Cancer Care Ontario's Computerized Physician Order Entry System: A Province-wide Patient Safety Innovation

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Abstract

More than one-third of all women and men in Canada will develop cancer during their lifetimes. Cancer patients typically require complex chemotherapy regimens, specific to their type and stage of disease, to slow or stop cancer cells from growing, multiplying, or spreading to other parts of the body. Despite the complexity of managing medication regimens for cancer patients and the associated risks to patient safety, current medical oncology practice throughout most of Canada is still to use paper-based tools, policies and procedures.

To increase patient safety by reducing prescription errors and to offer clinical decision support to medical oncologists across the province, Cancer Care Ontario (CCO) developed and implemented Canada's first, cancer-specific computerized physician order entry (CPOE) system. This e-health innovation is currently in use in 11 cancer centres, and represents the largest ambulatory oncology CPOE implementation in Canada, with a 100% implementation success rate, and greater than 90% physician adoption.

This paper describes the critical success factors in the design and implementation of CCO's CPOE system, including Web-based training and ease of administration to maximize physician adoption, incorporating point-of-care access to clinical practice guidelines into the tool, and the use of CPOE data to monitor and increase access to anti-cancer drugs and patient safety.

Cancer Treatment: Prime Candidate for a CPOE Solution

When it comes to medication safety, few diseases pose as big a challenge as cancer. Cancer encompasses over one hundred distinct diseases, and roughly half of all cancer patients will require chemotherapy in the course of treatment. A regimen of chemotherapy may be prescribed to destroy cancer cells, slow or control the growth and spread of a tumour, or relieve symptoms and improve a patient's quality of life. Chemotherapy is inherently toxic to cells and can cause a host of moderate to severe side effects. Since much of chemotherapy is infused intravenously, where the impact on the body is rapid and direct, there is little room for error, particularly in dosing. This is all the more important as cancer patients are likely to receive repeated infusions over time. To be both safe and effective, these regimens must be carefully tailored to the patient. If a dose is too low, it will not be strong enough to attack cancer cells; if too high, it could prove intolerable or even fatal.

Determining a safe and effective chemotherapy regimen is dependent on a patient's type of cancer; the size, spread and genetic expression of the tumour; the patient's age, body surface area (calculated from their height and weight), medication allergies and general health status; and other factors. Factors affecting the appropriateness of a given regimen include the intent of treatment (curative or palliative); the right medications; dosing schedule, and timing of treatment relative to surgery and radia-

Table 1. Ontario Chemotherapy Facts

- 63,000 new patients will be diagnosed with cancer in 2006.
- 25,000 patients will die from cancer in 2006.
- Depending on the type of cancer, between 30 and 60% of Ontario cancer patients receive some form of intravenous chemotherapy.
- Five-year relative cancer survival is high and growing for common cancers such as prostate (92%), breast (86%) and colorectal (60%) owing to advances in treatment, including new drug therapies.
- 60% of the clinical practice guidelines and evidence summaries produced by Cancer Care Ontario's Program in Evidence-Based Care are specific to chemotherapy.
- Over 50% of all chemotherapy drug orders across Ontario are placed using Cancer Care Ontario's computerized physician order entry system – OPIS 2000 and 2005

Source: Cancer Care Ontario, "Cancer System Quality Index, 2006," CCO site, retrieved August 7, 2006 <http://www.cancercare.on.ca/qualityindex2006>.

tion treatment; and the need for supporting medications to combat side effects.

At the same time, the number of established and emerging drug therapies available to treat cancer is staggering. In 2005, 400 anti-cancer medications were under development (in clinical trials or awaiting FDA approval) in the US alone (Pharmaceutical Research and Manufacturers of America 2005). This is two times the number of drugs that were under development in the US for mental illness, three times the number for heart and stroke, and five times the number for AIDS (ibid.). Worldwide, over 2,000 clinical trials specific to chemotherapy are currently recruiting patients (National Institutes of Health 2006). Over 200 of these are for breast cancer alone (ibid.). For approved chemotherapy medications, over 300 clinical practice guidelines are available internationally specifying indication, dose, timing and other aspects of optimal treatment (Agency for Healthcare Research and Quality 2006). For providers, staying on top of all of the available and emerging therapies, their precise indications and recommended dosing in the absence of clinical decision support is extremely challenging at best.

Despite the complexity of prescribing and managing medication regimens for cancer patients, current medical oncology practice throughout most of Canada is still to use paper-based tools, policies and procedures. Chemotherapy delivery occurs in outpatient settings by a multidisciplinary team of physicians, pharmacists and nurses. From the time a physician handwrites an order, the order gets interpreted, transcribed and dispensed by a pharmacist, and a nurse administers the chemotherapy at bedside, there is the potential for minor to severe adverse drug events to occur.

It is well known that over 20% of adverse events in Canada are drug- or fluid-related (Baker et al. 2004). There are no Canadian data to date on cancer-specific adverse events. However, in the US, it is estimated that 4% of all newly diagnosed cancer patients will experience some type of adverse event in the course of treatment, and that at least 2/3 of these are preventable (Dinning et al. 2005). In a recent study in the ambulatory chemotherapy setting at Dana-Farber Cancer Institute, Gandhi et al. (2005) found medication errors in 4% of adult chemotherapy orders. The most common of these were in drug ordering, followed by administering and dispensing errors. In the same study, it was shown that chemotherapy-related errors were significantly more likely to be serious than non-chemotherapy-related medication errors (48% compared to 12%).

The ability of computerized physician order entry (CPOE) systems to prevent medication errors has been shown in primary care (Tamblyn et al. 2003), and in several adult inpatient settings both in randomized controlled trials and prospective studies (Kaushal et al. 2003). As with patient safety in general, there is little data specific to cancer on the benefits of CPOE systems. However, a recent study evaluating the impact of a Web-based dose calculator on reducing errors in pediatric intravenous infusions found an 84% reduction in orders containing one or more errors (Lehmann et al. 2006). Researchers at the same children's hospital found that CPOE implementation in the pediatric chemotherapy department resulted in a 74% drop in improper dosing and a 91% drop in incorrect dosing calculations, among other benefits (Kim et al. 2006).

From a technical perspective, chemotherapy ordering is a very difficult process to automate. It involves a multitude of inputs, including the drugs themselves, drug-to-drug interactions, disease-to-drug interactions, dosing and scheduling, and the interface of these inputs with all the variables within a particular patient's profile. This unusual set of circumstances makes a cancer-specific approach to CPOE technology essential. More generic CPOE systems would simply not support the degree of functionality required.

Cancer Care Ontario's CPOE strategy uniquely meets the challenges of cancer care. In 2003, CCO surveyed 18 hospital sites in order to identify the factors that would influence the implementation of the initiative, to make recommendations to increase the probability of success and to start the process to gaining buy-in and support for the systems approach.

The key findings were as follows:

- Currently available versions of more generic hospital information systems cannot support the specific needs of computerized physician order entry for systemic therapy.
- It is not feasible for individual hospitals to maintain common chemotherapy drug formulary and clinical decision support rules.
- Physicians and pharmacists will support a well-managed provincial system, tied to Cancer Care Ontario and its mandate to improve quality of cancer services.

CCO has reconfirmed these findings on a regular basis over the past three years.

Cancer Care Ontario's CPOE System: OPIS 2005

In 1996, Cancer Care Ontario (CCO), the Ontario government's principal advisor on cancer care, began the design and implementation of the first jurisdiction-wide, cancer-specific CPOE system. CCO's OPIS (Oncology Patient Information System) 2005 was designed for use by physicians, pharmacists and nurses to increase patient safety and offer clinical decision support to medical oncologists province-wide. To date, versions of the system have been implemented in 11 institutions delivering chemotherapy, representing over 50% of all chemotherapy orders in the province, almost 500 prescribing physicians, and over 600,000 medications ordered every year. This e-health innovation, with greater than 90% physician adoption, represents the largest ambulatory oncology implementation in Canada.

In addition to its role in improving patient safety, CCO's CPOE system is a critical component of the organization's clinical knowledge transfer and brokerage functions. As new clinical guidelines are developed and integrated within the clinical decision support components of OPIS 2005, the system provides a vehicle to ensure broad uptake of best clinical practice across the province.

On the basis of 10 years' experience in the implementation, use and continuous enhancement of this system, we describe below the critical success factors in the design and implementation of a cancer-specific CPOE system.

Figure 1 shows the current use of OPIS/OPIS 2005 across Ontario.

On the basis of a 2003 Cancer Care Ontario survey of OPIS physician users, the vast majority of respondents said the system improved efficiency and safety and that they would be unwilling to practise without it:

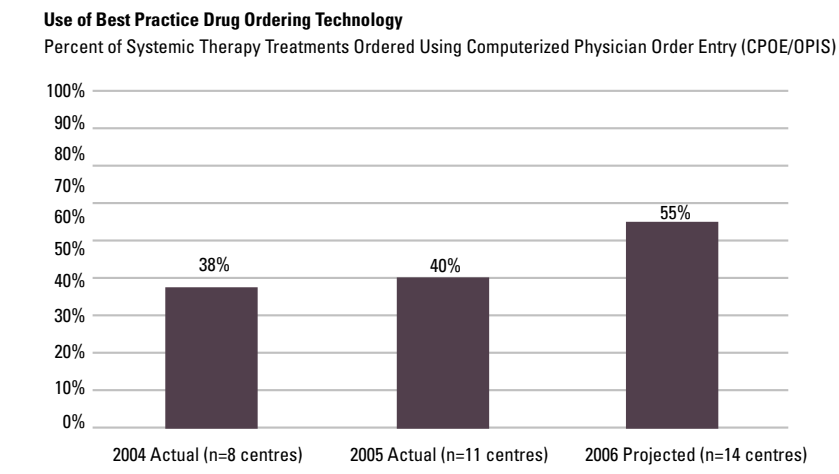
> If you remove OPIS 2000, we will have to reduce our patient load. (Medical oncologist, Ottawa Hospital Regional Cancer Centre)

> The system is easy to use, and it has everything we need. (Medical oncologist, Kingston Regional Cancer Centre)

> We have been trying to get our hospital administration to let us use OPIS 2000 on the inpatient floors. (Medical oncologist, Kingston Regional Cancer Centre)

> How do I get Grand River to be one of the first sites to implement OPIS 2005? (Glen Kearns, CIO, Grand River Regional Hospital)

Figure 1. Current use of OPIS across Ontario



Source: Cancer Care Ontario, New Drug Funding Program

Table 2. CPOE system functions and primary users

Function	Primary User(s)
1. Systemic therapy drug order entry	Physician
2. Non-systemic therapy drug order entry	Physician
3. Verbal order authorization	Physician
4. Drug funding program eligibility registration	Physician
5. Patient clinical information: • Disease registration and cancer staging • Patient cumulative drug dosage • Patient allergy alerts • Medication profile • Patient toxicity • Lab results entry	Physician, Nurse, Pharmacist
6. Electronic medication administration and chart review	Nurse
7. First Data Bank Drug Formulary management	Pharmacist
8. Chemotherapy regimen formulary management	Pharmacist

Of course, as with any clinical system, there are areas that require additional development, identification of issues and concerns by users and an upgrade of the technical infrastructure and platform. Building on its business model of stakeholder and expert input into improving the quality and accountability of cancer services in Ontario and its tight ties to the community of users, Cancer Care Ontario's CPOE strategy includes regular and active involvement of clinical and technology leaders in identifying, and prioritizing system improvements to meet evolving needs.

Integrated Clinical Decision Support (CDS)

Not only is the system tailored to medical oncology practice; it is also built to integrate with a facility's existing information management system. OPIS 2005 is designed to interface with any facility's hospital information system (HIS) so that complete information in a patient's profile, including demographics, disease, allergies and medication history, is pulled up as the order is being placed, dispensed and administered. This being the case, the real-time clinical decision support features include:

- *Cumulative dosing.* This feature keeps track of chemotherapy medications that have a maximum cumulative dose that can be given to a patient in his or her lifetime and alerts the ordering clinician when this maximum is reached.
- *Calculating creatinine clearance.* A creatinine clearance calculator is available (two formulas) for drugs such as Cisplatin and Carboplatin that require dosing based on the patient's creatinine clearance. The dosage of these medications is automatically calculated according to this value.
- *BSA calculations.* There are two formulas available in OPIS 2005 to calculate a patient's body surface area in order to automatically calculate the patient's ideal dose.
- *Maximum dose and minimum dose alerts.* Drugs can be set up so that alerts appear if a dose reaches the maximum or minimum value set.
- *Dose capping.* Drugs can be set up so that if the dose exceeds the allowed maximum, the dose will be capped at the specified value.
- *Allergy alerts.* Colour coding alerts for allergies and potential allergies. Allergy override reasons must be entered for drugs that are ordered where the patient may have an allergy or potential allergy to that drug.
- *Height and weight tolerance.* A tolerance can be set up, so that if a weight has changed by, say, 10%, the clinician ordering will receive an alert that a 10% change has occurred and will be asked whether he or she would like to recalculate the body surface area and change the ideal doses calculated on the basis of the previous body surface area.

The system comes with a menu of hundreds of pre-built chemotherapy regimens based on the latest available evidence.

The system allows the prescribing physician to override any of the automatic alerts on the basis of clinical judgment. In addition, physicians can determine eligibility, and enrol patients in the province's cancer drug funding program at the point of care.

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Robust Scalable Technology

As the implementation in 11 facilities across the province has shown, OPIS is easily disseminated in a variety of clinical environments. It is an Oracle development platform with interface capability enabling the system to be integrated into the hospital's existing clinical information system. In addition, facilities tailor the implementation of the tool to their clinicians' specific practice patterns. For example, in some facilities nurses access the system through a wireless mobile flat-screen device so that a patient's regimen and care information is available at the point of care.

In 2004, an informal market survey compared Cancer Care Ontario's CPOE system to commercially available systems and revealed that CCO's system had more in-depth functionality, including the seamless incorporation of clinical practice guidelines, and greater support for clinical workflow. Moreover, no commercially available system had achieved the physician adoption rate achieved by CCO. Importantly, in the rollout of OPIS 2005 to date, the system has generally proven to be easy for physicians, pharmacists and nurses to use.

Central Coordination of System Dissemination

One of the goals of Cancer Care Ontario's CPOE initiative is to implement the system wherever chemotherapy is delivered in Ontario. While established OPIS/OPIS 2005 users may find it difficult to imagine practising without it, the initial implementation represents an enormous change to current clinical practice. A recent and emerging body of literature (Koppel et al. 2005; Wears and Berg 2005) has identified new risks in the implementation of CPOE that can exacerbate patient safety and cause barriers to optimal physician workflow. The case studies in question highlight CPOE installations that have been poorly managed; do not adequately engage and tailor the system to end-users; and underestimate or fail to acknowledge the signifi-

cant change management and adoption support required to ensure successful implementation.

Mindful of these risks, Cancer Care Ontario has continued to adapt and improve its approach to CPOE implementation. The project has a well-developed methodology involving a six-month, rigorous implementation process to manage this change as effectively as possible. Key components include:

- Ensuring that a fully staffed project team exists at the target facility
- Gaining support from executive leadership, both clinical and administrative, at the facility
- Involving stakeholders (end-users and leadership) in decision-making processes to ensure a sense of ownership of the system and empowerment with the change
- Providing in-depth, on-site training, including "train the trainer" sessions, and instructor-led and independent Web-based training
- Ensuring extensive set-up of the system by on-site pharmacists prior to "go live" date to ensure systems are carefully tailored to the facility
- Extensive testing of the system at each facility
- Customized post-launch support and maintenance

CCO managed and continues to manage implementation of OPIS 2005 over multiple sites using Project Management Institute (PMI) methodology and a well-seasoned implementation staff with clinical, technology and project management experience and credentials. One of the critical success factors in site implementation is ensuring that there are clinician leaders within the CCO project team who not only understand the software, but also understand clinical workflow. This deep understanding of the clinical environment and of the change management challenges facing clinicians in the field – particularly physicians – has served to increase the credibility of the project, and ensured a solid change management approach.

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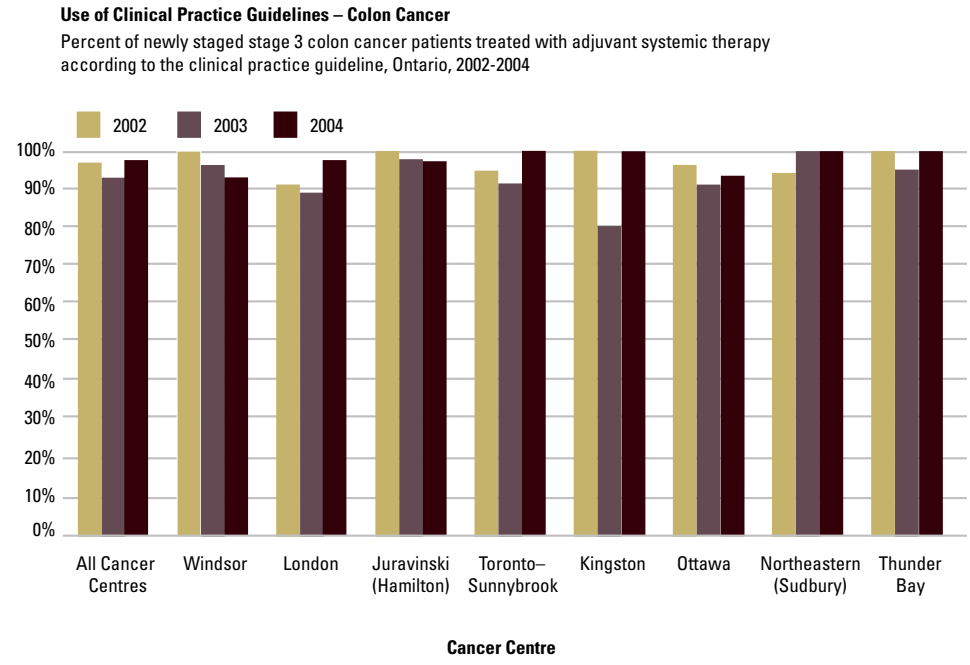
Demonstrated Utility beyond Medication Safety

In addition to the use of OPIS to manage cancer patients' chemotherapy regimens in the clinical setting, Cancer Care Ontario centrally monitors activity and system quality using data from participating sites. One of the core functions of Cancer Care Ontario is to manage the performance of the cancer system. Data from OPIS 2000 and 2005 have proved highly effective

Figure 2.



Source: Cancer Care Ontario, Activity Level Reporting

on this front. For example, data from the system are used to monitor and report publicly in the Cancer System Quality Index (Cancer Care Ontario 2006) on adherence to evidence-based clinical practice guidelines based on patients' type and stage of cancer (see Figure 2). Providing this type of report to clinical leadership assists in quality improvement efforts while demonstrating the broader benefits of the system.

Conclusion

The complexity of prescribing and managing cancer chemotherapy regimens makes it a prime candidate for a CPOE solution. Recognizing this, Ontario became the first jurisdiction to roll out a CPOE system in multiple institutions delivering chemotherapy. While most cancer-specific CPOE systems in use today have been implemented within a single institution, Ontario's system has been successfully implemented in 11 distinct institutions across the province. With support from Canada Health Infoway, next steps for the initiative are to implement OPIS 2005 at an additional five facilities across the province over the next two years. This has major implications for cancer patient safety across the province, since over 50% of all chemotherapy orders are already being ordered in Ontario using CCO's OPIS 2000 and 2005. The increased adoption and implementation of OPIS 2005 will enable the first-ever province-wide assessment of the impact of CPOE on cancer patient safety.

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