The next two chapters present details about selecting and configuring CDS interventions; before diving into those specifics, you might revisit the Part I Introduction to reinforce what it looks like when the CDS Five Rights approach is applied to specific clinical objectives. Specifically, the summary tables with CDS configurations for VTE prophylaxis (Figures PII-2 and PII-3) and diabetes management (Figures PII-4 and PII-5)—together with the related text—illustrate important end products from your CDS intervention planning efforts. Generic versions of the diagrams and tables in these figures are provided as Worksheets 6-2 and 6-3; you might peek ahead to that material to stimulate your CDS Team's thinking about how you might approach your chosen CDS objectives through available CDS intervention configuration dimensions.

You can also begin thinking about who will be affected by the new CDS objectives and corresponding interventions. We discuss this further in Chapters 6 and 7, but as a backdrop for that work, you might start meeting with these people and documenting (in forms such as Worksheet 5-3) results from your explorations. Similarly, you can begin considering the systems you have available to deliver interventions that address targeted objectives and using forms such as Worksheet 5-4 to document that information.

As you select objectives and prepare to develop interventions, you should confirm that key participants understand and are applying the CDS Five Rights framework. For example, it is a useful exercise to ask at the beginning, middle, and end of intervention configuration: "To accomplish our goal of '_____,' is this the right CDS intervention (package) communicating the right information to the right person(s) through the right channel(s) at the right time(s)?"

Fully leveraging the CDS Five Rights framework requires a detailed understanding of the palettes underlying each configuration dimension. Chapter 2 provides details about CDS program stakeholders (who), and Chapter 3 discusses pertinent systems (where). The specific information delivered (what) will depend on the improvement target. Workflow opportunities for CDS intervention (when) were introduced in Chapter 3 and are covered further in the following chapter. We next explore in detail the decision support formats (how) that are available to provide CDS interventions. Chapter 6 covers how to apply these formats to address specific objectives.

Clinical Decision Support Intervention Types

As stated before, it is essential to fully understand the intervention-types toolbox to ensure that you are applying the right intervention type—or package of intervention types—to meet specific improvement needs. There are different ways to classify the CDS intervention types in the toolbox, and there is currently no universally accepted categorization scheme. Previous editions of this Guide introduced a taxonomy based on broad use cases; since that time, feedback and new contributions from clinical users, academic informatics laboratories,[4] and multi-stakeholder panels[5] have helped to expand and reshape the list. For example, additional categories such as diagnostic decision aids and analytic tools have been more prominently included. The updated classification presented in Figure 5-5 and described next maintains the strategy used in earlier guidebook editions; that is, dividing interventions into easily recognized types based on their typical presentation and user interaction. In this updated version, the intervention types are further grouped by typical workflows in which they appear.

For each intervention type within these four major groupings, we next outline their benefits and give several examples of specific interventions within that type.

CDS During Data-entry Tasks

Smart Documentation Forms

Benefits: Provide complete documentation for care quality/continuity, reimbursement, legal requirements; reduce omission errors by making sure the clinician thinks about the items displayed on the form; reduce commission errors by ensuring criti-

Figure 5-5: Taxonomy of CDS Intervention Types

A. CDS during data-entry tasks
   1. Smart documentation forms
   2. Order sets, care plans and protocols
   3. Parameter guidance
   4. Critiques and warnings—"immediate alerts"

B. CDS during data-review tasks
   5. Relevant data summaries (single-patient)
   6. Multi-patient monitors
   7. Predictive and retrospective analytics

C. CDS during assessment and understanding tasks
   8. Filtered reference information and knowledge resources
   9. Expert workup and management advisors

D. CDS not triggered by a user task
   10. Event-driven alerts (data-triggered) and reminders (time-triggered)

cal data—such as allergies—are captured; provide coded data for other data-driven CDS interventions; in some cases, provide calculated risk scores based on entries made in the form. Provide prompts to acquire specific information in the format desired (for example, displaying "kg" for weight to ensure capture in the metric system as needed for subsequent dose calculation).

Examples:

- Checklists for a given procedure or workflow;
- Structured documentation forms for a given problem or presentation that help guide proper care and facilitate documentation for quality reporting;
- Clinical documentation forms that adjust their items based on the patient's condition;
- Patient self-assessment forms;
- Pre-visit questionnaire that captures health problems and current medications;
- Nursing documentation forms that also inform the care plan by the items that are checked;
- Online health risk appraisals;
- Medication administration record forms that automatically help track whether medications have been missed;
- Intelligent referral forms that ensure that proper information is passed along;
- Data flowsheets for viewing and entering a patient's preventive care or immunization information (usually a mixture of data entry forms and relevant data summaries).

Order Sets, Care Plans and Multi-step Protocols

Benefits: Promote adherence to care standards by making the right thing the easiest thing to do. They facilitate compliance with previously agreed-upon care policies, best practices and locally designed clinical pathways. Because they usually are quicker to use than "a la carte" ordering, they often rate high in physician acceptance, increasing the likelihood that they are used and their benefits realized. Multi-step protocols can include collected order sets or care plans that are designed to be used in sequence.

Examples:

- Order sets and care plans for standard and ICU inpatient admissions, ambulatory problem management and pre- and post-operative care;
- Conditional order sets that adjust for patient conditions, allergies, comorbidities or other variations;
- Recommender programs that suggest likely order sets and care plans based on admission diagnosis or other patient factors;
- Protocol helpers that lead a clinician to the various 'order sets' that are part of a multi-step pathway;
- Support for managing clinical problems over long periods and many encounters, such as a computer-assisted management algorithm for treating hyperlipidemia over many outpatient visits.

Parameter Guidance

Benefits: When writing orders or prescriptions (whether using an order set or not), these *proactive* interventions help ensure that drug doses and frequencies, as well as other diagnostic and therapeutic ordering parameters, are complete and correct. Parameter guidance may be provided as simple lists (such as for recommended drug dosages) or via more complex algorithms.

Examples:

- Suggested drug and/or dose choice lists integrated into ordering function—possibly modified by patient's kidney or liver function and age;
- Guided dose algorithms based on weight, body surface area (BSA) and other key parameters;
- Forms that facilitate entering complex orders such as insulin sliding scales and prednisone tapers (this can also be done as an order set but often is implemented within a single order in CPOE applications);
- Displays that help guide an order, for example, displaying hematocrit and crossmatch status when ordering blood products, or displaying kidney function when ordering medications where dosages must be adjusted if this function is abnormal;
- Template to ensure complete documentation of reasons and alternative options when ordering physical or chemical restraints;
- Total parenteral nutrition (TPN) ordering forms with built-in calculators to transform total sodium, potassium, calorie and CO_2 requirements into the appropriate solutions;
- Displaying additional important parameters, such as patient allergies, relevant lab test results, drug formulary status and/or drug costs when ordering a medication.

Critiques and Warnings (Immediate Alerts)

Benefits: These *reactive* interventions prompt the user to immediately address possible errors, hazards or quality improvement opportunities related to new data or orders just entered into an information system; they help enforce care standards and prevent adverse events. They also may provide critiques to help ensure that additional documentation or orders necessary to make an order safe and complete are entered.

Note: Because this intervention type is so easily recognized and relatively simple in structure, it is easy to overuse. See the discussion on "alert fatigue" in Chapter 7. Effectiveness requires careful attention to workflow and ensuring that critiques are only presented when the likelihood is high that the user will use it to change management.

Examples:

- Drug allergy warnings;
- Drug interaction warnings, for example, in response to a newly prescribed drug's interaction with other drugs, pregnancy, laboratory results or food;
- Inappropriate therapeutic duplication warning;
- Underdose/overdose alert after an order has been entered (often for checking total dosage of some component, which may derive from multiple orders);
- Critique asking for additional data entry to ensure that a radiology study is ordered for the right reasons;

A Note about the Term 'Alert'

The "alert" intervention type is commonly understood to mean any highly focused and important message that pops up more or less unexpectedly. Two important alert subtypes include:

- *Immediate critiques and warnings* that are urgent requests for clarification, correction or different action—often related to an order or prescription—based on an action the user just took or data they entered;[6]
- *Event-driven reminders and notifications* that are driven by asynchronous events, that is, care-related occurrences that occur outside care team members' workflows. These events include when highly abnormal test results are posted in the laboratory system, or when too much time passes after a particular test or clinical event without appropriate follow-up. Reminders and notifications are used to make the clinicians and patients aware that such events have occurred.

Because these alert subtypes relate to workflow in different ways, we have tried to address them separately. We would prefer to give them different terms altogether, but the generic term 'alert' is too well entrenched to easily replace or modify. In addition, it is important to link these alert types to the work directed toward preventing 'alert fatigue' (which largely speaks to excessive immediate critiques, such as drug-drug interaction warnings). Thus, we are keeping the word 'alert' in both names, while also offering terms that distinguish these two intervention types and their very different applications. Immediate critiques and warnings are described next, and event-driven reminders and notifications are the last intervention type discussed.

- Warning that a consequent order is probably needed: for example, for drug levels when ordering certain antibiotics or for premedication when ordering certain drugs or procedures;
- Suggesting more cost-effective drug, regimen or formulary-compliant option than the medication being ordered.

CDS During Data Review Tasks

Relevant Data Summaries (Single-patient)

Benefits: These concise presentations of important data optimize decision making for a specific patient's circumstances by ensuring all pertinent data are noted and considered. They organize complex data sets to help care team members better understand the overall clinical picture and to highlight needed actions.

Examples:

- Health maintenance flowsheet presented when the patient returns for an ambulatory visit, showing fulfilled and needed screening tests;
- Chart that displays a patient's immunization status and highlights vaccinations that are due or overdue;
- Quality-metric status sheet (for example, related to patient-specific Meaningful Use and value-based purchasing quality measures) that shows which care requirements are completed and needed for a particular patient overall or for a certain aspect of their care (such as for diabetes management);
- Patient rounding or action lists organized to highlight patient-specific items needing attention, such as abnormal or new values;

- ICU electronic "status board" that provides a filtered view of a patient's critical physiologic parameters, ventilator settings, intravenous medication delivery rates and other information to facilitate 'at-a-glance' decision making;
- Key parameters such as a patient's heart rate and pain level presented to the nurse prior to medication administration;
- Displaying the current level of care/evaluation and management (E&M) score given current level of documentation for the patient encounter.

Multi-patient Monitors

Benefits: Like single-patient relevant data summaries, these provide a filtered, organized, "at-a-glance" look at key parameters and facilitate using the right information for decision making from a large data set covering several patients. In these multi-patient situations, for which resources must be prioritized and clinician attention constantly re-directed, this proactive intervention prevents many omission errors and permits much faster response to important events. Like the relevant data summary, this type does not necessarily require an immediate clinician response.

Examples:

- Emergency department tracking system highlighting new patients, critical lab results, admission and disposition process, and other patient care and patient flow parameters;
- Operating room status monitor showing the procedure progress in each room, to facilitate rapid transitions and efficient resource utilization;
- Whole-service display of International Normalized Ratio (INR) values and warfarin dosing for an orthopedic post-op service;
- Patient-controlled analgesia service display, showing the current dosing and status for all patients on service, permitting changes to be made on all patients from one screen;
- Inpatient unit status monitor that lets the nurse see which patients have pending orders, due medications, or transfer/discharge events.

Predictive and Retrospective Analytics

Benefits: Whereas monitors display organized, real-time data elements in one place, analytics display data over time, compare them to benchmarks, enable users to drill down into data details to understand root causes, and in many other ways facilitate broad quality improvement projects. They can be used to help find the causes for results that CDS interventions are producing (for example, which clinicians are and are not adhering to care guidance supported by specific CDS interventions) and to monitor improvement trends. Predictive analytics use related techniques but can be applied to individual patients to risk-stratify them and to raise awareness about clinical hazards and opportunities. Analytics interventions may use much more sophisticated calculations and algorithms than is typical for most other CDS intervention types.

Examples:

- Retrospective displays of performance, control charts, benchmarks for strategic guidance and problem-spotting;
- Syndromic surveillance and biosurveillance tools to identify disease patterns, outcomes changes and epidemics;
- Predictive tool to stratify pressure-ulcer risk in individual patients, thus directing resources to those at highest risk;
- Tools for comparing performance of different practices or subgroups in a particular quality or safety objective, or assessing (via control charts) whether a clinical pathway or other intervention or intervention package has successfully improved care process and outcome metrics;
- Displays comparing which initiative—among three or four possible broad alternatives—has the greatest potential for driving improvement.

CDS During Assessment and Understanding Tasks

Filtered Reference Information and Knowledge Resources

Benefits: Clinicians experience frequent information needs in caring for patients, and many

of these are difficult to answer.[7] The information needs are diverse and span trying to integrate patient data into an accurate diagnostic picture and formulate an overall plan, to more focused needs such as understanding a medication's effects or proper dose, determining the best testing procedure, formulating a differential diagnosis, or deciding between several therapeutic options. Patients also experience many clinical information needs, and likewise experience important difficulties addressing them.[8] Many of these clinician and patient information needs can be addressed by material available in reference sources such as textbooks or guidebooks, journal articles, guidelines and other resources.

CDS reference interventions deliver information from these sources into clinician and patient workflow. Ideally, they filter the information based on patient and situational factors (such as care setting and intervention recipient), and deliver the most useful information in the most practical manner. This filtering is often accomplished through infobuttons or evidence links; the HL7 infobutton standard[9] is a mechanism to broker this information exchange between a reference source and a clinical application (such as an EHR or PHR) that delivers the information to the end user. Other information tools deliver images, charts, visually oriented reference, or specifically deliver relevant updates from recent research. The information itself may come from commercial references, such as drug information resources; from public resources, such as national guideline websites; or from local sources within a care delivery organization.

Examples:

- Infobutton linking from each entry in an active medication list in an EHR to a display for clinicians containing side effects and/or dosing for that medication; related links to drug information for the patient that can be printed and/or securely emailed to the patient;
- Infobutton linking from problem-list entry or review in an EHR to recent evidence-based treatment overviews for that problem;
- Link from patient's problems and medications in a PHR to self-management guidance and drug information sheets;
- Link from an immunization flowsheet to table listing standard immunization intervals;
- Links to calculators and nomograms, such as for drug dosing, within a CPOE system;
- Service that notifies clinicians and/or patients about recent research updates relevant to a patient's problems or medications;
- Order set links to explanatory information and evidence supporting the orders presented in the set;
- Health risk assessment results that generate a set of information resources and educational programs to be used by the patient.

Expert Workup and Management Advisors

Benefits: These applications typically use patient data from an EHR or (more commonly as of this writing) from direct user entry, to suggest diagnoses that may not have been considered; they also can suggest tests and workup steps that can further clarify the diagnosis. Although they are most commonly used for diagnostic purposes, the same model can be used to advise on recommended therapies specific to the patient's situation.

Examples:

- Diagnostic decision support program that accepts symptoms, signs and general test findings and suggests a ranked list of possible diagnoses;
- Workup advisor that suggests best next tests for patients, given their clinical findings;
- Visual dermatology guide that helps clinicians identify rashes based on characteristics such as color, size and texture;
- Antibiotic advisor that assesses, for a particular infection, the likely pathogens, local antibiotic sensitivities, and drug contraindications in order to provide recommended treatments.

CDS Not Triggered by a User Task

Event-driven Alerts and Reminders

Benefits: As noted in the sidebar presented earlier, these alert subtypes raise awareness about events

that are occurring outside routine, patient-specific workflows. These events can include newly posted abnormal lab results that suggest significant patient danger,[10] a new admission or discharge for a primary care physician's patient, and many others. These interventions can also detect important *non-events*, that is, when important events have *not* occurred in a prescribed time period or as indicated. For example, detecting and notifying that a patient has not had a particular cancer screening or disease-monitoring test, or health-maintenance exam, within the recommended time period. Similarly, they can detect and notify when a particular medication is indicated for a specific condition, and the patient has not received it. Alerts and reminders prevent omission errors and promote faster response to critical situations.[11]

Typically, important event-driven alerts must reach the target user through a notification mechanism (see Chapter 7), such as text message, secure email or appearance on a notification screen (see relevant data summaries and multi-patient monitors previously presented). Lower-urgency reminders that can wait for the patient's next in-person clinician encounter can be displayed on the patient's EHR facesheet and/or via their PHR.

Examples:

- EHR, text message or pager alert about an abnormal and critical lab result;[12]
- Notification about an abnormal mammogram or Pap smear finding;
- Reminder that a patient is due for a flu shot or other immunization;
- Alert that a critical follow-up lab test has not been performed within the recommended time period;
- Notification that restraint orders or indwelling catheters must be renewed after a specific time period has elapsed;
- Program that generates standard letters to patients about their lab results, with varied text, depending on whether the result is normal or abnormal;
- Adverse event detector that monitors proxies for adverse events, such as when antidotes for overdoses and allergic reactions (such as naloxone, diphenhydramine) are used;
- User-requested notification when an important lab result is available or other key event has occurred;
- Disease management alert; for example, notification that there are needed therapeutic or monitoring interventions based on guidelines/evidence and patient-specific factors.

Chapter 6 explores in more detail how to select from among these intervention types to efficiently and effectively meet your improvement objectives. For now, you can begin considering which intervention types are available in your information systems and which would be most implementable, usable, valuable and cost-effective for the different improvement targets you have selected.

Other Interventions/Considerations

Manage the CDS/CPOE Interplay

In some organizations that are early in their CDS program efforts, clinicians might consider CDS and CPOE to be the nearly the same. This occurs especially when there is major organizational attention to a new CPOE rollout, and there is intense focus on developing and rolling out imbedded order sets and alerts. While there is certainly positive interplay between CDS interventions and CPOE applications, it is important for clinicians and other stakeholders to understand that they are different. The CDS Five Rights framework can be helpful in clarifying important distinctions: CPOE is a *delivery channel* for *CDS interventions* which may include alerts, order sets and other *intervention types*, that convey *information* about drug prescribing safety concerns and support evidence-based orders for a particular situation.

Ideally, you should gain organizational comfort with—and begin implementing—CDS interventions before the CPOE launch date. CPOE is a difficult enough change process to manage without the additional stressors associated with a newly deployed CDS program. If possible, have your organization adopt protocol-driven care and CDS interventions delivered via other channels before adapting these approaches for the CPOE channel. Otherwise, a