MEDINFO 2019: Health and Wellbeing e-Networks for All
L. Ohno-Machado and B. Séroussi (Eds.)

doi:10.3233/SHTI190316

Evaluation of a Nationwide e-Prescribing System

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Abstract

Electronic prescribing, defined as the electronic generation and transmission of a medication order for community-dwelling patients, is presented as an essential technology to improve medication use. The objective of this study was to evaluate a nationwide e-prescribing system in Quebec, Canada. A mixed-method study was conducted from July 2017 until June 2018. A descriptive analysis of e-prescription usage was performed using aggregated usage data, combined with an exploratory descriptive analysis of the e-prescribing system from the perspective of users of two electronic health records (EHR) and pharmacy management systems (PMS) (n=9 prescribers; 8 pharmacy technicians and 11 pharmacists). Overall, the adoption of the system was low, with only 2% of prescriptions being electronically transmitted and retrieved during the study period. Alignment problems were identified on the prescriber's and receiver's side, generating safety issues, and hindering the potential for benefits realization.

Keywords:

Electronic Prescribing, Medication Adherence, Health Information Technology

Introduction

Improving safety and quality of medication use in primary care is a priority, both for clinical and economical reasons. For more than two decades, electronic prescribing (e-prescribing) has been presented as an essential technology to support clinicians and patients towards this goal[1]. While the technology may differ by jurisdictions, the terms e-prescribing usually refers to any computerized system used to generate and communicate information related to medication prescriptions for community-dwelling patients[2]. The opioid epidemic, off-label use, polypharmacy and potentially inappropriate medications are examples of clinical issues that are promised to be resolved, or reduced, with e-prescribing[3.4]. Many jurisdictions around the world have implemented nationwide e-prescribing systems, including the generation of a prescription using a computer system (with or without a clinical decision support system), and the electronic transmission of the prescription to the dispensing pharmacy. European countries are leading the way, with Finland, Denmark and Sweden at almost 100% of the outpatient prescriptions being transmitted electronically[5–7].

While it is already known that e-prescribing can support the decision making processes of clinicians, and reduce legibility and transcription problems, it is also known that it can create new problems and errors at all steps of the medication management process[8–10]. Precisely, issues with the design of the e-prescribing feature have already been described, leading to e-prescriptions of highly variable quality[11], while the transmission and reception models are heterogeneous in different jurisdictions, and pose various issues for the pharmacy work processes[12,13].

In Quebec, a nationwide e-prescribing system was implemented in 2013, in a central pull model, connecting all primary care electronic record systems with pharmacy management systems for electronic transmission of the prescriptions. The objective of this study was to evaluate the system after its full implementation, focusing on the adoption of the system in the province, and its quality for improving the prescribing and dispensing processes in primary care.

Methods

Description of the e-Prescribing System

The e-prescribing system is managed by the Ministry of Health, and is constituted of a central repository of e-prescriptions that are generated from certified electronic health record (EHR) systems, and then accessible to certified pharmacy management systems (PMS) in the province for importation and execution in pharmacies. All prescribers (e.g. general physicians, nurse practitioner) using a certified EHR system can use their local e-prescribing feature to generate an e-prescription, that is then validated when transmitted to the central e-prescription repository. Pharmacists and their team can then log-in to the central repository for a given patient, and import e-prescriptions in their local PMS to dispense the medication. The system uses a national index registry for patient identification, and Drug Identification Numbers (DIN) as the index for medication identification. DINs are managed by Health Canada and issued for every medication that receives approval to be marketed in Canada. They uniquely identify the product name, the active ingredient, the manufacturer, the strength, the pharmaceutical form, and the route of administration. At the time of the study, only EHR and PMS in the outpatient setting were certified for connection with the e-prescription repository. No feature was designed for the patients. Details on the system have been described elsewhere[14].

Data Collection and Analysis

A mixed-method study was conducted in parallel, from July 2017 until June 2018. First, a descriptive analysis of usage of the e-prescribing system was performed, using aggregated usage data provided by the Ministry of Health. Information available included the number of prescriptions dispensed by all retail pharmacies in the province, to all citizens with a health insurance number (mandatory), the number of electronic prescriptions (eRx) sent by prescribers using a certified EHR system, and the number of eRx retrieved by pharmacists, by region and in the whole province (population approximately 8 million inhabitants). Adoption was estimated by calculating the proportion of eRx compared to the total number of prescriptions dispensed, per month. To triangulate these observations, one pharmacy was visited to manually gather all prescriptions

executed within a typical week, and classify them per type (manuscript vs electronic). The proportion of prescriptions of each type was calculated per day.

Second, an exploratory descriptive study was conducted by interviewing and observing users of the e-prescribing system, both on the prescribing and receiving sides. Purposeful selection of high users was performed based on the declared regular usage of the system, specifically in regions targeted for their high adoption of e-prescribing (based on usage data). Two commercial EHR systems and 5 PMS were analyzed (details on participants are presented in Table 1).

On the prescriber side, frequent e-prescribing users were invited to participate to an interview and an observation session using think aloud protocols around defined prescribing scenarios. Semi-structured interview guide was elaborated to describe their usage of the system, their work process, and their experience with using the system on a daily basis. Moreover, typical scenarios were designed from previous studies[15], to identify problems related to the e-prescribing feature, including all steps of the process (medication review and reconciliation, medication selection, validation and transmission of the e-prescription[16]. Users were encouraged to "think aloud" and verbalize their thoughts as they were completing the scenarios. Their screen and voice were then recorded. Seven physicians and 2 nurses participated (See Table 1).

On the pharmacy side, all users (pharmacists and pharmacy technicians) of the PMS in a given pharmacy were invited to participate. A convenient sample of prescriptions was executed while the screen and the voice of the user were recorded. Semi-structured interviews were also conducted with users, including open questions about their usage of eRx, their work process, and their experience with using the system on a daily basis. Overall, 11 pharmacists and 8 pharmacy technicians participated (see Table 1).

Audio files were transcribed. Verbatim and thematic content analysis was performed to describe the flow of each step of the process, and identify alignment problems per step of the process. Videos were used to confirm the problem identified as described previously[17]. Emerging codes were allowed, until saturation of the findings. This project was approved by the ethics committee of the Université de Montréal, and all participants consented before their participation.

Table 1 – Data Gathered

Systems	Participants
PMS A	1 pharmacist 4 technical assistants
PMS B	4 pharmacists 4 technical assistants
PMS C	3 pharmacists
PMS D + E	3 pharmacists
EHR A	4 physicians
EHR B	3 physicians 1 nurse practitioner 1 nurse

Legend: PMS = Pharmacy management system; EHR = Electronic Health Record

Results

Adoption

The number of eRx sent and retrieved by all prescribers and pharmacies in the province are presented in Figure 1, and compared to the total number of prescriptions dispensed in retail pharmacy during the study period (target for eligible prescriptions). The total number of eRx sent represented on average 13% of all prescriptions dispensed during the study period (10% in July 2017, and 14% in March 2018). Hence, the adoption was low on the prescriber side, with a total number of individual clinicians sending eRx varying from 2,397 clinicians in July 2017, to 3,946 clinicians in March 2018 (while the potential is more than 10,000 clinicians, including general practitioners and nurse practitioners).

In terms of pharmacy, this observation is reflected in the fact that the vast majority of prescriptions that were received were not electronically transmitted (Table 2). When analyzing the characteristics of all prescriptions dispensed in a typical pharmacy, we observed that while 55% of all new prescriptions were created through an EHR, only 35% were actually transmitted electronically. This means that 20% of prescriptions were generated by using an e-prescribing system, but were printed instead of electronically transmitted. Interestingly, almost one fourth of all prescriptions (23%) were still manuscript in this pharmacy located in the region with the highest rate of adoption of eRx in the Province. This suggests that even if the adoption of EHR in primary care in Quebec has increased, the adoption of the e-prescribing feature is lagging.

Moreover, the level of use is low in pharmacy, where only 2% of prescriptions were actually received electronically on average during the study period. When compared to the eRx that were sent, only 16% were retrieved by pharmacists, leading to the vast majority of eRx "sleeping" in the central e-prescribing repository (which will be deleted after two years).

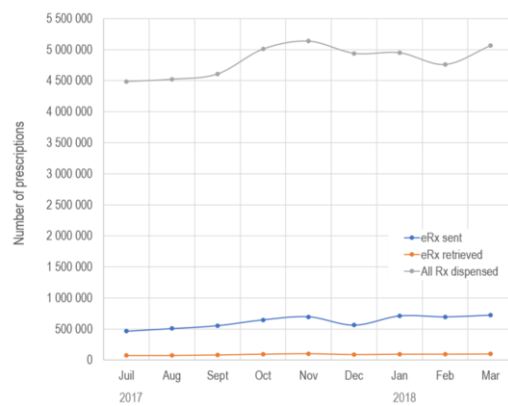

Figure 1 – Level of Use of e-Prescribing in Quebec

Problems on the Prescribers' Side

The main problems that were identified on the prescriber's side were related to the following features: a) design of the medication order; b) the absence of clinical decision support including information about the dose and the characteristics of patients (except allergies); c) the absence of a feature for electronic prescription requests; d) the systematic printing of a paper copy of the prescription.

Table 2 – Proportion of Prescriptions Executed in a Typical Pharmacy During Five Consecutive Weekdays, per type (in June, 2018)

Type of prescriptions	Total	Mean (SD) per day	%
Manuscript	99	20 (7)	23%
Printed form	27	5 (3)	6%
Fax	63	13 (4)	15%
EHR-printed	84	17 (5)	20%
EHR-electronically	149	30 (14)	35%
Verbal	8	2 (1)	2%
Total	430	86	100%

a) First, the design of the medication order were all based on a product-based design using DINs (Fig 2A). Here, the product refers to what you can take in your hand as a patient (e.g. tablet of 500 mg of acetaminophen made by Apotex). The product includes information about the brand, the pharmaceutical form (e.g. tablet, liquid, inhaler), the molecule that is aimed to be administered (e.g. acetaminophen) and the amount of the molecule within this product (or the strength, e.g. 500 mg). This type of design requires the user to select the product (e.g. Apo-acetaminophen comp. 500 mg), and the instructions are built using the number of "unit" the patient has to take, based on the formulation of the product (e.g. 2 tabs). In contrast, the molecule-based medication ordering (Fig. 2B) would require the prescriber to select a molecule and its route, following by the dose and the frequency. The problems we identified with the product-based design were the error-prone selection of the medication, because the list of products was long, and was not up to date. For example, all clinicians were wrongly able to validate the order of a product that is not on the market anymore in Canada (Lasix™) (Fig 3A1).

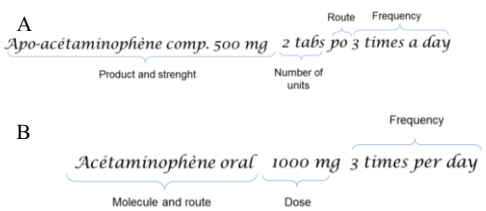

Figure 2 – Product-Based Design of the Medication Order (A) Observed, Compared to the Molecule-Based Design (B)

b) Second, no system had clinical decision support integrating information related to the dose, or the characteristics of the patients (such as age or diagnostic). Consequently, all clinicians were wrongly able to validate a prescription at a lethal dose, for example if they thought it was for an adult and it was actually for a child. The absence of structured and standard information required for intelligent alerts was limiting the utility of the decision support feature from the point of view of prescribers (Fig 3A2).

c) Third, the feature for requesting prescription repeats, from pharmacists or from patients, was not available. Patients would need to call their prescribers, and pharmacists would need to send paper requests by fax to get repeats of an ongoing prescription. This was seen as a major irritant by most prescribers and pharmacists interviewed, given the volume of transactions it generated per day. Moreover, a safety issue was associated with this situation, because most prescribers would not add this paper prescription to their electronic record, and would simply manually sign the request, and send it back to the pharmacy. The electronic record of patients would then become incomplete (Fig 3A3).

d) Finally, the last problem was due to systematic printing of a paper copy of the prescription when the electronic transmission was validated. Consequently, it was not infrequent that prescribers would manually modify the paper copy or a writable PDF form that was created before printing, while the electronic copy would remain unchanged (Fig 3A4). This creates a major safety issue because two copies of the same prescription would then exist. An unclear legal status for the electronic prescription seemed to have led to this situation, where vendors and prescribers were being told that they had to print a paper copy, and pharmacists, that they have to wait for the paper prescription to be allowed to retrieve the eRx.

Problems on the Receivers' Side

The main problem in pharmacy was related to the fact that the execution of a prescription always began with a paper copy of the prescription (Fig 3B1). Pharmacy staff were not informed when an electronic prescription was available for one of their patients, given the design of the system that was developed without a feature for allowing a push or an alert to an assigned pharmacy. The only way for pharmacists to know that an electronic prescription was available was a sign (a logo or a number depending on the EHR) on the paper copy of the prescription. Moreover, in three (out of 5) pharmacy systems, viewing eRx for a given patient would require the staff to execute a request, while in two other pharmacy systems, eRxs for a given patient would be visible from the summary page of the patient record without a specific action. Moreover, because most prescriptions were not electronic, pharmacy staff struggled to adapt their process to a relatively "rare" event.

At the second step of the process, when the eRx repository was accessed, the first problem was associated with the absence of visual aid or code to target medications associated with the same order (Fig 3B2.1). For pharmacy staff, this would mean that they had to be carefully reviewing the list of medications in the repository (that can be long given the low adoption on the pharmacy side) to select precisely the ones that they would need to import. Because orders are chronologically ordered in the repository, this created confusion for some participants. Even though batch importation of many medications was possible with some systems, it was not the case in all of them, constraining the execution process at the pharmacy (Fig 3B2.2).

Once all medications would have been imported in the local pharmacy system, the auto-population of the different fields of the prescriptions was problematic (Fig. 3B3). For all prescriptions, at least one field had to be manually modified, namely the instructions, that were free text (even if initially structured in the prescriber's EHR system). A manual copy-paste of the instructions, from the eRx to the pharmacy system, was possible in some PMS, but not all. For other fields, such as medication ID, prescriber ID, quantity, refills, and duration, manual modifications were also frequent, indicating a lack of standardization. Moreover, it seemed that manual modifications were more frequent with some pharmaceutical forms or some type of prescribers: while capsules and tablets were usually correctly auto-populated in the PMS, other pharmaceutical forms (inhalers, injectables, drops, creams) seemed to create problems more frequently. Similarly, while physicians as a prescriber were generally correctly auto-populated in the PMS, residents, nurse practitioner and nurses seemed to generate more manual modifications in the local pharmacy system for the prescriber ID field.

Finally, the last problem identified for the validation in the PMS was the absence of a visual representation of the original eRx, that is required by pharmacist in the final step of the validation process (Fig 3B4). More problematic, one PMS had no

inalterable version of the eRx available, leading to an impossibility for the pharmacist to know if the staff had manually changed any field during their execution process, a shortfall creating an important risk of error.

Overall, the execution of a prescription using the paper copy was generally perceived as quicker and easier for pharmacy staff, while they recognized that a printed (electronic) prescription was easier to read than a manuscript prescription.

Discussion

To our knowledge, this is the first study to evaluate an e-prescribing system fully implemented in Canada, both from the prescriber and the receiver's sides. While the potential for positive outcomes associated with computerized provider order entry (CPOE) for medications have been demonstrated in some settings, many safety issues have been documented[16,18,19]. Our study adds to this literature by highlighting some specific challenges hindering adoption and increasing the risk of technology-induced errors in the medication management process.

First, our results suggest that the misalignment between the system and the prescribing and dispensing processes were numerous, with no simple workarounds for users. Second, the implementation of the transmission feature was still not completed, hindering the potential for benefits at various steps. Third, the quality of e-prescription needs to be improved, and safety issues were identified both by prescribers and pharmacists using the system with their respective EHR or PMS. Consequently, the level of use of the system was low, with only 2% of prescriptions being electronically transmitted and retrieved in pharmacy. Overall, the low adoption of e-prescribing that was observed in this study is probably essentially related to the poor quality of the system from the user's point of view, both on the prescriber's and the receiver's side.

On the Incomplete Implementation of the System

E-prescribing consists of different features that all needs to be coherently implemented for benefits to be actualized, from the request, to the creation & validation of the order, and finally its transmission. While the adoption of EHR with an e-prescribing feature for creation of orders has increased drastically in the past decade in Quebec, our results suggest that the implementation is still incomplete. First, only 2% of prescriptions were electronically transmitted and retrieved during the study period. While many prescribers, such as clinicians in acute care centers, do not have access to a certified EHR including the e-prescribing feature in Quebec, our results also suggest that many prescribers have access to an EHR to create their medication orders, but then only print it (or they may electronically fax it to the pharmacy). It is thus important that further research on e-prescribing considers this distinction between the creation of the order and its transmission, where one step of the process can be electronic, and not the other.

Moreover, even when prescribers were using the transmission feature, we have observed a systematic printing of the paper copy of the prescription, sometimes associated with manual modifications of the paper copy as a work-around for the design of the feature. This creates a major safety issue, with an increased risk of error because two different copies of the same prescriptions are created. While e-prescribing is being presented as a technology designed specifically to decrease the risk of falsification, by ensuring the integrity of prescriptions, this situation undermines the credibility of the system, and reduces its potential for benefits at this step.

On the Quality of e-Prescription

Our results suggest that the quality of e-prescription transmitted through the system could be improved. Specifically, two elements were problematic: 1) the limited decision support, with no alert including dose or patient-related characteristics; 2) the product-based design of the e-prescription, not well aligned with the cognitive process of prescribing medications, because it includes information about the packaging and the format that was not useful for clinicians. A recent study by Quist and colleagues have already described the high variability in the display of medication names in different CPOE systems in US (both inpatient and outpatient)[20]. Our study suggests that the structure of the prescription order, and specifically the logic behind the selection of the medication (product-based or dose-based) might be more important than the name of the medication itself. Precisely, caution attention needs to be dedicated to the fields, their format and content, and their reference terminology (if any). This is not yet standardized in an electronic format in the Canadian setting, as observed in this study. Consequently, on the pharmacy side, the auto-generation of the various fields was associated with problems, where manual manipulations were required, decreasing the potential for benefits realization here again. While this lack of standardization was already described during the pilot phase of the technology, no changes to the system were made in the past 5 years[14]. This first study since the full implementation of the system highlights the need for further research on the usability of this e-prescribing system, including a more diverse sample of commercial systems and users.

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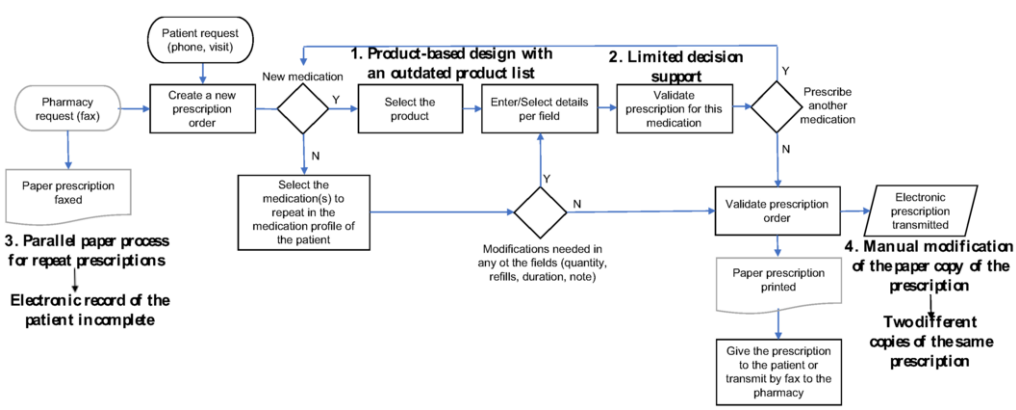

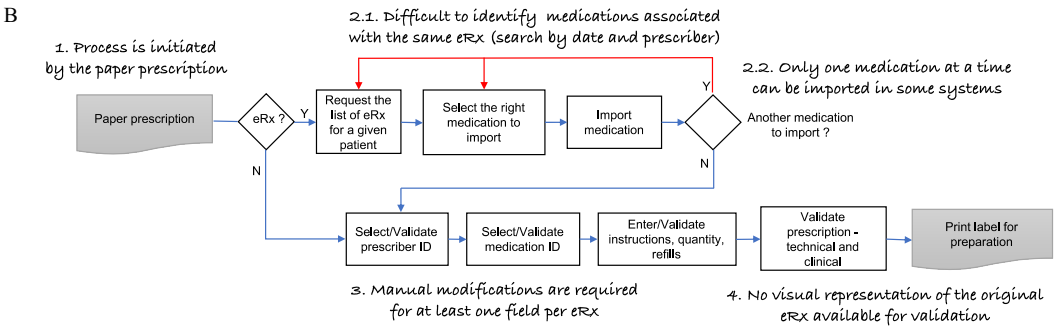

Figure 3 – Problems Identified on the Prescriber's Side (A) and Pharmacy's Side (B)

Conclusions

The adoption of a nationwide e-prescribing system was impeded by the low quality of the system, and its incomplete implementation, where the dispensing processes were based on the paper copy of the electronic prescription. Overall, this study highlights the need for improved certification mechanisms of EMR and PMS related to e-prescribing feature at the level of the province, as well as a proactive implementation strategy addressing the identified issues. Further research should also analyze the design of the prescription order, and adopt a standardized way to describe different types of design for medication prescription to improve our ability to compare systems and their effectiveness to improve the medication management processes.

Acknowledgements

Canada Health Infoway funded this study. Aude Motulsky was financially supported by the Centre de recherche du CHUM and the FRQ-Santé. We thank all participants for their time and willingness to contribute to this study.

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