on average, increase hospital costs by $6,000 to $8,000 (Pinto et al., 2008). Among a group of patients treated with PCI, intraprocedural use of heparin (as opposed to bivalirudin) resulted in a 67% increase in risk of severe acquired thrombocytopaenia and use of low–molecular weight contrast material was associated with a 34% increase in risk of severe acquired thrombocytopaenia (Labriolle et al., 2007).
6	Angiography	Wide regional variation in rates of elective PCI suggests that some patients may not be appropriate candidates for elective PCI.	Rates of PCI varied more than tenfold among Medicare enrollees living in different regions in 2003 according to the Dartmouth Atlas (Center for the Evaluative Clinical Sciences, 2005). Less than 50% of Medicare patients undergo stress testing to document ischemia within the 90 days prior to elective PCI (Lin et al., 2008).	A study of more than 1,500 patients undergoing PCI at a major teaching hospital found that 13% of patients with no baseline angina reported worse quality of life one year following the procedure and 50% of patients with no baseline angina reported no difference in quality of life (Spertus et al., 2004).
9	Angiography	The indications for PCI and stent selection (e.g., angina status, prior medical therapy, anatomical findings, flow) are often poorly documented.	Unknown	Missing information in medical charts has been shown, across a range of specialties, to lead to medication errors and poorer-quality patient management and can negatively affect patient outcomes (Physician Documentation Expert Panel, 2006).

Gap	Gap Category	Clinical Performance Gap	Magnitude of Performance Gap	Consequences of Performance Gap
17	Angiography	Many patients referred for coronary CTA for an evaluation of CAD are asymptomatic, and rates of cardiac MRI and cardiac CT procedures vary widely across regions.	28% of patients referred for CTA for an evaluation of CAD at a large teaching hospital over five months in 2008 were asymptomatic (Blankstein et al., 2010). Rates of cardiac MRI and cardiac CT procedures vary widely across regions (Hartford, Roos, and Walld, 1998).	Patients who receive CTA are exposed to significant levels of radiation (Einstein et al., 2007).
10	Patient-centeredness	Many patients undergoing PCI have limited understanding about the relative benefits and risks of the procedure.	Data on patient education practices are not widely available.	In a survey of 80 patients who recently underwent PCI at a New York hospital, 30% of patients thought the reason for PCI was solely to prevent subsequent MIs, and 14% of patients thought they were no longer at risk for MI (D'Elia et al., 2011). A review of seven studies that assessed patient understanding of PCI found that 78% of patients believed that PCI would extend their life expectancy and 71% believed that PCI would prevent future MIs (Chandrasekharan and Taggart, 2011).
16	Patient-centeredness	Few patients with CAD have access to personal health data or tools that can help them manage their condition.	Unknown	Many providers believe that access to personal health records will motivate patients to collaborate with their physicians and to be active participants in decisionmaking (Detmer et al., 2008).
12	Patient-centeredness	The differential benefits, risks, and follow-up care required for DESs versus bare metal stents are often not discussed with the patient prior to his or her undergoing PCI.	Unknown	In a survey of 80 patients who recently underwent PCI at a New York hospital, 50% of patients did not know what type of stent they received (D'Elia et al., 2011). A study of patients who underwent coronary stenting found that 44% of patients could not identify the type of stent they received and 46% of patients believed that there was no risk associated with stopping their antiplatelet medication (Trentman et al., 2008).

NOTE: CK-MB = creatine kinase–MB. HR = hazard ratio. DNA = deoxyribonucleic acid.

Table D.2. Clinical Decision Support Opportunity Matrix for Percutaneous Coronary Intervention

Gap	Gap Category	Clinical Performance Gap	Action That Can Be Taken to Reduce the Performance Gap	Information Needed by CDS System	Potential Work Flow Insertion Points (relevant personnel	Potential CDS Opportunities to Reduce Performance Gaps: Documentation Forms/ Templates	Potential CDS Opportunities to Reduce Performance Gaps: Relevant Data Presentation	Potential CDS Opportunities to Reduce Performance Gaps: Order Set or Ordering Tool	Potential CDS Opportunities to Reduce Performance Gaps: Protocol or Pathway Support	Potential CDS Opportunities to Reduce Performance Gaps: Smart Links to Reference Information	Potential CDS Opportunities to Reduce Performance Gaps: Alerts/ Reminders
7	STEMI	Many STEMI patients who are candidates for primary PCI receive PCI outside of the recommended door-to-balloon time (i.e., 90 minutes).	For patients presenting with ischemic symptoms: Expedite ECG analysis to diagnose STEMI. Assess likely time to PCI (in relation to pain onset and arrival time) Expedite activation of cath lab	ECG tracing Time of symptom onset Recent cath lab activation times Cath lab call schedule	Field triage (EMT, cardiologist, ED physician) ED assessment (ED physician, cardiologist)	Smart form that presents ECG data and key milestone times and includes a table for diagnosis, including LBBB and posterior MI, and automates cath lab activation after STEMI diagnosis if timing is deemed appropriate	n/a	n/a	Application that utilizes patient onset of symptoms, known expected response times, and cath lab activation times to offer a prediction as to whether timely PCI is possible	n/a	Alert triggered when door-to-balloon time has exceeded recommended benchmark
8	STEMI	Many STEMI patients who are candidates for thrombolysis receive the treatment outside of the recommended door-to-needle time (i.e., 30 minutes).	For patients presenting with STEMI: Expedite administration of thrombolysis for those unlikely to receive timely PCI	ECG tracing Time of symptom onset	Field triage (EMT, cardiologist, ED physician) ED assessment (ED physician, cardiologist) Medication orders (ED physician, cardiologist, ED nurse)	EHR-based flow sheet for thrombolysis with target completion times per step and appropriate adjunct therapy	n/a	Thrombolysis order set for STEMI to guide physician through what is needed, how to administer, and what to monitor	n/a	n/a	Alert triggered when door-to-needle time has exceeded recommended benchmark

Gap	Gap Category	Clinical Performance Gap	Action That Can Be Taken to Reduce the Performance Gap	Information Needed by CDS System	Potential Work Flow Insertion Points (relevant personnel	Potential CDS Opportunities to Reduce Performance Gaps: Documentation Forms/ Templates	Potential CDS Opportunities to Reduce Performance Gaps: Relevant Data Presentation	Potential CDS Opportunities to Reduce Performance Gaps: Order Set or Ordering Tool	Potential CDS Opportunities to Reduce Performance Gaps: Protocol or Pathway Support	Potential CDS Opportunities to Reduce Performance Gaps: Smart Links to Reference Information	Potential CDS Opportunities to Reduce Performance Gaps: Alerts/ Reminders
1	STEMI	Nearly half of patients with STEMI receive no reperfusion therapy or receive delayed reperfusion (>12 hours after onset).	For patients presenting with acute chest pain: Expedite ECG analysis to diagnose STEMI Assess atypical symptoms (e.g., shortness of breath) at time of presentation Assess likely time to PCI (in relation to ED presentation) Activate cath lab or administer thrombolysis	Symptoms Documentation of symptom onset time	Field triage (EMT, cardiologist, ED physician) ED triage (ED intake staff, ED nurse, ED physician) ED assessment (ED physician, cardiologist) Results handling (ED physician, cardiologist)	EHR-based flow sheet for suspected STEMI	Display ECG data, TIMI/GRACE scores, and likely time of symptom onset.	n/a	n/a	n/a	Alert to inform ED physician and staff of possible ACS diagnosis triggered by abnormal biomarkers
5	Non-STEMI	Many high-risk patients with non-STEMI fail to receive early invasive care, while many low-risk patients receive early invasive care unnecessarily.	For patients presenting with possible non-STEMI: Identify high-risk patients who may benefit from early intervention. Tailor intervention strategy to patient risk	TIMI score GRACE score Other predictors of benefit from early invasive strategy (e.g., hemodynamic instability)	ED triage (ED intake staff, ED nurse, ED physician) ED assessment (ED physician, cardiologist) Results handling (ED physician, cardiologist)	EHR-based flow sheet that uses patient data to guide ED physicians into delivering early invasive or selective invasive strategies for non-STEMI	Display TIMI and/or GRACE risk scores and other clinical data that facilitate triage.	n/a	n/a	n/a	Reminder to calculate TIMI or GRACE scores for patients presenting with suspected ACS.

Gap	Gap Category	Clinical Performance Gap	Action That Can Be Taken to Reduce the Performance Gap	Information Needed by CDS System	Potential Work Flow Insertion Points (relevant personnel	Potential CDS Opportunities to Reduce Performance Gaps: Documentation Forms/ Templates	Potential CDS Opportunities to Reduce Performance Gaps: Relevant Data Presentation	Potential CDS Opportunities to Reduce Performance Gaps: Order Set or Ordering Tool	Potential CDS Opportunities to Reduce Performance Gaps: Protocol or Pathway Support	Potential CDS Opportunities to Reduce Performance Gaps: Smart Links to Reference Information	Potential CDS Opportunities to Reduce Performance Gaps: Alerts/ Reminders
9	STEMI and non-STEMI	Patients with STEMI or non-STEMI receive dosages of antithrombotic therapies in excess of best practice recommendations.	For patients requiring antithrombotic therapy: Determine the ideal antithrombotic therapy based on patient characteristics Evaluate effectiveness/harms and consider switching when indicated	Benefits and risks of antithrombotic drug classes (e.g., clopidogrel/ prasugrel, LMWH, UFH, ticagrelor, bivalirudin) Current and previous antithrombotic medications	ED assessment (ED physician, cardiologist) Medication orders (ED physician, cardiologist)	n/a	n/a	Order set that prioritizes drug classes according to guidelines and gives standard dosing values	n/a	Link to AHA/ACC recommendations for antithrombotic therapy	Alert if dosage order is different from standard dosing based on patient-specific information.
2	Discharge medications	Some patients never fill prescriptions for clopidogrel therapy following DES implantation.	For patients undergoing DES implantation: Ensure that prescription is written Take action(s) to ensure that prescription is filled (e.g., educate patients, conduct outreach)	Patient's filling status	Data review (cardiologist, ED nurse, case manager) Orders (cardiologist) Education (cardiologist, ED nurse, case manager)	Template that allows documentation of predischarge counseling about clopidogrel use	n/a	DES discharge order set that includes outpatient clopidogrel prescription	n/a	n/a	Alert if prescription is not filled within expected window

Gap	Gap Category	Clinical Performance Gap	Action That Can Be Taken to Reduce the Performance Gap	Information Needed by CDS System	Potential Work Flow Insertion Points (relevant personnel	Potential CDS Opportunities to Reduce Performance Gaps: Documentation Forms/ Templates	Potential CDS Opportunities to Reduce Performance Gaps: Relevant Data Presentation	Potential CDS Opportunities to Reduce Performance Gaps: Order Set or Ordering Tool	Potential CDS Opportunities to Reduce Performance Gaps: Protocol or Pathway Support	Potential CDS Opportunities to Reduce Performance Gaps: Smart Links to Reference Information	Potential CDS Opportunities to Reduce Performance Gaps: Alerts/ Reminders
4	Discharge medications	Many patients discontinue clopidogrel therapy within 6 months of DES implantation (12 months of continuous therapy are recommended).	For patients recently undergoing DES implantation: Assess adherence Take action(s) to ensure adherence to therapy (e.g., initiate a pillbox counter system, conduct outreach)	Patient's refill status Patient SES characteristics (e.g., insurance status)	Data review (cardiologist, ED nurse, case manager) Orders (cardiologist) Education (cardiologist, ED nurse, case manager)	Smart form that displays fill status and allows documentation of counseling about clopidogrel adherence	Display patient's refill history and factors predictive of adherence (e.g., insurance status).	n/a	n/a	n/a	Alert if prescriptions are not refilled within expected window
11	Discharge medications	Patients sometimes receive DESs despite being at high risk for nonadherence to long-term antiplatelet therapy required (for financial or other reasons).	Assess risk factors for nonadherence to antiplatelet therapy Discuss risks of nonadherence with patient	Risk factors for nonadherence to antiplatelet therapy	Data review (cardiologist, ED nurse, case manager) Education (cardiologist, ED nurse, case manager)	n/a	Display risk factors for nonadherence	n/a	n/a	Link to patient education materials relating to risks of poor adherence	n/a
3	Discharge medications	Many patients undergoing PCI are not prescribed statins at discharge despite having no contraindications.	For patients being discharged following PCI: Evaluate suitability for statins Prescribe statins or document contraindication(s)	Lipid levels Current medications History of statin treatment, including side effects Contraindications for statin therapy	Documentation (cardiologist, cath lab nurse) Orders (cardiologist) Discharge tasks (cardiologist, cath lab nurse)	Documentation template for statin history, dose, and side effects	n/a	Order set that includes statins along with other medications commonly prescribed at discharge from the cath lab	Support for appropriate starting doses and appropriate steps for dose escalation based on CVD risk	n/a	Reminder followed by alert to prescribe statin prior to discharge if not yet ordered

Gap	Gap Category	Clinical Performance Gap	Action That Can Be Taken to Reduce the Performance Gap	Information Needed by CDS System	Potential Work Flow Insertion Points (relevant personnel	Potential CDS Opportunities to Reduce Performance Gaps: Documentation Forms/ Templates	Potential CDS Opportunities to Reduce Performance Gaps: Relevant Data Presentation	Potential CDS Opportunities to Reduce Performance Gaps: Order Set or Ordering Tool	Potential CDS Opportunities to Reduce Performance Gaps: Protocol or Pathway Support	Potential CDS Opportunities to Reduce Performance Gaps: Smart Links to Reference Information	Potential CDS Opportunities to Reduce Performance Gaps: Alerts/ Reminders
6	Angiography	Wide regional variation in rates of elective PCI suggests that some patients may not be appropriate candidates for elective PCI.	For patients being considered for PCI: Document all elements needed to determine appropriateness Determine whether elective PCI meets ACC/AHA appropriateness criteria	Data elements needed to determine appropriateness	Documentation (cardiologist, cath lab nurse, office nurse) Data review (cardiologist)	n/a	Display appropriateness rating and/or elements needed to determine appropriateness rating	Order tool that requires input of data elements and returns appropriateness rating	Critical pathway for elective PCI that specifies appropriate escalation of medical therapy and timing of PCI	n/a	Alert if elective PCI is ordered for an inappropriate indication
9	Angiography	The indications for PCI and stent selection (e.g., angina status, prior medical therapy, anatomical findings, flow) are often poorly documented.	Locate data elements needed for documenting indication for PCI/stent Document indication	Data elements needed to assign indication	Data review (cardiologist) Documentation (cardiologist, cath lab nurse, office nurse)	Documentation template to record indication for procedure during office visit	Display lab values, imaging results, and other data needed to assign indication	n/a	n/a	n/a	Reminder to document indication for procedure or device prior to the procedure
10	Patient-centeredness	Many patients undergoing PCI have limited understanding about the relative benefits and risks of the procedure.	Before procedure: Ensure that patients have ample time to ask questions. Assess patient's understanding of benefits and risks	Details of procedure Patient-level clinical data	Cath lab intake (cath lab nurse) Cath lab discharge (cardiologist, cath lab nurse)	Automated consent form that includes patient-specific benefit/risk data	n/a	n/a	n/a	Link to educational materials that are archived and readily available to give to patients	Reminder to assess patients' comprehension of risks and benefits prior to the procedure

NOTE: EMT = emergency medical technician. LMWH = low–molecular weight heparin. UFH = unfractionated heparin. SES = socioeconomic status.

Table D.3. Clinical Decision Support Evidence Table: Documentation Forms and Templates for Percutaneous Coronary Intervention

Tool		Brief Description	Practice Setting	Impact on Performance Gaps	Impact on Workflow	Citation
1.	Template for outpatient cardiac rehabilitation with feedback	CARDSS to improve compliance with practice guidelines for outpatient cardiac rehab. Guidelines were integrated into each practice's EHR system. Physicians entered a patient's data into template and were fed back a patient-specific rehabilitation program recommendation for each of four rehab programs—exercise, education therapy, relaxation, and lifestyle change—based on practice guidelines. The system provides a rationale for its choice and provides links to relevant research.	21 cardiology outpatient clinics in the Netherlands	CDS increased concordance with guideline recommendations for exercise therapy by 3.5%, for education therapy by 23.7%, and for relaxation therapy by 41.6%. There was no significant change in guideline concordance for the use of lifestyle change therapy. The tool reduced rates of both overuse and underuse.	No data presented	(Goud et al., 2009)

NOTE: CARDSS = Cardiac Rehabilitation Decision Support System.

Table D.4. Clinical Decision Support Evidence Table: Relevant Data Presentation for Percutaneous Coronary Intervention

Tool		Brief Description	Practice Setting	Impact on Performance Gaps	Impact on Workflow	Citation
2.	PCI-TPI	The PCI-TPI was designed to support the choice between immediate thrombolytic therapy and delayed primary PCI for acute MI. The PCI-TPI provides patient-specific predictions, at the time of the presenting ECG, of 30-day mortality for no reperfusion treatment, thrombolytic therapy, and PCI.	The test characteristics of this instrument were assessed using a combined database of patients with STEMI treated with thrombolytic therapy or PCI from numerous trials and registries.	The tool was shown to have good predictive validity and discrimination. These predictions were found to perform well on the C-PORT trial database and to accurately identify those patients most likely to benefit from PCI versus thrombolysis.	No workflow disruption by design: Model estimates are presented directly on the ECG.	(Kent, Ruthazer, Griffith, Beshansky, Grines, et al., 2007; Kent, Ruthazer, Griffith, Beshansky, Concannon, et al., 2008)

NOTE: PCI-TPI = PCI Thrombolytic Predictive Instrument. C-PORT = Cardiovascular Patient Outcomes Research Team.

Table D.5. Clinical Decision Support Evidence Table: Order Set and Ordering Tool for Percutaneous Coronary Intervention

Tool		Brief Description	Practice Setting	Impact on Performance Gaps	Impact on Workflow	Citation
3.	Order sets for ACS	Guideline-based computerized order sets for ACS implemented in the ED. ED physicians completed one of three order forms depending on a patient's risk level (high-risk ACS, intermediate ACS, low-risk ACS), and each order set contained guideline information to help physicians select appropriate orders. Patient-specific information was *not* incorporated into the order set.	Washington University Medical Center	Use of order sets increased after implementation; however, there was no improvement in overall compliance with any of the guideline recommendations.	No data presented	(Asaro, Sheldahl, and Char, 2006)

Table D.6. Clinical Decision Support Evidence Table: Protocol or Pathway Support for Percutaneous Coronary Intervention

Tool		Brief Description	Practice Setting	Impact on Performance Gaps	Impact on Workflow	Citation
4.	Clinical pathway for cardiac rehabilitation after AMI	Get with the Guidelines–based clinical pathway for referral and enrollment into cardiac rehabilitation after AMI. The clinical pathway culminates in a written referral (including program name and contact information). The article does not mention whether the pathway is computerized or paper-based.	Boston Medical Center	Use of the pathway was associated with higher referral rates for CR (55% of patients were referred, compared with 20–30% commonly cited in the literature)	No data presented	(Mazzini et al., 2008)
5.	Critical care pathway for ACS	An ACSETS critical care pathway was implemented in a 4-hospital system in Buffalo, New York. The critical care pathway embedded guideline-based treatment.	Four-hospital system in Buffalo, New York	Appropriate ACS medication use improved in the first 24 hours and at discharge Length of stay was significantly reduced, but inpatient mortality was not significantly reduced. One-year adjusted mortality was significantly reduced among MI patients but not UA patients.	No data presented	(Corbelli et al., 2009)
6.	ACI-TIPI	The ACI-TIPI computes the probability that a patient presenting at the ED truly has acute cardiac ischemia and, if the patient is having an AMI, the likely outcome benefits of thrombolytic therapy.	10 hospital EDs in the United States	Among patients without cardiac ischemia, use of the ACI-TIPI was associated with a reduction in CCU admissions from 14% to 10% Among patients with AMI or UA, use of ACI-TIPI did not change appropriate admission to the CCU or telemetry unit at hospitals with high-capacity CCUs or telemetry units	No data presented	(Daudelin and Selker, 2005)

NOTE: AMI = acute MI. CR = cardiac rehabilitation. ACSETS = Acute Coronary Syndrome Emergency Treatment Strategies. UA = unstable angina. ACI-TIPI = acute coronary ischemia time-insensitive predictive instrument. CCU = cardiac care unit.

Table D.7. Clinical Decision Support Evidence Table: Reference Information and Guidance for Percutaneous Coronary Intervention

Tool		Brief Description	Practice Setting	Impact on Performance Gaps	Impact on Workflow	Citation
7.	SYNTAX Score to determine PCI complexity	The SYNTAX Score is a calculated by a computer program consisting of sequential and interactive self-guided questions. The score measures the complexity of CAD and takes into account such factors as total occlusions, side branches, ostial and aorto stenosis, bifurcations, trifurcation, calcified lesions, thrombus, length of lesions, tortuosity, and diffuse disease. Higher SYNTAX Scores indicate a more highly complex procedure and worse prognosis.	Used data from SYNTAX, an ongoing multinational trial	In the PCI population, a higher SYNTAX Score was significantly associated with major adverse cardiac or cerebrovascular events Numerous studies have demonstrated the predictive validity of the SYNTAX score	No data presented	(Sianos et al., 2005)

Table D.8. Clinical Decision Support Evidence Table: Alerts and Reminders for Percutaneous Coronary Intervention

Tool		Brief Description	Practice Setting	Impact on Performance Gaps	Impact on Workflow	Citation
8.	Reminder system for heparin and aspirin use	Reminder system based on national guidelines for prophylactic heparin and aspirin use in inpatient settings. Reminder was provided during order entry process.	Single public teaching hospital in Indianapolis, Indiana	Reminders significantly increased the use of subcutaneous heparin (32% among patients exposed to the intervention versus 19% in the control group. Reminders also increased the use of aspirin at discharge (36% versus 28%).	No data presented	(Dexter et al., 2001)
9.	Alert for missed diagnosis of acute cardiac ischemia	ACI-TIPI-IS. This system included alerts for immediate follow-up for patients with potentially missed diagnoses of ACI (e.g., patients who were discharged from the ED with high ACI-TIPI values or who had positive cardiac biomarkers). The alert triggered an email or pager message to the ED.	Single demonstration has been conducted to date	Alerts and feedback reports were successfully delivered to more than 70 physicians	No data presented	(Daudeline and Selker, 2005)

NOTE: ACI-TIPI-IS = ACI-TIPI information system.

Table D.9. Percutaneous Coronary Intervention Gap Statements, Round 2

PCI Gap Survey	Importance
1. Nearly half of patients with STEMI receive no reperfusion therapy or receive delayed reperfusion (>12 hours after onset)	2 1 4 8 1 2 3 4 5 6 7 8 9 **(9.0, 0.8, A)**
2. Some patients never fill prescriptions for clopidogrel therapy following DES implantation.	1 3 5 6 1 2 3 4 5 6 7 8 9 **(8.0, 0.7, A)**
3. Many patients undergoing PCI are not prescribed statins at discharge despite having no contraindications.	1 5 6 3 1 2 3 4 5 6 7 8 9 **(8.0, 0.7, A)**
4. Many patients discontinue clopidogrel therapy within 6 months of DES implantation (12 months of continuous therapy are recommended)	3 2 6 4 1 2 3 4 5 6 7 8 9 **(8.0, 0.8, A)**
5. Many high-risk patients with non-STEMI fail to receive early invasive care, while many low-risk patients receive early invasive care unnecessarily.	1 1 5 5 3 1 2 3 4 5 6 7 8 9 (8.0, 0.9, A)
6. Wide regional variation in the rates of elective PCI suggests that some patients may not be appropriate candidates for elective PCI.	1 2 4 2 6 1 2 3 4 5 6 7 8 9 **(8.0, 1.4, A)**
7. Many STEMI patients who are candidates for primary PCI receive PCI outside of the recommended door-to-balloon time (i.e., 90 minutes).	1 8 4 2 1 2 3 4 5 6 7 8 9 **(7.0, 0.6, A)**
8. Many STEMI patients who are candidates for thrombolysis, receive treatment outside of the recommended door-to-needle time (i.e., 30 minutes).	1 1 7 3 3 1 2 3 4 5 6 7 8 9 **(7.0, 0.9, A)**
9. The indications for PCI and stent selection (e.g., angina status, prior medical therapy, anatomical findings, flow) are often poorly documented.	3 5 4 3 1 2 3 4 5 6 7 8 9 **(7.0, 0.9, A)**
10. Many patients undergoing PCI have limited understanding about the relative benefits of risks of the procedure.	2 2 6 3 2 1 2 3 4 5 6 7 8 9 **(7.0, 0.9, A)**
11. Patients sometimes receive DESs despite being at high risk for nonadherence to the long-term antiplatelet therapy required (for financial or other reasons).	1 2 5 5 2 1 2 3 4 5 6 7 8 9 **(7.0, 1.1, A)**

PCI Gap Survey	Importance
12. The differential benefits, risks, and follow-up care required for DESs versus bare metal stents are often not discussed with the patient prior to his or her undergoing PCI.	1 4 4 5 1 1 2 3 4 5 6 7 8 9 **(7.0, 0.9, I)**
13. Antithrombotic therapies prescribed to patients with STEMI or non-STEMI receive dosages in excess of best practice recommendations.	1 1 3 3 7 1 2 3 4 5 6 7 8 9 **(7.0, 1.1, I)**
14. Patients with chronic kidney disease sometimes receive coronary angiography without having received adequate prehydration for the procedure.	1 2 1 5 4 2 1 2 3 4 5 6 7 8 9 **(7.0, 1.1, A)**
15. Some patients experience preventable bleeding complications after PCI due to the cumulative effect of anticoagulants and antiplatelet agents given in the perioperative and interoperative period.	3 4 5 3 1 2 3 4 5 6 7 8 9 **(7.0, 1.1, I)**
16. Few patients with CAD have access to personal health data or tools that can help them manage their condition	1 2 4 3 5 1 2 3 4 5 6 7 8 9 **(7.0, 1.1, I)**
17. Many patients referred for coronary CTA for an evaluation of CAD are asymptomatic, and rates of cardiac MRI and cardiac CT vary widely across regions.	1 3 2 3 5 1 1 2 3 4 5 6 7 8 9 **(7.0, 1.2, I)**
18. Non-STEMI is often diagnosed based on enzyme markers (e.g., troponin) that have poor specificity, leading to overdiagnosis.	1 5 1 4 2 2 1 2 3 4 5 6 7 8 9 **(7.0, 1.3, I)**
19. Many STEMI patients are not referred for cardiac rehabilitation despite having no contraindications.	2 8 2 2 1 1 2 3 4 5 6 7 8 9 **(6.0, 0.7, I)**
20. Not every facility monitors radiation exposure to patients undergoing cardiac procedures.	2 3 4 6 1 2 3 4 5 6 7 8 9 **(6.0, 1.0, I)**
21. Many STEMI patients who receive primary PCI outside of the recommended door-to-balloon time are better candidates for thrombolysis.	2 6 1 5 1 1 2 3 4 5 6 7 8 9 **(6.0, 1.1, I)**
22. Wide variation exists in the amount of contrast used for coronary angiography.	1 5 3 4 2 1 2 3 4 5 6 7 8 9 **(6.0, 1.2, I)**

PCI Gap Survey	Importance
23. Many STEMI patients who are candidates for PCI receive thrombolysis instead.	1 1 2 2 3 4 2 1 2 3 4 5 6 7 8 9 **(6.0, 1.4, I)**

Table D.10. Percutaneous Coronary Intervention Gap and Clinical Decision Support Opportunities, Round 2

PCI Gap/CDS Opportunity	Compatibility	Potential Impact
Gap 1: nearly half of patients with STEMI receive no reperfusion therapy or receive delayed reperfusion (>12 hours after onset).	**n/a**	**n/a**
Opportunity a: EHR-based flow sheet for suspected STEMI	1 7 4 1 1 2 3 4 5 6 7 8 9 (7.0, 0.7, A)	1 1 2 5 3 1 1 2 3 4 5 6 7 8 9 (7.0, 0.9, I)
Opportunity b: display ECG data, TIMI/GRACE scores, and likely time of symptom onset.	1 6 3 3 1 2 3 4 5 6 7 8 9 (7.0, 0.8, A)	1 6 5 1 1 2 3 4 5 6 7 8 9 (7.0, 0.7, A)
Opportunity c: alert to inform ED physician and staff of possible ACS diagnosis triggered by abnormal biomarkers	1 3 4 5 1 2 3 4 5 6 7 8 9 (8.0, 0.8, A)	1 1 8 1 2 1 2 3 4 5 6 7 8 9 (7.0, 0.7, A)
Overall rating	5 8 1 2 3 4 5 6 7 8 9 **(8.0, 0.4, A)**	1 1 8 3 1 2 3 4 5 6 7 8 9 **(7.0, 0.5, A)**
Gap 2: some patients never fill prescriptions for clopidogrel therapy following DES implantation.	**n/a**	**n/a**
Opportunity a: template that allows documentation of predischarge counseling about clopidogrel use	5 4 4 1 2 3 4 5 6 7 8 9 (8.0, 0.7, A)	6 2 4 1 1 2 3 4 5 6 7 8 9 (6.0, 0.9, I)
Opportunity b: DES discharge order set that includes outpatient clopidogrel prescription	4 4 5 1 2 3 4 5 6 7 8 9 (8.0, 0.7, A)	3 4 2 3 1 1 2 3 4 5 6 7 8 9 (6.0, 1.1, I)
Opportunity c: alert if prescription not filled within expected window	2 1 1 7 2 1 2 3 4 5 6 7 8 9 (8.0, 0.8, A)	1 4 4 3 1 1 2 3 4 5 6 7 8 9 (7.0, 0.8, I)
Overall rating	4 8 1 1 2 3 4 5 6 7 8 9 **(8.0, 0.4, A)**	2 2 6 3 1 2 3 4 5 6 7 8 9 **(7.0, 0.7, I)**
Gap 3: many patients undergoing PCI are not prescribed statins at discharge despite having no contraindications.	**n/a**	**n/a**
Opportunity a: documentation template for statin history, dose, and side effects	5 7 1 1 2 3 4 5 6 7 8 9 (8.0, 0.5, A)	4 5 4 1 2 3 4 5 6 7 8 9 (7.0, 0.6, I)

PCI Gap/CDS Opportunity	Compatibility	Potential Impact
Opportunity b: order set that includes statins along with other medications commonly prescribed at discharge from the cath lab	1 7 5 1 2 3 4 5 6 7 8 9 (8.0, 0.5, A)	1 2 8 2 1 2 3 4 5 6 7 8 9 (8.0, 0.5, A)
Opportunity c: support for appropriate starting doses and appropriate steps for dose escalation based on CVD risk	3 1 9 1 2 3 4 5 6 7 8 9 (8.0, 0.5, A)	1 3 2 5 2 1 2 3 4 5 6 7 8 9 (7.0, 1.0, I)
Opportunity d: reminder followed by alert to prescribe statin prior to discharge if not yet ordered	1 8 4 1 2 3 4 5 6 7 8 9 (8.0, 0.4, A)	1 3 6 3 1 2 3 4 5 6 7 8 9 (8.0, 0.7, A)
Overall rating	1 1 A 1 1 2 3 4 5 6 7 8 9 **(8.0, 0.3, A)**	1 6 6 1 2 3 4 5 6 7 8 9 **(7.0, 0.6, A)**
Gap 4: many patients discontinue dopidogrel therapy within 6 months of DES implantation (12 months of continuous therapy are recommended).	**n/a**	**n/a**
Opportunity a: smart form that displays fill status and allows documentation of counseling about clopidogrel adherence	1 8 3 1 1 2 3 4 5 6 7 8 9 (7.0, 0.5, A)	1 1 4 4 2 1 1 2 3 4 5 6 7 8 9 (7.0, 1.0, I)
Opportunity b: display patient's refill history and factors predictive of adherence (e.g., insurance status).	2 2 4 4 1 1 2 3 4 5 6 7 8 9 (7.0, 0.9, I)	1 1 4 3 4 1 2 3 4 5 6 7 8 9 (7.0, 1.0, I)
Opportunity c: alert if prescriptions not refilled within expected window	1 1 1 9 1 1 2 3 4 5 6 7 8 9 (8.0, 0.5, A)	1 2 3 5 2 1 2 3 4 5 6 7 8 9 (8.0, 0.9, A)
Overall rating	1 4 8 1 2 3 4 5 6 7 8 9 **(8.0, 0.5, A)**	1 3 4 5 1 2 3 4 5 6 7 8 9 **(7.0, 0.8, I)**
Gap5: many high-risk patients with non-STEMI fail to receive early invasive care, while many low-risk patients receive early invasive care unnecessarily.	**n/a**	**n/a**
Opportunity a: EHR-based flow sheet that uses patient data to guide ED physicians into delivering early invasive or selective invasive strategies for non-STEMI	2 4 3 4 1 2 3 4 5 6 7 8 9 (8.0, 0.9, A)	1 2 2 4 2 2 1 2 3 4 5 6 7 8 9 (7.0, 1.3, I)
Opportunity b: display TIMI and/or GRACE risk scores and other clinical data that facilitate triage.	2 7 4 1 2 3 4 5 6 7 8 9 (8.0, 0.5, A)	1 1 3 6 2 1 2 3 4 5 6 7 8 9 (8.0, 0.8, A)

PCI Gap/CDS Opportunity	Compatibility	Potential Impact
Opportunity c: reminder to calculate TIMI or GRACE scores for patients presenting with suspected ACS.	1 2 5 5 1 2 3 4 5 6 7 8 9 (8.0, 0.8, A)	1 1 4 3 3 1 1 2 3 4 5 6 7 8 9 (7.0, 1.5, I)
Overall rating	1 2 9 1 1 2 3 4 5 6 7 8 9 **(8.0, 0.5, A)**	3 4 5 1 1 2 3 4 5 6 7 8 9 **(7.0, 0.8, A)**
Gap 6: wide regional variation in rates of elective PCI suggests that some patients may not be appropriate candidates for elective PCI.	**n/a**	**n/a**
Opportunity a: display appropriateness rating and/or elements needed to determine appropriateness rating	6 6 1 1 2 3 4 5 6 7 8 9 (8.0, 0.5, A)	2 7 3 1 1 2 3 4 5 6 7 8 9 (7.0, 0.7, A)
Opportunity b: order tool that requires input of data elements and returns appropriateness rating	1 2 8 2 1 2 3 4 5 6 7 8 9 (8.0, 0.6, A)	1 1 3 5 3 1 2 3 4 5 6 7 8 9 (8.0, 1.0, A)
Opportunity c: critical pathway for elective PCI that specifies appropriate escalation of medical therapy and timing of PCI	1 1 1 4 4 2 1 2 3 4 5 6 7 8 9 (7.0, 1.2, A)	1 1 2 5 3 1 1 2 3 4 5 6 7 8 9 (7.0, 1.0, I)
Opportunity d: alert if elective PCI is ordered for an inappropriate indication	1 1 2 6 3 1 2 3 4 5 6 7 8 9 (8.0, 0.9, A)	1 1 1 2 3 2 3 1 2 3 4 5 6 7 8 9 (7.0, 1.5, I)
Overall rating	1 4 5 3 1 2 3 4 5 6 7 8 9 **(8.0, 0.7, A)**	2 5 3 3 1 2 3 4 5 6 7 8 9 **(7.0, 1.0, A)**
Gap 7: many STEMI patients who are candidates for primary PCI receive PCI outside of the recommended door-to-balloon time (i.e. 90 minutes)	**n/a**	**n/a**
Opportunity a: smart form that presents ECG data and key milestone times; includes a table for diagnosis, including LBBB and posterior MI; and automates cath lab activation after STEMI diagnosis if timing is deemed appropriate	2 3 5 1 2 1 2 3 4 5 6 7 8 9 (7.0, 1.1, I)	2 2 5 4 1 2 3 4 5 6 7 8 9 (7.0, 0.9, I)
Opportunity b: application that utilizes patient onset of symptoms, known expected response times, and cath lab activation times to offer a prediction as to whether timely PCI is possible	1 3 7 2 1 2 3 4 5 6 7 8 9 (7.0, 0.6, I)	1 4 5 3 1 2 3 4 5 6 7 8 9 (7.0, 0.8, I)
Opportunity c: alert triggered when door-to-balloon time has exceeded recommended benchmark	1 1 3 6 1 1 1 2 3 4 5 6 7 8 9 (7.0, 0.8, I)	1 2 4 4 1 1 1 2 3 4 5 6 7 8 9 (5.0, 1.2, A)

PCI Gap/CDS Opportunity	Compatibility	Potential Impact
Overall rating	1 3 5 4 1 2 3 4 5 6 7 8 9 **(7.0, 0.7, I)**	1 4 5 3 1 2 3 4 5 6 7 8 9 **(7.0, 0.7, I)**
Gap 8: many STEMI patients who are candidates for thrombolysis receive the treatment outside of the recommended door-to-needle time (i.e., 30 minutes).	**n/a**	**n/a**
Opportunity a: EHR-based flow sheet for thrombolysis with target completion times per step and appropriate adjunct therapy	1 3 7 2 1 2 3 4 5 6 7 8 9 (8.0, 0.5, A)	4 5 4 1 2 3 4 5 6 7 8 9 (7.0, 0.6, I)
Opportunity b: thrombolysis order set for STEMI to guide physician through what is needed, how to administer, and what to monitor	1 7 5 1 2 3 4 5 6 7 8 9 (8.0, 0.5, A)	1 4 5 3 1 2 3 4 5 6 7 8 9 (8.0, 0.7, A)
Opportunity c: alert triggered when door-to-needle time has exceeded recommended benchmark	1 1 5 6 1 2 3 4 5 6 7 8 9 (7.0, 0.7, A)	1 3 6 1 2 1 2 3 4 5 6 7 8 9 (6.0, 0.9, I)
Overall rating	3 A 1 2 3 4 5 6 7 8 9 **(8.0, 0.2, A)**	4 3 6 1 2 3 4 5 6 7 8 9 **(7.0, 0.8, I)**
Gap 9: the indications for PCI and stent selection (e.g., angina status, prior medical therapy, anatomical findings, flow) are often poorly documented.	**n/a**	**n/a**
Opportunity a: documentation template to record indication for procedure during office visit	2 2 6 3 1 2 3 4 5 6 7 8 9 (8.0, 0.7, A)	1 3 1 6 2 1 2 3 4 5 6 7 8 9 (8.0, 0.9, I)
Opportunity b: display lab values, imaging results, and other data needed to assign indication	2 5 4 2 1 2 3 4 5 6 7 8 9 (7.0, 0.8, A)	1 4 3 2 3 1 2 3 4 5 6 7 8 9 (7.0, 1.2, I)
Opportunity c: reminder to document indication for procedure or device prior to the procedure	1 2 6 4 1 2 3 4 5 6 7 8 9 (8.0, 0.7, A)	1 2 5 4 1 1 2 3 4 5 6 7 8 9 (7.0, 1.0, A)
Overall rating	2 1 8 2 1 2 3 4 5 6 7 8 9 **(8.0, 0.5, A)**	1 1 2 2 6 1 1 2 3 4 5 6 7 8 9 **(8.0, 1.1, I)**
Gap 10: many patients undergoing PCI have limited understanding about the relative benefits and risks of the procedure.	**n/a**	**n/a**

PCI Gap/CDS Opportunity	Compatibility	Potential Impact
Opportunity a: automated consent form that includes patient-specific benefit/risk data	7 3 3 1 2 3 4 5 6 7 8 9 (7.0, 0.7, A)	2 1 5 3 2 1 2 3 4 5 6 7 8 9 (7.0, 0.9, A)
Opportunity b: link to educational materials that are archived and readily available to give to patients	4 4 5 1 2 3 4 5 6 7 8 9 (8.0, 0.7, A)	3 2 5 2 1 1 2 3 4 5 6 7 8 9 (7.0, 0.9, I)
Opportunity c: reminder to assess patients' comprehension of risks and benefits prior to the procedure	1 4 6 2 1 2 3 4 5 6 7 8 9 (8.0, 0.6, A)	1 2 5 2 2 1 1 2 3 4 5 6 7 8 9 (6.0, 1.0, I)
Overall rating	4 7 2 1 2 3 4 5 6 7 8 9 **(8.0, 0.5, A)**	1 5 5 1 1 1 2 3 4 5 6 7 8 9 **(7.0, 0.8, I)**
Gap 11: patients sometimes receive DESs despite being at high risk for nonadherence to long-term antiplatelet therapy required (for financial or other reasons).	**n/a**	**n/a**
Opportunity a: display risk factors for nonadherence	1 2 4 3 3 1 2 3 4 5 6 7 8 9 (6.0, 1.0, I)	1 4 1 4 3 1 2 3 4 5 6 7 8 9 (7.0, 1.2, I)
Opportunity b: link to patient education materials relating to risks of poor adherence	2 1 6 2 2 1 2 3 4 5 6 7 8 9 (7.0, 0.8, A)	1 4 2 6 1 2 3 4 5 6 7 8 9 (6.0, 0.9, I)
Overall rating	2 1 6 4 1 2 3 4 5 6 7 8 9 **(7.0, 0.7, A)**	4 2 7 1 2 3 4 5 6 7 8 9 **(7.0, 0.8, I)**
Gap 13: antithrombotic therapies prescribed to patients with STEMI or non-STEMI receive dosages in excess of best practice recommendations	**n/a**	**n/a**
Opportunity a: order set that prioritizes drug classes according to guidelines and gives standard dosing values	1 2 5 5 1 2 3 4 5 6 7 8 9 (8.0, 0.7, A)	1 1 2 7 2 1 2 3 4 5 6 7 8 9 (8.0, 0.7, A)
Opportunity b: link to AHA/ACC recommendations for antithrombotic therapy	1 3 2 5 2 1 2 3 4 5 6 7 8 9 (8.0, 1.1, I)	2 2 4 2 2 1 1 2 3 4 5 6 7 8 9 (6.0, 1.5, I)
Opportunity c: alert if dosage order is different from standard dosing based on patient-specific information.	2 8 3 1 2 3 4 5 6 7 8 9 (8.0, 0.4, A)	1 9 2 1 1 2 3 4 5 6 7 8 9 (7.0, 0.4, A)

PCI Gap/CDS Opportunity	Compatibility	Potential Impact
	1 2 8 2	3 5 4 1
Overall rating	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
	(8.0, 0.5, A)	**(7.0, 0.7, A)**

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