Clinical Decision Support for Colon and Rectal Surgery: An Overview

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Abstract

Clinical decision support (CDS) has been shown to improve clinical processes, promote patient safety, and reduce costs in healthcare settings, and it is now a requirement for clinicians as part of the Meaningful Use Regulation. However, most evidence for CDS has been evaluated primarily in internal medicine care settings, and colon and rectal surgery (CRS) has unique needs with CDS that are not frequently described in the literature. The authors reviewed published literature in informatics and medical journals, combined with expert opinion to define CDS, describe the evidence for CDS, outline the implementation process for CDS, and present applications of CDS in CRS.CDS functionalities such as order sets, documentation templates, and order facilitation aids are most often described in the literature and most likely to be beneficial in CRS. Further research is necessary to identify and better evaluate additional CDS systems in the setting of CRS.

Keywords

- clinical decision support systems
- colorectal surgery
- electronic health records
- patient safety

Objectives: On completion of this article, the reader should be able to define and provide examples of clinical decision support for colon and rectal surgery.

Following the two seminal and influential Institute of Medicine reports, "To Err Is Human"[1] and "Crossing the Quality Chasm,"[2] clinicians and healthcare organizations have been implementing electronic health records (EHRs) in an attempt to achieve the sought-after transformational breakthroughs to improve quality and service while simultaneously reducing costs. Further, early studies of computerized provider order entry (CPOE) with embedded clinical decision support (CDS) suggest that such systems could significantly reduce the rate of medication errors by as much as 81%.[3–9] However, these transformations have been much harder to achieve than anyone expected.[10,11] More recently the American Recovery and Reinvestment Act (ARRA) stimulus with its Health Information Technology for Economic and Clinical Health (HITECH) Act has significantly increased the pressure on healthcare providers to implement state of the art EHRs with at least a minimal amount of CDS with the Meaningful Use Regulation, led by the Centers for Medicare and Medicaid Services and the Department of Health and Human Services.[12,13]

Historically, the majority of CDS for patient care has been developed for internal medicine. The literature on CDS therefore is primarily focused on applications, interventions, and outcomes outside of the surgical subspecialty domain. Colon and rectal surgery (CRS) practice, however, has unique needs for health information technology (HIT) and CDS that may differ from what is traditionally described.[14] Although many of the clinical examples described in the literature are not directly applicable to CRS, we nevertheless believe that CDS can be beneficial in CRS settings. In this article, we define CDS,

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describe the evidence for CDS, outline the implementation process for CDS, and present some potential applications of CDS in CRS.

Definition of Clinical Decision Support

Several definitions of CDS have been described in various manuscripts, textbooks, and regulations.[15] One broad definition for 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."[16] That said, CDS is often best defined by examples. Some of the most familiar examples of CDS are drug-drug interaction alerts, computerized dosing reminders, and guideline-based order sets. These are tools, generally embedded in an EHR, to help clinicians make decisions or remind them of data or facts they may have forgotten or overlooked.

Several approaches for providing and classifying CDS exist. In particular, one recent report describes a taxonomy for CDS, providing definitions and examples of each CDS type.[17] The major categories within the taxonomy include medication dosing support, order facilitators, point of care alerts or reminders, relevant information display, expert systems, and workflow support. We describe these categories in detail with several examples relevant to CRS below.

Evidence for Clinical Decision Support

Extensive literature has described the effect of several different types of CDS on patient, process, and cost outcomes.[18–22] Most studies report benefits of CDS implementations on process outcomes; examples of these include appropriate ordering of medications, preventive therapies, and laboratory test result monitoring.[20,23] A recent systematic review determined that the random-effects combined odds ratios for studies reporting adherence to recommendations for preventive services, ordering clinical studies, and prescribing appropriate treatments was 1.42, 1.72, and 1.575, respectively, confirming a positive effect of CDS on process outcomes.[23]

In addition to improved process outcomes, CDS has also resulted in significant cost savings.[23] One study reported a net savings of $16.7 million and net operating budget savings of $9.5 million over 10 years, citing renal dosing guidance, nursing time utilization, specific drug guidance, and adverse drug event prevention as items resulting in the greatest cumulative savings.[22] However, initial costs of implementing HIT to deliver CDS are extremely high, often limiting implementations in smaller or less well-funded organizations from realizing these savings.[24] With the release of the Meaningful Use Regulation, which includes incentive payments for those attesting prior to 2015,and penalties beginning afterward for those who have not attested, in the coming several years, implementation of CDS will continue to increase.[12]

Despite these findings and the initial promise of CDS success at improving patient outcomes, only a few centers have rigorously demonstrated significant, positive findings with CDS.[18,23] Further, many of these studies focused on custom-built CDS implemented within locally developed health information technology systems in large, academic medical centers, and further research is necessary to better quantify the benefits of CDS across all healthcare settings and to demonstrate the scalability of CDS for subspecialty settings.[25]

The Clinical Decision Support Implementation Process

Creating a CDS program for any organization or practice is a difficult undertaking. It is important to build a shared vision among all stakeholders within the organization or practice, including how the CDS interventions will enhance clinical, operational, and financial performance.[26] The vision should be informed by both internal and external factors. Currently, external regulatory pressures such as Meaningful Use, combined with internal pressures to develop and/or participate in an Accountable Care Organization (ACO),[27] are driving these decisions in many healthcare organizations. Once the goals of a particular CDS program have been identified, the organization can begin to identify specific clinical objectives to address.The organization should attempt to broadly integrate these new CDS-focused objectives into existing clinical governance, planning, and operational committees.[28]

The next major hurdle is identifying the key personnel who will be responsible for the actual development and implementation of the CDS interventions. Key roles to be filled include clinical champions responsible for encouraging and teaching other clinicians regarding reasons for and use of the CDS interventions; technical resources responsible for implementing the CDS logic within the EHR; and administrative supporters who must ensure that there will be adequate funding for new parts of the technical architecture, have access to external consultants and vendor personnel that may be required to help implement the CDS, and test the new interventions.[29] The organization must also investigate what is feasible, given the technical limitations of their particular EHR and other HIT systems coupled with the availability, accuracy, and timeliness of the data required to drive the CDS.[30]

The organization should also consider how they will measure and monitor the effect of each CDS intervention because a critical component of any CDS intervention implementation is proper testing.[31] These tests must be done at many different levels. For example, a technical person needs to ensure that the intervention performs as expected (e.g., storage of specific data values leads to the appropriate alert appearing in a pop-up window, or entry of a specific problem onto the patient's problem list creates a link to an appropriate order set). Similarly, each intervention must be tested by clinicians to ensure that it makes sense within their normal clinical workflow. Finally, following go-live, the intervention needs to be monitored closely to ensure that it is working as expected (e.g., the alert is firing when expected, but not more often than necessary, or the order set is appearing for patients with the appropriate conditions and the correct default items within the order set are selected).The organization should make sure that there is a mechanism to allow clinicians to provide feedback to the HIT staff regarding any potential issues with the CDS.[32] These complaints should be quickly investigated and fixed if necessary. Finally, the organization should carefully monitor the intervention to ascertain whether it has positively affected the originally defined clinical objective.[33] Often, the intervention will need to be optimized in some manner to get the desired outcome.[34,35] ►**Fig. 1** provides a diagram that illustrates the iterative nature of the CDS implementation process. It is important to note that it is not uncommon for CDS interventions to have to be modified in some way following implementation to get the desired effect.

Applications of Clinical Decision Support for Colon and Rectal Surgery

►**Table 1**[36–46] depicts the previously described CDS taxonomy[17] and provides several examples of CDS relevant to CRS, with references when applicable. Medication dosing support is the first category of CDS and includes medication dose adjustment, formulary checking, dose checking, default doses, and indication-based ordering. This category of CDS has been demonstrated to be highly effective in both improving patient safety and reducing associated costs.[22,47] Although few examples specific to CRS have been described in the literature, several examples exist that may be relevant, including dosing advisors for antibiotics based on renal function.[47]

Order facilitators are the next category of CDS, including order sentences, subsequent or corollary orders, indication-based ordering, and order sets. For busy surgeons, order facilitators can reduce the amount of time spent entering orders and leave more time for providing patient care. Order sets, collections of orders that are grouped by a specific clinical purpose, are frequently used by hospitals to ensure adherence to guidelines or protocols.[48] In surgical settings, order set examples include those for admission to the CRS service or for postoperative care of patients.[48,49]

Point-of-care alerts and reminders comprise the third category of CDS, representing one of the CDS types most frequently evaluated in the literature. This type of CDS prompts clinicians about drug-condition, drug-drug, and drug-allergy interactions; reminds clinicians to assess specific care items; and notifies clinicians about critical laboratory values or high-risk states. These reminders can be passive alerts that display additional text, change existing text colors, or show images, without interrupting the workflow, and can also be interruptive alerts, which require that providers acknowledge or respond to the alert before resuming order entry.[50,51] For colon and rectal diseases, alerts often prompt primary care providers to order or remind patients about cancer-screening tests or to follow up with patients after abnormal screening test results.[52–54] Alerts can also be beneficial directly to CRS practice, given the protocoled nature of many CRS conditions and the high number of potential interactions with antibiotics and other medications frequently ordered.

The fourth type of CDS is relevant information display. This type ensures that clinicians have up-to-date and necessary patient data to make decisions in providing care to the patients, such as showing recent laboratory test values during medication ordering. Specific examples for CRS have not been extensively described in the literature, although knowledge about laboratory trends or cost of care is an important consideration for clinicians across all care settings.

Expert systems are the fifth type of CDS, and these apply advanced logic or computational methods to assist clinicians in ordering, diagnosing, treating, and interpreting elements within the EHR. One example specific to CRS includes a study that applied statistical methods to predict outcomes for patients with diverticulitis.[55] Another study evaluated a treatment planning system that suggests volume resuscitation and medication therapy, such as use of antibiotics and vasopressors, for surgical patients identified as having sepsis, and found that use of the CDS improved mortality in the observed patients.[56]

The final type of CDS is workflow support, including order routing, registry functions, medication reconciliation, automatic order termination, order approvals, free-text order parsing, and documentation aids. Registry functions are especially important for CRS, where appropriate patient follow-up is imperative for providing optimal care. For

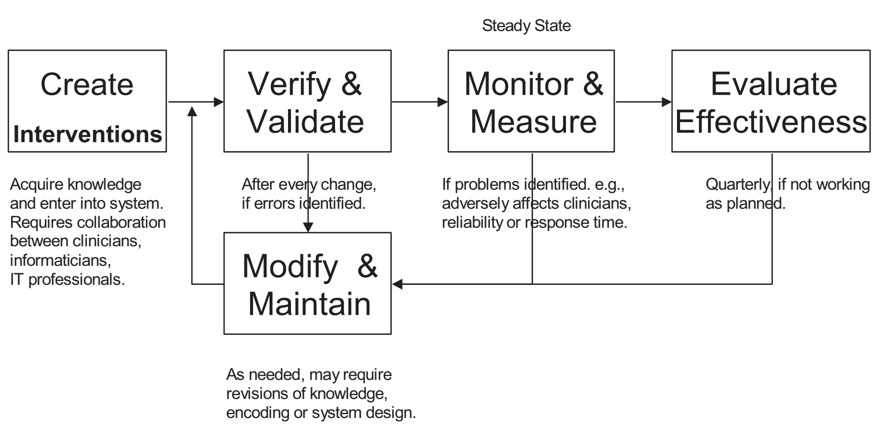

Fig. 1 An overview of the clinical decision support design, development, implementation, and evaluation lifecycle. Adapted from Osheroff et al.[16]

Table 1 Types of clinical decision support and examples relevant to colon and rectal surgery

Type	Example
Medication dosing support	
Medication dose adjustment	Dosing advisor for antibiotics based on renal function.[47]
Formulary checking	Suggest nifedipine ointment as a more cost-effective alternative to diltiazem ointment in the treatment of anal fissure.[36]
Single-dose range checking	Alert on a single dose of acetaminophen 2 g for postoperative analgesia.
Maximum daily dose checking	Alert on a total daily dose of acetaminophen 7 g for postoperative analgesia.
Maximum lifetime dose checking	Alert if the total cumulative amount of radiation therapy exceeds the recommended maximum amount in the setting of neoadjuvant chemoradiotherapy for rectal cancer.[37]
Default doses/pick lists	Provide a list of 100 mg, 200 mg, 300 mg, 400 mg, 600 mg, and 800 mg doses for ibuprofen with a default of 400 mg for postoperative analgesia in adults following an anorectal procedure.
Indication-based dosing	Order 2% diltiazem ointment topically for anal fissure, but 60 mg three times daily by mouth for hypertension.
Order facilitators	
Medication order sentences	Allow the provider to order “Heparin 5000 Units Subcutaneously t.i.d.” as a single unit for perioperative thromboembolic disease prophylactic prevention.
Subsequent or corollary orders	Order hemoglobin test when mesalamine is ordered.
Indication-based ordering	Suggest perioperative intravenous antibiotics at the time of starting an abdominal surgery.[38,39]
Service-specific order sets	Colorectal surgery inpatient admission order set[49]
Condition-specific order sets	Abdominal pain order set
Procedure-specific order sets	Postoperative colectomy order set[48]
Condition-specific treatment protocol	Inflammatory bowel disease treatment protocol
Transfer order set	Transfer to surgery step-down unit order set
Nonmedication order sentences	Allow the provider to order “Call HO for temperature > 101, SBP > 180, DBP < 90, HR > 120, HR < 50, RR > 30, RR < 10, O_2 saturation $< 92\%$” as a single unit.
Point of care alerts/reminders	
Drug/condition interaction checking	Alert when a provider orders metronidazole in the setting of *Clostridium difficile* colitis for a female patient of childbearing age.
Drug/drug interaction checking	Alert about the possibility of thrombosis when a provider orders omeprazole in a patient receiving clopidogrel.[40]
Drug/allergy interaction checking	Alert when a provider orders cefotetan for perioperative antibiotics in a patient with a documented penicillin allergy.
Plan of care alerts	Reminders to reassess the need for restraints and reorder if necessary at least every 24 h.
Critical laboratory value checking	Notify providers about positive FOBT results.[54]
Duplicate order checking	Alert when a provider orders metoprolol in a surgical patient with active order for atenolol or when it is already on the medication list.
Care reminders	Remind providers to order a yearly FOBT for patients between 45 and 85.[52,53]
Look-alike/sound-alike medication warnings	Warn providers ordering prednisone or prednisolone to ensure that they have chosen the drug they intended.
Ticklers	Alert a provider when colonoscopy has been ordered but not scheduled or performed within three months.
Problem list management	When ordering mesalamine, ask the provider if he/she would like to add inflammatory bowel disease to the problem list if not already documented.[41]
Radiology ordering support	Order a CT scan of the abdomen and pelvis (rather than only the abdomen) in a patient with abdominal pain to ensure full visualization of the peritoneal cavity.
IV/PO conversion	Convert patient from IV metronidazole to PO metronidazole when patient is no longer NPO.

Table 1 (*Continued*)

Type	Example
High-risk state monitoring	Alert the provider to order contact precautions for patients with known methicillin-resistant *Staphylococcus aureus* colonization.
Polypharmacy alerts	Alert the provider that a patient is on >8 medications and suggest pharmacy consult.[42]
Relevant information display	
Context-sensitive information retrieval	Allow the provider to link directly to prescribing information for a medication at the time of ordering.[19]
Patient-specific relevant data displays	Display recent creatinine levels when ordering Fleets Phospho-Soda with a bowel preparation.
Medication/test cost display	Indicate that a CBC costs $66 at the time of ordering.
Tallman lettering	Show prednisone and prednisolone as predniSONE and prednisoLONE in a pick list.[43]
Context-sensitive user interface	Provide a special interface for chemotherapy order entry, which might include relevant data display, special facilities for ordering complex or time-based protocols and reference information.
Expert systems	
Antibiotic ordering support	Suggest metronidazole for empiric antibiotic therapy for patients with suspected *Clostridium difficile*.
Ventilator support	Unless the FiO_2 is already at 1.0, suggest increasing the FiO_2 by 0.1 if the PaO_2 is > 50 but < 60 mmHg in patients with acute respiratory distress syndrome.[44]
Diagnostic support	Provide a tool to help providers distinguish between types of inflammatory bowel disease and related conditions.
Risk assessment tools	Estimate 10-year diverticulitis recurrence risk for a patient with complicated diverticulitis.[55]
Prognostic tools	Estimate survival for colorectal cancer patients based on pathologic tumor grade and stage.[45]
Transfusion support	Suggest fresh frozen plasma for patients with a high INR and taking warfarin.
Nutrition ordering tools	Suggest increased protein in TPN for patients with active infection.
Laboratory test interpretation	Based on microbiology sensitivity testing, report that a patient with an intraabdominal abscess has vancomycin-resistant *enterococcus* and needs to be placed on contact precautions.
Treatment planning	A computerized system to facilitate management of surgical sepsis.[56]
Triage tools	Computer-based recommendations for patients with acute abdominal pain.[46]
Syndromic surveillance	City-wide reporting and monitoring of emergency department chief complaints to detect *E. coli* O157:H7 outbreaks.
Workflow support	
Order routing	Route order for stoma marking to wound ostomy continence nursing.
Registry functions	Send a letter to eligible patients to recommend FOBT.[57–59]
Medication reconciliation	Upon postprocedure admission, automatically generate a preadmission medication list based on outpatient medication orders and pharmacy dispensing data.
Automatic order termination	Automatically terminate antibiotic orders after the conclusion of the order duration.
Order approvals	Send all colonoscopy orders to CRS for approval.
Free-text order parsing	Allow the user to enter the text "amox 500 mg QID 10d" and translate that to a complete, structured amoxicillin order that can be automatically processed by the pharmacy system.
Documentation aids	Structured documentation template for a CRS visit that has common findings.

Abbreviations: t.i.d., three times daily; HO, house officer; SBP, systolic blood pressure; DBP, diastolic blood pressure; HR, heart rate; RR, respiratory rate; FOBT, fecal occult blood test; CT, computed tomography; IV, intravenous; PO, by mouth; NPO, nothing by mouth; CBC, complete blood count; INR, international normalized ratio; TPN, total parenteral nutrition; CRS, colon and rectal surgery; QID, four times daily.

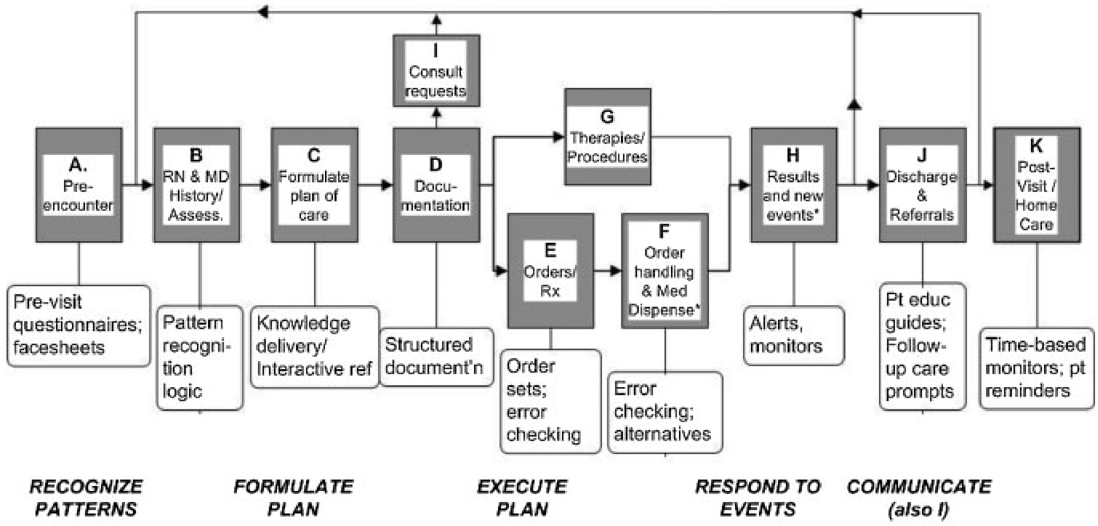

Fig. 2 Flowchart of clinical workflow with core actions and typical clinical decision support opportunities. Adapted from Osheroff et al.[16]

example, several studies have described reminders sent to patients, through mailed letters or telephone calls, to remind patients about completion of fecal occult blood tests.[57–59]

Challenges for Clinical Decision Support

Despite the reported benefits CDS can provide, several barriers and challenges exist that frequently prevent patient safety and other healthcare improvements. One challenge is that CDS is often not implemented in a manner that allows it to be as effective as possible in practice. First, CDS must be presented in a manner that fits into the optimal workflow for clinicians and is intuitive for clinicians to view and respond.[60,61] ►**Fig. 2** depicts the basic workflow for clinical encounters, indicating core actions that are associated with each step in the workflow and CDS interventions that are appropriate for each core action.[16]

CDS must also be specific and relevant to both the clinician and patient receiving the CDS. For example, an alert about a medication contraindicated in pregnancy should be suppressed for a patient who is postmenopausal or has had a hysterectomy. However, it can be difficult to implement highly specific CDS systems, as these require that relevant patient information be computable in acoded instead of free-text format. When coded or structured data are not available, some computation methods may be applied to transform the free-text information into coded data, using techniques such as natural language processing.[62] These methods have been applied to process surgical and pathology reports, which could improve CDS delivered to CRS clinicians.[63–65]

Further problems arise with ineffective CDS solutions, such as alert fatigue, which occurs when clinicians receive too many CDS alerts and subsequently ignore many alerts that are displayed by the system.[66] Studies have found that 49–96% of alerts displayed to clinicians are overridden, most often due to frequent alerts that are irrelevant or not serious.[67] To prevent alert fatigue, it is necessary that institutions effectively evaluate and refine the implementation of any CDS tool both prior to and following implementation.[68] Computer-based pharmacy surveillance of patients with high-risk conditions or of alerts with high rates of overrides may also prevent errors when the CDS is insufficient.[69,70]

Another challenge to implementing effective CDS is the difficulty in managing and sharing CDS knowledge.[71,72] Currently, most CDS systems are implemented locally, and replicating these systems at other institutions requires considerable effort by HIT staff and may be prone to errors. The development of methods for sharing CDS across institutions and EHRs could increase CDS adoption. One approach to sharing CDS utilizes a service-oriented architecture, where CDS interventions are hosted remotely and institutions can subscribe to receive CDS without having to develop and maintain the services locally.[73] Another approach might involve CDS repositories, where an organization makes rules available, and the rules are downloaded locally, where they can be maintained, modified, and integrated into existing EHRs.[71]

Conclusion

CDS can be an effective method to improve clinical processes and patient safety. Given the episodic nature of CRS care, CDS such as order sets, documentation templates, and any variety of order facilitation aids is most likely to be beneficial in CRS, whereas other types of CDS (such as registry management tools) or reminders may be more useful for primary care providers. However, colon and rectal surgeons can still play an important role in developing CRS-related CDS for other providers by, for example, participating in the development of screening reminder systems that help primary care providers select appropriate screening tests and intervals. Even though the tools would primarily be used by primary care providers, colon and rectal surgeons have special expertise that could contribute to the process of development. Further research is necessary to identify and better evaluate additional CDS systems in the setting of CRS.

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