

Improving Patient Safety through Computerized Drug Management: The Devil Is in the Details

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ABSTRACT

Electronic prescribing and computerized drug management can improve the safety, quality and cost-effectiveness of prescribing. However, if the problems that lead to avoidable adverse events are not addressed by information technology (IT), there is a risk of making considerable investment without the expected return of error reduction and improved patient safety. Improving the safety of prescribing is particularly important in ambulatory care, where most drugs are prescribed. To improve patient safety, IT solutions should be developed that provide (1) access to the list of all currently active drugs; (2) alerts for relevant prescribing problems (therapeutic duplication, excess doses, dose adjustment for weight [children, elderly] and renal impairment, and drug-disease, drug-drug, drug-age and drug-allergy contraindications); (3) the capacity to electronically submit medication stop orders to the dispensing pharmacy; and (4) integration of electronic prescriptions into pharmacy software to avoid transcription errors. To improve quality of prescribing, IT solutions should be capable of providing physicians with reminders and alerts for evidence-based preventive care and disease management based on patient-specific drug, disease, therapeutic intent and other relevant clinical information. To improve the cost-effectiveness of prescribing, IT solutions should be developed to provide the cost of medication at the time the prescription is written and evidence-based alerts for drugs of choice recommendations when appropriate.

Medical errors may be reduced through electronic health records (EHRs). Yet there is clearly no “silver bullet” remedy as the causes of avoidable errors are indeed multifaceted. Even the most “Star Wars” of information technology (IT) solutions cannot reduce errors unless they target the precise and critically important causes. The rah-rah rhetoric of the dot-com bubble pervades the territory of healthcare – promising returns that are not only unrealistic but totally off target in relationship to the challenges faced by health professionals in caring for their patients. Multi-million dollar failures in EHR implementation have been documented, and most seem to have a common cause (Littlejohns et al. 2003; Sicotte et al. 1998). EHR technologies are implemented that do not solve problems in the delivery of care and thus provide no added value for users that would make it worthwhile for health professionals to migrate from a paper to an electronic system (Miller and Sim 2004). If this gap between what is needed and what is provided by IT is not addressed, there is a risk of making considerable investment without the expected return of error reduction and improved patient safety. In this regard, high priority has been placed on the introduction of computerized systems to reduce avoidable errors in prescribing and drug management (Armstrong and Chrischilles 2000; Moulds 2003; Schiff and Rucker 1998). Yet there is considerable variation in the capacity of computerized systems to address the critical problems that produce errors in drug management, particularly in ambulatory care, where most drugs are prescribed (data provided by IMS Canada, 1999).

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The intent of this commentary is to identify the problems that compromise the safety of prescription drug therapy in ambulatory care and the IT solutions needed to address them. Quality and cost-effectiveness of prescription drug treatment, while important priorities, cannot be efficiently addressed until physicians are using computerized drug management systems for the majority of their practice population.

SAFETY

The Problems

The potential benefits of drug treatment are compromised by avoidable errors in the drug, dose and duration of therapy prescribed. Drug-related illness accounts for 5–23% of drug-related hospital admissions (Grymonpre et al. 1988; Hurwitz 1969; Ives et al. 1987) and is now claimed to be the sixth-leading cause of mortality in the United States (Lazarou et al. 1998). Results from population surveys indicated that 24–29% of seniors were taking at least one medication that is contraindicated in the elderly (Tamblyn et al. 1994; Wilcox et al. 1994), and 8–29% were prescribed at least one inappropriate drug or drug combination (Ferguson and Maling 1990). Similar estimates of the prevalence of inappropriate prescribing are found in clinic-based and institutional reviews of prescriptions (Beers et al. 1992, 1993; Bloom et al. 1993; Kurfees and Dotson 1987; Lesar et al. 1990; Maronde et al. 1971; Shorr et al. 1990; Svarstad and Mount 1991) and in a Canada-wide assessment conducted as part of the Canadian Health and Aging Survey (Hogan and Ebly 1995). Multiple prescribing physicians and dispensing pharmacies increase the risk of avoidable errors (Tamblyn et al. 1996), likely because of the inability to readily access accurate information on all current prescriptions. Transcription errors, mistakes made in transcribing the written prescription into the appropriate drug dispensed, are estimated to occur in 15% of prescriptions (Kistner et al. 1994), of which 1.5% might cause serious harm (Kistner et

al. 1994). Indeed, there is sufficient concern over this avoidable source of error that the US Medicare Prescription Drug and Modernization Act of 2003 requires the nationwide implementation of an electronic prescription drug program by January 1, 2006 (Blendon et al. 2002). Florida has already implemented state legislation that requires typed rather than handwritten prescriptions.

The Objective for IT Solutions

IT solutions should be able to reduce avoidable errors in prescribing and dispensing by providing (1) access to the list of currently active drugs; (2) alerts for relevant prescribing problems (therapeutic duplication, excess doses, dose adjustment for weight [children, elderly] and renal impairment, and drug-disease, drug-drug, drug-age and drug-allergy contraindications); (3) the capacity to electronically submit medication stop orders to the dispensing pharmacy; and (4) integration of electronic prescriptions (e-Rx) into pharmacy software to avoid transcription errors.

Requirement 1

No professional should be prescribing or dispensing without access to a patient's list of current medications. The optimal approach for providing physicians and pharmacists with information on current medication is to electronically retrieve information from community-based pharmacies' software on all dispensed prescription medications (commonly referred to as a pharmanet). The assembly of claims-based information on dispensed medications, such as is used by Rx-Hub in the United States, is a second alternative, but only if all prescription information is retrieved, not just those drugs that are covered by the insurer. It would be ideal if patients also had access to their medication file so that they could add over-the-counter drugs and naturopathic products and receive drug-related product information. While Alberta is in the process of developing a pharmanet, the B.C. PharmaNet, developed in the early 1990s, is only now considering how to provide community-based physicians with access to current drug lists, even though they prescribe the majority of medications (data provided by IMS Canada, 1999). Despite the obvious benefits for patient safety, the failure to provide prescribing physicians with current drug information can only be explained by a poor match between what IT solutions are developed and what are needed.

Requirement 2

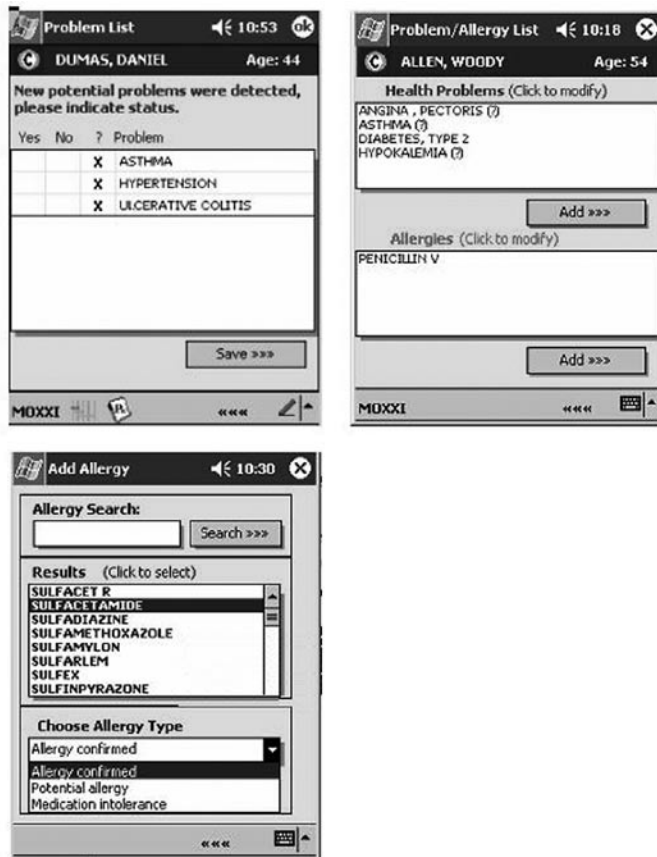
All prescriptions (dispensed and new) should undergo computerized review for therapeutic duplication, excess doses and drug-disease, drug-drug, drug-age and drug-allergy contraindications; the computer should alert the professional about potential problems at the time these drugs are prescribed or dispensed to minimize opportunities for human error. Prototypes for automated drug reviews in hospital-based order entry systems have been successfully developed because complete information on current medication is available through in-hospital pharmacy information systems (Bates et al. 1998). However, in ambulatory-based care, the development of IT solutions to detect prescription errors has been extremely limited as no information is typically available on current drugs, diseases or allergies, at least not in a standardized coded form that could be used for drug problem surveillance. As a result, most systems in ambulatory care require the physician to enter relevant drug information to determine potential problems (Schiff and Rucker 1998). Almost all computerized screening programs are

limited to drug-interaction screening, even though drug-interaction problems account for relatively few avoidable adverse drug-related events (Soumerai and Lipton 1995).

One of the greatest gaps is between what is needed to address potential prescribing errors and what is included in provincial and federal plans for IT development. Consider the obvious: Drug-disease and drug-allergy surveillance cannot be conducted unless there is a method to (1) collect and upload relevant disease and allergy data and (2) code disease and allergy information in a standardized format so that data can be used to construct alerts for clinically relevant drug-allergy and drug-disease problems (Schiff and Rucker 1998). Yet there is no apparent plan to collect disease information or drug allergy data as part of the \$1.2 billion Canada Health Infoway (CHI) investment. In this respect, the CHI plan has failed to attend to key elements needed to address the patient safety agenda. The challenge is how to retrieve these data easily, before we achieve the more difficult and long-term goal of implementing a full EHR (Miller and Sim 2004). The Quebec-based MOXXI III (Medical Office of the Twenty-First Century phase III) prototype has provided a proof-of-concept solution for how disease and allergy data can be collected through e-Rx and integrated drug management systems, without the requirement of a full EHR (Figure 1). Strategic stepwise developments to obtain the critical data needed to minimize errors are essential if error-reduction strategies are to be implemented rapidly in the population.

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Figure 1. MOXXI's automated problem and allergy lists

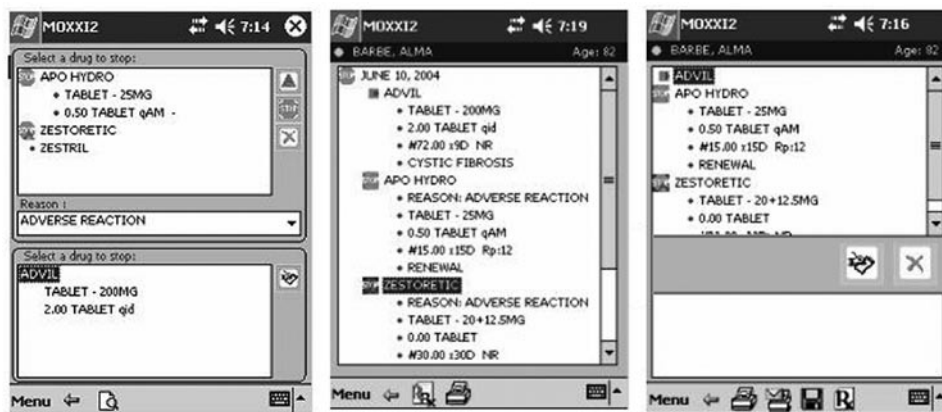


Requirement 3

Physicians should be able to transmit medication stop and change orders electronically to the dispensing pharmacy to avoid adverse drug events due to communication failures. Typically, when a medication is to be stopped or changed, physicians advise their patients and the patients, in turn, provide this information to their pharmacist. This approach is prone to failure as less than one minute is spent in the average doctor-patient encounter in communicating information about treatment decisions (Ong et al. 1995), and most patients remember less than 50% of the information communicated during the visit (Dowell et al. 2002). As a result, patients may continue to refill prescriptions for drugs that have been stopped as well as new medication prescribed. This dilemma is particularly problematic for patients admitted to hospital. Medications are stopped at admission and re-prescribed in hospital. For the most vulnerable elderly patients, about half of their medication is changed during hospitalization (Beers et al. 1989), and new medication is re-prescribed at discharge. Upon discharge, patients and community-based pharmacists are confronted with a host of new medications as well as outstanding refills from pre-hospitalization therapy. The primary care physician is unable to advise the pharmacist about current treatment as he or she will be lucky to receive a hospital discharge summary within three months, if ever. For this reason, community-based, emergency room and hospital-based physicians need to be able to efficiently communicate stop and change orders to the community-based pharmacies. With an integrated e-Rx and pharmanet system, the current drug list could readily be used to transmit stop- and change-medication orders to dispensing pharmacies. Despite the obvious benefits of this functionality for improving safety as well as efficiency in communication, it has never been implemented. The first trial of stop-change orders worldwide is being conducted in the MOXXI III prototype in Quebec (Figure 2).

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Figure 2. MOXXI's prescription stop/change orders

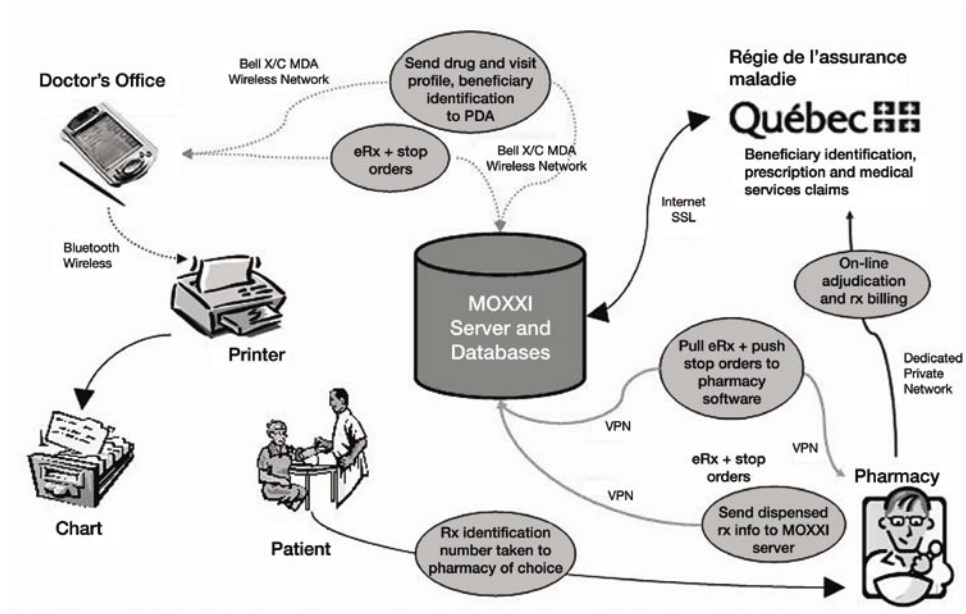


Requirement 4

Prescriptions should be transmitted electronically and integrated into pharmacy software programs to eliminate transcription errors. The handwritten prescription is an obvious recipe for dispensing errors. Dispensing errors could be minimized by requiring a typed prescription, and virtually eliminated by the capacity to send

and integrate electronic prescriptions into pharmacy software. Quebec was the first province to establish standards for electronic prescribing through a joint committee of the Order of Pharmacists and College of Physicians. On the basis of these standards, a prototype for transmitting electronic prescriptions to community-based pharmacies was developed. A key requirement of pharmacy owners was that patients should be able to decide, after leaving the physician's office, where they would fill their prescription. As a result, pharmacies use a unique prescription number to pull prescriptions from a central server, and once client data are verified, a prescription is automatically integrated into their software (Figure 3).

Figure 3A. Architecture of the MOXXI III integrated e-Rx system



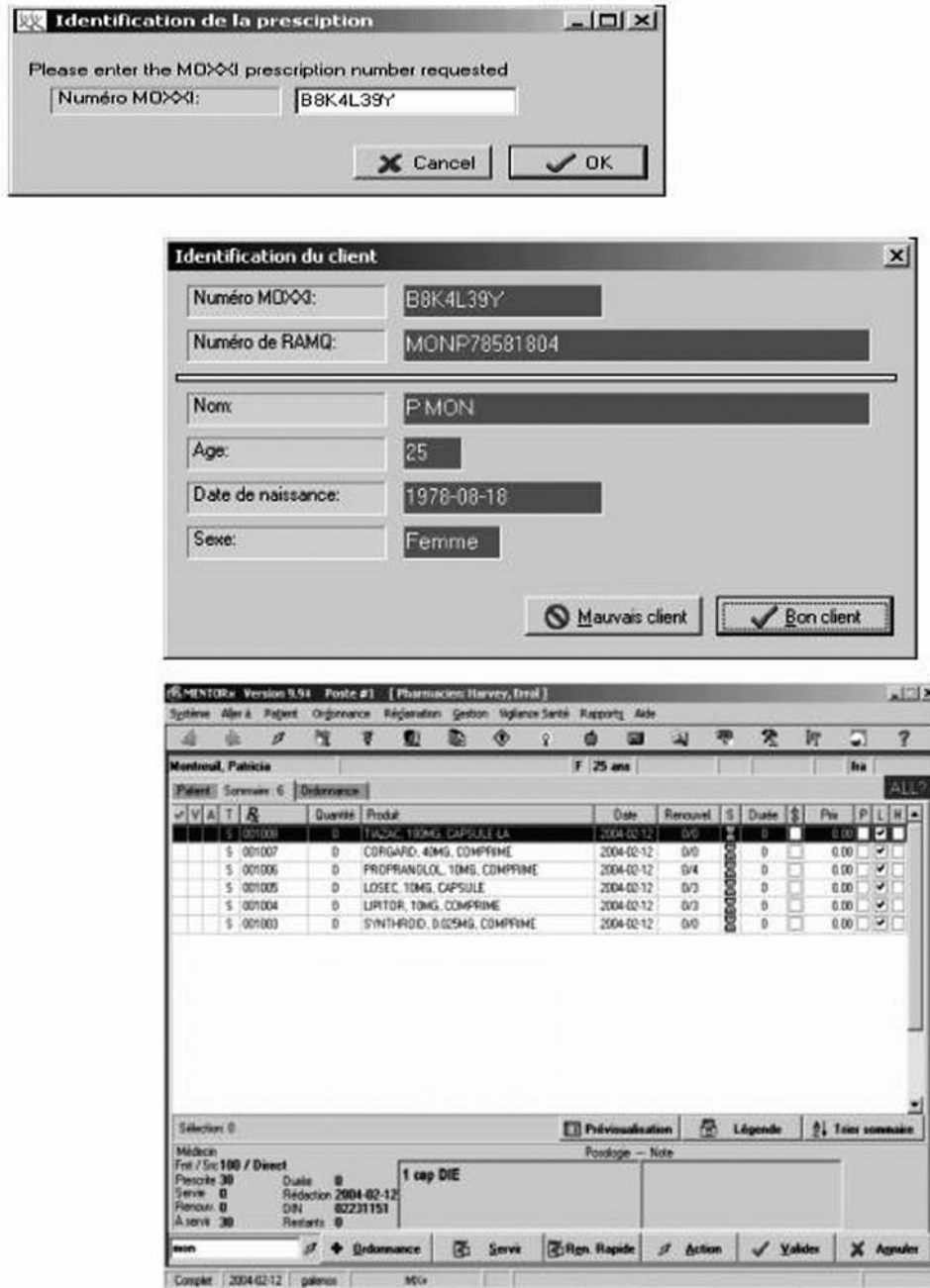
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QUALITY

The Problems

Prescription medication can be expected to improve health status if it is prescribed in accordance with current scientific evidence. In this respect, both over- and underuse of prescription medication has been documented. Overuse of medication is particularly evident in drug groups that may be used to treat common complaints, such as antibiotics for viral infections (Avorn et al. 1988; Brook et al. 1989; DeSantis et al. 1994; Katz et al. 1990; McConnell et al. 1982; Pitts and Vincent 1989), nonsteroidal anti-inflammatory drugs (NSAIDs) for musculoskeletal problems (Ashton 1991; Hogan et al. 1994; Holt and Mazzuca 1992; Keys et al. 1992; Mazzuca et al. 1991; Roth 1988) and sedatives-hypnotics for anxiety and insomnia (Ashton 1991; Cafferata and Meyers 1990; Copperstock 1971; Garrard et al. 1991; Hohmann 1989; Morabia et al. 1992; Raynes 1979; Schnarch et al. 1993; Tamblyn et al. 1994; Westerling 1988; Weyerer and Dilling 1991). Unnecessary use of benzodiazepines and NSAIDs is considered to be an important and potentially avoidable risk factor for falls (Campbell et al. 1989, 1990; Cutson et al. 1997; Granek et al. 1987; Mendelson 1996; Neutel et al. 1996;

Figure 3B. Integration of the e-Rx into pharmacy software



Prudham and Evans 1981; Sobel and McCart 1983; Sorock and Shimkin 1988; Tinetti and Speechley 1989; Tinetti et al. 1986, 1988), fractures (Cumming and Klineberg 1993; Herings et al. 1995; Jensen and Nielsen 1991; Ray et al. 1987; Taggart 1988) and gastrointestinal bleeds (Bloom 1988, 1991; Committee on Safety of Medicines 1986; Gabriel et al. 1991; Garcia Rodriguez et al. 1992; Greene and Winickoff 1992; Griffin et al. 1991; Guess et al. 1988; Henry et al. 1987, 1996; Hochberg 1992; Hogan et al. 1994; Langman et al. 1994; Laporte et al. 1991; Smalley et al. 1995), particularly in the elderly (Bloom 1991; Graves 1985; Hogan et al. 1994; Ministry of Health and Social Services 1993). On the other hand, underuse of effective treatments such as beta

blockers for secondary prevention of myocardial infarction (MI) (McLaughlin et al. 1996; Pashos et al. 1994; Soumerai et al. 1997) and inhaled steroids for asthma (Crain et al. 1998; Engel et al. 1989; Friday et al. 1997; Gottlieb et al. 1995; Griffiths et al. 1996; Hartert et al. 1996; Homer et al. 1996; Horn and Cochrane 1989; Kesten et al. 1993; Legorreta et al. 1998; Shelley et al. 1996; Wareham et al. 1993) is also common. Only 21–53% of MI survivors receive recommended preventive therapy (beta blockers) (McLaughlin et al. 1996; Pashos et al. 1994; Soumerai et al. 1997). This problem alone results in an estimated 705 avoidable deaths and admissions among the 6,272 elderly MI survivors in Quebec each year (Levy et al. 1998). Furthermore, potentially avoidable visits, procedures and hospitalizations attributable to suboptimal management of asthma are considered to be important contributors to the cost of asthma care – an estimated \$297 million in Canada every year (Krahn et al. 1996).

The Objective for IT Solutions

IT solutions should be able to improve evidence-based prescribing by providing physicians with reminders and alerts for (1) evidence-based preventive care and (2) disease management based on patient-specific clinical information.

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Requirement 1

To trigger relevant treatment recommendations, the therapeutic intent for each prescription needs to be documented, as well as current health problems and other relevant clinical data (e.g., laboratory results). To facilitate the application of evidence-based guidelines for disease management to prescribing decisions, patient-specific recommendations should be provided at the time prescribing decisions are being made (Bates et al. 1998; Burack et al. 1994; Dexter et al. 1998; Evans et al. 1998; Frame et al. 1994; Hunt et al. 1998; McPhee et al. 1989, 1991; Montgomery et al. 2000; Mungall et al. 1994; Pestotnik et al. 1996; Poller et al. 1993; Rind et al. 1994; Turner et al. 1994; Vadher et al. 1997; Verner et al. 1992; Wagner et al. 2001). This is because computer-generated recommendations and reminders have a substantially greater impact on prescribing decisions than does feedback or academic detailing (Beers et al. 2003). To trigger the appropriate guideline, you need to know why the drug is being prescribed. Pharmacists also need to know the treatment indication for a prescription as a safety check to verify that they are dispensing the right medication, as well as to counsel patients appropriately about taking their medications. As many drugs have multiple indications, documentation of the treatment indication at the time an electronic prescription is being written should be required. The MOXXI III prototype has instituted required documentation of therapeutic intent as part of the electronic prescription system (Figure 4). Documentation of the treatment indication appears to be feasible, acceptable to physicians and productive of valid indications (Tamblyn et al. 2004).

Requirement 2

Disease management guidelines should be selected that target common problems, are supported by level 1 evidence from clinical trials, can be implemented using the clinical data available and can be updated easily and inexpensively to accommodate changes in the evidence. Guidelines vary in quality, and recommendations within guidelines vary in the strength of evidence used to support them. In the absence of a rigorous approach to the identification and development of computer-based guide-

lines for patient-specific treatment recommendations, there is a risk that computer-generated recommendations may cause more harm than good. Methods such as the AGREE appraisal instrument (AGREE Collaboration 2003) should be employed to judge and select high-quality guidelines, and Graham's assessment tools should be employed to select level 1-supported recommendations. As physicians are resistant to entering data to obtain patient-specific treatment recommendations, selected guidelines should be limited to those that use available clinical data (Maviglia et al. 2003). As science changes rapidly, models of guideline translation and updating through rules engines such as those used by the Brigham and Women's Hospital group should be implemented (Maviglia et al. 2003). As the mandate of CHI is to improve the quality of care through an interoperable EHR, it would be appropriate and desirable for CHI to play a leadership role in this area.

Figure 4. MOXXI documentation of a treatment indication

The screenshot shows the MOXXI Rx Pad interface. At the top, it displays 'Rx Pad' with a back arrow, a clock showing 5:27, and a close button. Below this, the patient's name 'DUF, E' and 'Age: 25' are shown. The 'Drug' field contains 'SALBUTAMOL' and a 'Search' button. There are radio buttons for 'Generic' and 'Trademark', with 'Trademark' selected. The 'Dose/Form' dropdown is set to '1MG/ML INH.NEBULE'. The 'Pos' field is '1 dose QID'. The 'Dur' field has a dropdown set to 'D' and a 'Qty' field set to '40'. The 'Rep' field is empty. The 'Ind' field is expanded to show a list of indications: 'ASTHMA', 'ASTHMA, EXERCISE INDUCED', 'BRONCHITIS', 'BRONCHOSPASM', 'COPD', 'EMPHYSEMA', and 'RENEWAL'. At the bottom, there is a 'MOXXI' logo, a stylized 'R' symbol, and a 'Sample Preview' button.

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COST-EFFECTIVENESS

The Problems

Drug expenditures are responsible for an increasing proportion of health costs. In 2000, 15.4% of healthcare spending in Canada – \$15.1 billion – was on drug treatment, whereas less than \$1.8 billion was spent on drugs two decades ago (Canadian Institute for Health Information 2003). The annual increase in drug expenditures, 5% worldwide and 11% in Canada (PMPRB 2002), has been attributed primarily to two factors: the availability of new drug treatments (34% of the increase) and increased utilization rates (24% of the increase) (Anderson et al. 1993). Population aging, even in Canada, accounts for a surprisingly small proportion – less than 15% (Anderson et al. 1993). While increasing drug expenditures may be an appropriate response to the availability of better treatments, less than 2% of new drugs reviewed by the Canadian Patented Medicine Prices Review Board (PMPRB) in 2002 were classified as breakthrough treatments that would offer substantial improvement over existing therapies

(PMPRB 2002). The majority of new drugs were treatments that offered little or no improvement over existing medicines (38%) or new dosage or delivery forms for existing drugs (61%). Similarly, increasing utilization rates do not appear to be a reflection of new drugs targeting otherwise “untreated” populations but, rather, an increase in the number of prescriptions per person among those already using drug therapy (Régie de l’assurance-maladie 2003).

While the choice of a drug may be clinically appropriate, it may not be cost-effective. Ideally, the least expensive drug is selected among drugs that have equivalent clinical benefits for the treatment of a given condition. This is important because patients bear the cost, and higher out-of-pocket expenditures negatively impact on medication compliance and lead to avoidable hospital admissions (Tamblyn et al. 2001). Studies of prescribing rates for new drugs suggest that prescribing consistently exceeds the expected incidence of health problems for which such drugs would be indicated (Bradlow and Coulter 1993; Ferguson and Maling 1990; Maxwell et al. 1993; McGavock et al. 1993; Morton-Jones and Pringle 1993a, 1993b). Physician knowledge of the costs of the drugs they prescribe is notoriously poor (Hershey et al. 1986; Ryan et al. 1990; Steele et al. 1989), and there are dramatic differences in the rates of prescribing new and more costly drugs among different physicians (Molstad et al. 1990; Pitts and Vincent 1989). When physicians are surveyed with respect to their drug choices for hypothetical cases, unnecessarily costly drugs are selected in 79% of prescriptions (Holmes 1992).

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The Objective for IT Solutions

IT solutions should (1) provide physicians with the cost of medications at the time of prescribing and (2) provide recommendations, when appropriate, for alternative less expensive medication that may be equally effective.

Requirement 1

Physicians should know the cost of the prescription medication selected at the time they are prescribing. Prescription costs vary by drug and quantity dispensed. To enable automated calculations, the drug directive (frequency of administration and duration of treatment) needs to be standardized. There are presently no standards. Costs for medications vary over time, by province and by pharmacy and between publicly and privately insured patients. Methods of retrieving and updating cost information should be incorporated into an integrated drug management system to minimize overhead in maintaining current cost data.

Requirement 2

Evidence-based drugs of choice recommendations should be implemented for common health problems and incorporated into an electronic prescribing system to provide individualized patient recommendations. With the availability of treatment indications, recommendations for first-, second- and third-line therapies can be incorporated into computer-based treatment recommendations. By retrieving a 12-month drug history, treatment recommendations for first-line therapy could be appropriately targeted at new users of treatment. The selection of recommendations will require the same systematic and rigorous assessment as for disease management guidelines.

CONCLUSION

Electronic prescribing could improve patient safety, but the devil is in the details. Unless e-Rx is part of an integrated drug management system that addresses the key causes of errors that lead to adverse events, there is a risk of investing in ITs that will not address the problem.

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