Review

Impacts of second-generation electronic prescriptions on the medication management process in primary care: A systematic review

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ABSTRACT

Objective: To describe second-generation electronic prescription (eRx) technologies and identify their impacts on the medication management process in primary care. Second-generation eRx technologies have focused on networking various stakeholders so that they can communicate electronically.

Method: Using key words, a search was conducted of the relevant databases up to January 2011. A manual search was conducted of the bibliographies of the studies as well as the prior systematic reviews found. The tables of contents of the major periodicals in the field were also searched. This included studies of the impacts of eRx technologies that allow electronic circulation of information between prescription sites and dispensing sites, independent of the methodology used. A structured form was used to extract the data. The studies' impacts were classified by stage in the medication management process (prescription, transmission of the prescription, execution of the prescription and use of the medication).

Results: Nineteen observational studies were included in this review. Most of them (10/19) have evaluated users' perceptions using interviews, focus groups or questionnaires. Two technology models stand out: the push model, under which the prescriber directs the prescription toward a specific pharmacy, and the pull model, under which any authorized pharmacy can download a given prescription into its system. The push model is the most widely used, particularly in the United States. Communication between prescribers and dispensers is usually unidirectional, and communications standards have to be defined. The only demonstrated impacts of second-generation eRx technologies were found at two levels: positive impacts on the quality of the pharmacological profile available to professionals, and negative impacts on the execution of prescriptions in pharmacies. Stakeholders' perceptions were mixed and reflected considerable differences according to context, the type of technology used, the intensity of its use and its maturity. Electronic transmission of prescriptions provides a new way to monitor patient compliance.

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Conclusion: There is little empirical data demonstrating benefits to second-generation eRx technologies, even if it is a highly promoted model for improving primary care quality. More research is required, with studies that measure the impacts of second-generation technologies using empirical data and conducted in the context of actual use. Future studies should also employ the same terminology and provide full descriptions of context, type of technology and intensity of use.
on the context. Efforts to implement second-generation eRx
technologies have not been so far able to draw on a full
understanding of the potential impacts of these technologies. This
is where we make a contribution.

The main objective of this systematic review is to synthe-
size the knowledge from published studies that evaluated the
impacts of a second-generation eRx technology on medication
management in primary care. More specifi cally, we answer the
following questions: (1) what is the current state of research
on second-generation eRx technologies, and (2) what are the
impacts, both demonstrated and potential, of these technolo-
gies on the medication management process in primary care?
For the purposes of this review, an electronically transmitted
prescription (ETP) refers to the direct, computer-to-computer
transmission of information on prescriptions, from a pre-
scriber to a medication dispenser and, depending on the type
of technology, through a third party [8,9]. Therefore this sys-
tematic review does not consider handwritten prescriptions,
prescriptions printed out using an eRx technology and pre-
scriptions sent electronically by fax.

The results of this review may prove useful to adminis-
trators and decision makers implementing the much
sought-after second-generation eRx technologies, profession-
als involved in the use of these technologies, and investigators
interested in their implementation and use.

2. Method

2.1. Literature search

We searched for relevant articles in English and French based
on key words in the title or abstract, and MeSH terms using
Ovid MEDLINE (1950 to January 2011), Ovid MEDLINE In-
Process, and Embase (1980 to January 2011). In order to find
relevant articles in the social sciences and in cognitive sci-
cence, we searched the following databases: Current Content
(1993 to January 2011), PsycInfo (1967 to January 2011), Social
Science Citation Index (1979 to January 2011), Science Citation
Index (1979 to 2011), Conference Proceedings Citation Index –
Science (1990 to January 2011), and Conference Proceedings
Citation Index – Social Science & Humanities (1990 to January
2011) (using the ISI Web of Knowledge). A manual search was
also conducted of the bibliographies of certain publications
(studies and prior systematic reviews). Similarly, the tables of
contents of major periodicals in this field were reviewed. Fig. 1
presents the complete research strategy, including the terms
used.

Version X3 of EndNote was used to manage the data and
eliminate duplications. First, the articles were selected on
the basis of their titles and abstracts, when available. Rele-
vant publications were obtained and each was evaluated by
two reviewers applying the inclusion and exclusion criteria
independently. When their conclusions differed, the review-
ers discussed the case with a third reviewer to arrive at a
consensus. In order to develop our understanding of expected
and unexpected technology-related impacts, we decided not
to limit the selection of studies based on the methodology
used.

2.2. Data extraction

Data on the context, the technology and its impacts were
extracted from each article using a structured form. The
impacts reported by the authors were extracted if they were
related to the medication management process, based on
a classifi cation scheme developed by Bell et al. [2,10]. More
specifi cally, we were interested in the following stages in
the process: prescription, transmission of the prescription, exe-
cution of the prescription and use of the medication. This
model allowed us to relate the observed impacts on the var-
ious stakeholders involved in the medication management
process, without limiting the impacts to one stakeholder in
particular. The studies’ methodologies were described using a
classifi cation scheme developed by the University of Califor-
nia San Francisco Stanford Evidence-Based Practice Center that
has been used before in two systematic reviews [Kauishal et al.
[11] and Eslami et al. [6]].

3. Results

As presented in Fig. 1, our database searches led to an initial
sample of 1140 articles once duplications had been removed.
Initial screening of abstracts rendered 77 articles eligible for
full text review. Based on the full-text review, 19 studies were
excluded because the technology did not correspond to our
definition of second-generation eRx technology (e.g. electron-
ically sent fax prescription, smart cards). Thirty-eight studies
were excluded because evaluation of the impacts of the use
of the technology was not a main objective of the study (e.g.
descriptive studies of adoption). Four studies were excluded
because the evaluation addressed another component of the
system than electronic prescription and its transmission (e.g.
reminders to patients, safety alerts to prescribers). One study
was excluded because the prescription was delivered to hos-
pitalized patients, leaving 15 articles for detailed analyses.
Another four articles were added to the sample following a
manual review of the bibliographies of the included studies,
of prior systematic reviews and of the tables of contents of the
major journals in the fi eld. The final sample for this review
therefore consisted of a total of 19 articles.

3.1. General description of the studies

Detailed information on the studies’ characteristics (context,
type of technology, level of use of the technology, methodology,
and evaluated results) is presented in Table A1 in Appendix.
Most of the studies were conducted in the U.S. (47%) [9,12–19]
and Sweden (26%) [20–24]. One study was conducted in each
of the following countries: Canada [25], the United Kingdom
[26], the Netherlands [27], Italy [28] and Singapore [29]. Two
modes of prescription transmission were found: the push
model (see Fig. 2A), in which the prescriber must specify the
pharmacy to which the prescription will be sent, and the pull
model (see Fig. 2B), in which the prescriber sends the pre-
scription to a data warehouse that can be accessed by all
authorized pharmacies. In the pull model, it is the patient
who generates execution of the prescription, while in the push
model, the pharmacist can execute the prescription without
the patient being present. The push model is more widely used (it is the predominant model in the U.S.), and the sample included only three studies of the push model [20,24,25]. It should be noted that the dominant model in Sweden has changed: studies conducted before 2006 studied the push model [21–23], which was replaced by the pull model that is now present throughout the country [20,24]. Most of the studies (14/19) were conducted at over five different prescription sending sites or prescription receiving sites, while three studies [12,14,28] were conducted at a single site (one sending site

**CONCEPT 1 : Electronic prescription**
1. Electronic prescribing*
2. Drug Therapy, Computer-assisted*
3. Communication network*
4. Electronic transfer of prescription
5. Electronic transmission of prescription
6. Electronically transmitted prescription
7. Electronically transferred prescription
8. Electronic prescription
9. E-prescribing
10. E-prescription
11. Electronic medical prescription
12. Electronic prescription system
13. E-Rx
14. On-line prescribing
15. On-line prescription
16. 1 OR 2 OR 3 OR ~ OR 15

*: MeSH terms used in OVID Medline and Embase

**CONCEPT 2 : Ambulatory pharmacy**
1. Outpatient*
2. Pharmacy*
3. Pharmacist*
4. Community health services*
5. Community network*
6. Ambulatory care*
7. Physicians, Family*
8. Family practice*
9. Primary health care*
10. Outpatient clinic
11. Outpatient pharmacy
12. Primary medical care
13. Outpatient Care
14. Primary care
15. General practitioners
16. Community pharmacy
17. Chain pharmacy
18. Ambulatory pharmacy
19. 1 OR 2 OR 3 OR ~ OR 18

*Fig. 1 – Key words and MeSH terms (*) used in the research strategy, and search flow.*
and one receiving site). In eight of the studies, the technology used was the same at all the sites (homogeneous system: same vendor, same system) [12,14,19,22,25,27–29], while in nine of the studies, different technologies were used at different sites (heterogeneous technology: different vendors, different systems) [9,13,15–18,20,24,26]. Most of the data collected in the published studies came from 2006 or before, with five studies conducted before 2000 [12,14,23,27,28], and only three studies were conducted after 2006 [19,24,29], a paradoxical observation in opposition with the increasing popularity of health information exchange model taking place in healthcare system reforms.

The level of use of the technology differs from one study to another (see Appendix for a detailed description). In ten studies, ETPs represented over 15% of the prescriptions written or processed [12,14,20–24,27–29]. In nine studies, the level of use was highly variable either between sites or over time [9,13,15–19,25,26]. For example, at two sites visited by Grossman et al. [13], the physicians continued to produce handwritten prescriptions, and it was the nurses who entered the prescriptions in the electronic system. This limits the value of physicians’ opinions about the technology. Similarly, among the physicians that Wang et al. [17] consider to be users of the eRx technology, only 37% said that they used it in all their prescribing (an average of 178 eRx/month), while 17% said that they had abandoned the technology.

All the studies included in this review are observational, with or without a control group (Level III or Level IV, respectively). Most of the studies (13/19) are Level III studies: transversal studies [9,15–18,20–23], before and after studies [12,14,26], and one longitudinal study with a control group [27]. Six studies had Level IV designs, meaning that they are observational studies with no control group [13,19,24,25,28,29]. Finally, two Level III studies also included a Level IV design for a portion of the study [21,22]. The sample contains no experimental study (Level I) and no quasi-experimental study (Level II). The data used to evaluate the technology usually came from the perceptions of users (physicians or pharmacists and their staff) (10/19 studies) and/or patients [9], and sometimes it was completed by the investigators’ observations [13,26] (but little detailed information is provided on how these observations were included in the analysis). Two

![Fig. 2](image-url)

**Fig. 2** – The push model (A) and the pull model (B) of electronic prescription transmission. (A) The push model works like a mailman: (1) when prescribing, the physician indicates which pharmacy the prescription should be sent to; and (2) the technology directs the prescription toward the pharmacy identified when the physician entered the information. Only this pharmacy can receive the eRx, i.e. download the prescription into its system. (B) The pull model works like a mail box: (1) the physician sends the prescription to a centralized warehouse; and (2) all authorized pharmacists have access to the eRx in the warehouse and can download it into their systems.
studies used self-reporting of the work process or prescription interventions [14,18], while one study directly observed the pharmacist’s work in order to analyze the impacts of the technology [20]. Four studies calculated the rate of unclaimed prescriptions based on data in the pharmacies’ computers or the computers of the organizations or companies distributing the medications, or based on copies of the prescriptions obtained from participating pharmacies [12,21–23]. In three studies, patients were questioned on the reasons for their non-compliance [21,22,28]. Finally, one study performed a comparative analysis of patients’ medication records by comparing the list of medications given verbally by the patient with that given by the physician and that given by the pharmacist [27].

The main results of the included studies have been organized according to the stage of the medication management model (1 = prescription, 2 = transmission of the prescription, 3 = execution of the prescription at the pharmacy, 4 = use of medication) and are presented in Table 1.

3.2. Impacts associated with the prescription stage

There are two distinct aspects to the quality of a clinician’s prescription: a fair and complete pharmacological profile and the selection of a clinically and economically relevant treatment. Only one study measured the technology’s impacts on the quality of pharmacological profiles [27]. By assessing the degree of fit between lists given by patients, physicians and pharmacists, the researchers observed a significant difference between the group with electronic communications (45%) and the group that relied on paper-based communication (31%). The pharmacological profiles of patients were more complete and up to date in the group communicating electronically. However, there were still significant differences between what medications the patients said they were taking and those that the physicians and pharmacists believed they were taking. Professionals interviewed on this subject in other studies did not perceive positive impacts of the technology with regard to the completeness or accuracy of pharmacological profiles available to physicians [13,17,19,24]. In these cases, it would appear that this result is related to the technology’s immaturity: the pharmacological profile available to clinicians was not up to date, usually because of the number of medications clogging the system’s memory.

Furthermore, seven studies report professionals’ perceptions of the impacts of eRx on prescription quality [13,15,17,19,24,25,29]. These perceptions were sometimes positive [15,17,29] and sometimes neutral or mixed [13,19,24,25]. For example, 82% of the physicians using eRx surveyed by Pizzi et al. [15] believed that one of the benefits of the technology was that there were fewer prescription errors. However, no study has measured such reductions. Similarly, the professionals participating in two studies mentioned that the technology had little effect on adherence to formularies, even if the prescribers had access to the formularies when they were choosing the medication [13,17].

On the other hand, physicians had mixed perceptions of the technology’s impact on the time it takes for them to write prescriptions. For example, 87% of physicians surveyed by Tan et al. [29] were satisfied with the time it took to write a prescription, and 52% of the physicians surveyed by Pizzi et al. [15] believed that the technology could save prescription preparation time, while certain prescribers interviewed by Weingart et al. [19] believed that sometimes it took more time to write a prescription using the technology.

3.3. Impacts associated with the transmission stage

Here the technology promises to improve security and efficiency in the transmission of prescriptions to pharmacies. None of the studies evaluated the issue of process security. As for efficiency, the studies discussed impacts with respect to the time it takes to manage prescription transmission and the time spent by patients waiting at their pharmacies. Two studies report clinicians’ perceptions that the technology allowed their staff to spend less time sending prescriptions to pharmacies [13,19]. In principle, under the push model patients spend less time waiting for prescriptions to be filled at the pharmacy since the pharmacist can prepare the prescriptions as they arrive throughout the day. This was the perception of some of the physicians participating in two studies [15,19], and most of the patients participating in the Lapane et al. study [9]. Many pharmacists (and their teams) surveyed by Rupp and Warholak [16] were also of the opinion that patients expected their prescriptions to be prepared and ready when they arrived at their pharmacies, which was perceived as pressure. However, Sugden and Wilson [26] reported that the patients participating in pilot projects in the United Kingdom generally waited longer at the pharmacy after the technology had been implemented under both the push and the pull models [26]. The researchers attributed this problem to the pharmacists’ inexperience or to data transmission problems.

3.4. Impacts associated with the pharmacist execution stage

Benefits are also expected in the prescription execution stage in terms of the quality and efficiency of the process. Electronic prescriptions should in principle be of better quality, and the elimination of data entry by pharmacists should reduce the risk of errors (transcription and interpretation) as well as facilitate execution by the pharmacist. On this issue, the results reported by the studies were mixed. Professionals in six studies perceived positive impacts: they felt that the prescriptions were clearer, easier to read and more complete [13,15,16,19,25,29], and felt that they had to make fewer calls to physicians [13,25] and intervene in the prescriptions less often [29]. On the other hand, these perceptions were not confirmed in studies by Murray et al. [14] and Astrand et al. [20], whose analyses were based on empirical data. These studies analyzed pharmacists’ work processes, comparing ETPs with traditional hand-written prescriptions, and obtained negative results. Astrand et al. [20] observed an increase in the number of calls that pharmacists had to make to clarify information before dispensing an ETP (2% of ETPs require a call, compared to 1.2% of traditional prescriptions). The data that most often needed to be checked was on dosage and directions for use. According to the authors, this type of problem resulted from the widespread use among physicians of abbreviations that pharmacists’ computer systems could not recognize [20].
Table 1 – Main impacts identified in the studies.

<table>
<thead>
<tr>
<th>Process stage</th>
<th>Impact on</th>
<th>Positive impact</th>
<th>No impact or mixed impact</th>
<th>Negative impact or problem created</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Demonstrated(^a)</td>
<td>Perceived(^b)</td>
<td>Demonstrated</td>
</tr>
<tr>
<td>Prescription</td>
<td>Pharmacological profile</td>
<td>More accurate and complete pharmacological profile [27]</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Little effect on the accuracy and completeness of the pharmacological profile [17,24]</td>
<td>Incomplete or inaccurate pharmacological profile [13,19]</td>
</tr>
<tr>
<td></td>
<td>Prescription quality</td>
<td>May reduce prescription errors [15,17,29]</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Time spent writing a</td>
<td>Satisfaction with the time spent writing prescriptions [29]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>prescription</td>
<td></td>
<td>Little effect on time spent writing prescriptions [13,15]</td>
<td></td>
</tr>
<tr>
<td>Transmission</td>
<td>Management of sending</td>
<td>May reduce the time spent managing the sending of prescriptions to pharmacies by clinical staff [13,19]</td>
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<td></td>
<td>prescriptions</td>
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<tr>
<td></td>
<td>Patient waiting time at</td>
<td>May reduce patients’ waiting time at pharmacies [15,19]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>pharmacies</td>
<td>Patients expect to be able to receive their medication more quickly at their pharmacy [9]</td>
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</tr>
<tr>
<td>Execution</td>
<td>Technical aspects of the</td>
<td>Improved prescription readability and clarity for pharmacists [13,15,16,19,25,29]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>prescription</td>
<td>Made prescriptions more complete [15]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Entry of prescription</td>
<td>Made prescription entry into the computer easier for pharmacists [29]</td>
<td></td>
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<td>into the computer and</td>
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<td>verification of the</td>
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<td></td>
<td>prescription</td>
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\(^{a}\) Demonstrated indicates that the impact was observed in the studies.

\(^{b}\) Perceived indicates that the impact was perceived by the participants in the studies.
Murray et al. [14] observed a 45.8% increase in the time spent on “problem-solving activities involving prescription” (p. 550). According to the authors, “this had much to do with physicians’ learning more about the various medications stored in the pharmacy inventory and the need for pharmacists to help them deal with a variety of prescribing issues that were new to them” (p. 550).

This type of negative impact was also reported in studies by Rupp and Warholak [16] (pharmacists), Motulsky et al. [25] (pharmacists) and Wang et al. [17] (physicians). Warholak and Rupp [18] found that 3.8% of ETPs required that pharmacists intervene, most of the time (32.7%) because information was missing from the prescription. No study found that the technology resulted in time being saved entering prescriptions into the pharmacist’s system. In the Murray et al. study [14], the time spent entering prescriptions was the same before and after introduction of the eRx system. The time that pharmacists saved by not having to enter prescriptions was equal to the time lost validating the fields entered into the system by the physicians. The pharmacists interviewed by Motulsky et al. [25] felt that they were spending less time entering information with the technology only when the ETP had over three medications.

### 3.5. Impacts associated with the patient use stage

In terms of the patient’s use of medication, the technology is expected to improve the quality of medication use as a result of improvements to each stage in the process. No study in our sample evaluated such indicators. However, some studies examined a new phenomenon resulting from the electronic transmission of prescriptions: evaluations of patients’ primary compliance through unclaimed prescriptions. Five studies [12, 21–23, 28] evaluated the rate of prescriptions written but not claimed, which ranged from 1.55% [23] to 2.8% [28]. Three studies asked patients about their non-compliance [21, 22, 28]. Overall, their non-compliance was either intentional (the patient still had medication at home or did not need the prescription) or unintentional (the patient did not know that a prescription had been sent to the pharmacy, or the prescription had been sent to the wrong pharmacy). One study analyzed the effectiveness of implementing systematic calls to patients when the ETPs were considered essential by the medical team [28]. This intervention was considered effective since all of the patients involved (6–8 per month) eventually came to pick up their medication following the call.

### 4. Discussion

To our knowledge, this is the first systematic review on the impacts of second-generation eRx technologies, which are used to circulate information by electronic means. Some systematic reviews have evaluated the impacts of eRx technologies, but they included all technologies without specifically targeting the system’s capacity for electronic communication. Our searches led to the inclusion of 19 studies, only 3 of which were conducted since 2006. This trend does not reflect current research on eRx technologies,
which has grown exponentially in since 2000 [6]. Also, this trend does not reflect the popularity in policy terms of health information exchange models. All the studies in this review were observational. Excluding the studies that have examined the phenomenon of non-compliance, only four studies used empirical data, which came from sources other than questionnaires or interviews/focus groups [14,18,20,27]. Only two of these studies were conducted in the U.S. [14,18], including one that was conducted almost 15 years ago [14].

The main impacts of eRx are expected in the prescribing behavior of physicians: faster data entry, greater relevance, fewer errors, fewer adverse drug reactions. Our results suggest that second-generation technologies do not appear to reduce the time required to issue prescriptions, and may even increase it [6,30,31]. The technology may change physicians’ prescribing behavior, but little is known about the clinical consequences of such changes [32]. It is in terms of the quality of the information available to professionals that second-generation technologies appear to have a significant and novel impact: they can improve the quality of the pharmacological profile available to physicians and pharmacists. One study found this positive impact from a homogeneous technology with bidirectional electronic communication of information between prescribers and physicians [27]. This had not been observed in the North American studies, where the technologies and communication standards are very heterogeneous. This suggests that the pharmacological profiles available to different clinicians are often out of date. The study by van der Kam et al. [27] also suggested an important role for patient validations of the information in their files: there were still significant differences between the electronic profiles available to the professionals and the medications that the patients said they were taking. When professionals use only files from the list of prescribed medications, either as dispensed by the pharmacies or as reimbursed by insurers, they do not have an accurate view of medication use. More studies are needed to better understand the scope and extent of this type of problem in other contexts. This result nevertheless underscores the importance of developing functions that allow patients to check their pharmacological profiles and make corrections.

Second-generation eRx technologies also promise specific impacts in terms of the quality and efficiency of the prescription transmission and execution stages. We found no study demonstrating impacts on process quality, while professionals’ perceptions were found to be mixed. As for process efficiency, the specialists felt that pharmacists should be able to process ETPs more quickly and patients should not wait as long [3]. Our review found no study that has demonstrated this type of positive impact. On the contrary, two of the studies analyzed pharmacists’ work processes, comparing ETPs and handwritten prescriptions, and obtained negative results. There appear to be various barriers to the potential benefits: (1) delayed transmission of the prescription; (2) problems integrating the prescription into the pharmacist’s system; and (3) problems interpreting the prescription, requiring pharmacists to call physicians for clarifications. The communications problems serve as a reminder that, in addition to being reliable and secure, a transmission network needs to be fast if it is to represent an improvement over the traditional information transmission method. Prescription integration problems stemmed from an incomplete standardization of the information generated by eRx technologies. A report by the National Opinion Research Center identified two priority standards for electronic prescription transmission: one for instructions to patients (i.e. dosage) and one to ensure the compatibility of different databases on medications, doses and pharmaceutical forms [10]. The abundance of different databases is complicating communication between systems. Similarly, greater harmonization of the practices of pharmacists and physicians may improve the integration of an ETP in pharmacists’ information systems. Less use of free text and personal abbreviations is essential.

Our results also suggest that when pharmacists are interpreting the prescription, the ETPs may create as many or more problems than handwritten prescriptions, as has been observed in hospital settings [33,34]. Even though several studies found that professionals appreciate the clarity of prescriptions when handwritten prescriptions are eliminated, studies have demonstrated that the problems increase [14,20]. It should nevertheless be mentioned that the results from Murray et al. [14] may not be transferable, since the prescriptions were sent to a single pharmacy and the data was collected only one month after implementing the eRx technology in the practice setting. Other studies are therefore required in order to better understand the disturbances created by eRx in the prescription execution process in pharmacies, and in particular under the heterogeneous push model widely used in North America.

Finally, ETPs offer an added value that was difficult to attain in the traditional context of organization in primary care. Prescriptions written but not claimed ended up in patients’ pockets under the traditional method. With second-generation eRx technologies, electronic prescriptions can be traced easily. The five studies that examined this phenomenon found that the problem was not encountered often (approximately 2% of the time), compared to estimates for handwritten prescriptions (approximately 15%) [35]. This finding raises an important issue that should direct research on how to better understand differences between patients’ prescription and consumption habits when a technology is used to generate prescriptions. Furthermore, given the great number of prescriptions prepared each day in a community pharmacy, these unclaimed prescriptions can quickly fill the shelves of pharmacies under the push model. Second-generation eRx technologies therefore create disturbances in pharmacists’ work processes that each setting needs to learn how to manage. Should an ETP be systematically prepared, as soon as it enters the pharmacy? Should the patients be called first? Should some medications be considered higher priority and the patients for them systematically called? One study demonstrates that systematically calling patients about prescriptions considered essential led to their full compliance [28]. More studies are therefore needed in order to better understand how to better integrate ETPs into the prescription execution process in pharmacies, and what types of interventions are likely to have significant and positive impacts on patient compliance.
5. Strengths and limitations of the study

An inherent limitation of any systematic review lies in the research strategy and predefined inclusion and exclusion criteria. There is always the possibility that we missed some articles that, if included, would have affected the conclusions of this review. However, we believe that our research strategy was for the most part inclusive, given the key words used and the databases consulted, which strengthens our review. Furthermore, we decided to not limit the selection of studies based on the methodology used, and this allowed us to include a variety of studies in our sample and reveal a wide range of impacts throughout the medication management process. On the other hand, this decision complicated analysis, since it became difficult to distinguish perceived or even hoped-for impacts from actual impacts measured using empirical data. Second-generation eRx technologies imply a communication between various sites (at least one prescriber and one dispenser site), which induce a great heterogeneity in the level of use, even within one study (e.g. [13,29]), making it difficult to analyze the different results. Moreover, our analysis revealed that often the studies provided little detailed information on the technologies, which appears to be a common problem in published studies evaluating IT in health [36]. Consequently, it can at times be difficult to distinguish which impacts result from each of the technology’s specific functions. Finally, given the great heterogeneity of study settings (medication management models, community pharmacy practices), level of use and characteristics of eRx technologies in the various settings, the results of the studies are not easily transferable.

6. Conclusion and recommendations

This systematic review has shed light on the current state of our knowledge on the impacts of second-generation eRx technologies on medication management. There is little empirical data supporting the supposed benefits of these technologies. In fact, our data suggest that the technologies are not mature enough, in the sense that communication is usually unidirectional, only from the prescriber to the dispenser, while information on the medications actually bought in pharmacies cannot be consulted when prescriptions are written. In addition, communications standards do not appear to have been defined, complicating efforts to harmonize various systems provided by different vendors in a context of very heterogeneous practices. All efforts to develop and implement second-generation eRx technologies should therefore be harmonized with standardization efforts. Furthermore, the observation that pharmacists face more problems should be of interest to both community pharmacists and technology developers. Community pharmacists have an interest in becoming more involved in technology development efforts in order to ensure that the different aspects of their practice are well understood and integrated. Developers should also make an effort to develop functions that will allow patients to validate their pharmacological profiles. Overall, more research is needed in terms of studies that measure the impacts of second-generation technologies based on empirical data, in the context of actual use. Furthermore, the studies reveal that eRx can be used to assess patient compliance, paving the way for new interventions to improve compliance. Finally, we encourage researchers interested in eRx technologies to make detailed descriptions of the context of their studies and the technology’s specific functions, expressed with a shared terminology. This will make comparisons and knowledge synthesis easier.

Summary points

What was already known before this study

• The use of electronic prescription (eRx) technologies is increasing in primary care
• eRx technologies are being promoted as a way to improved the quality of medication use

What this study has added to our knowledge

• The importance of distinguishing two generations of eRx technologies (first-generation [stand-alone technology] and second-generation [networking technology]), and the different transmission models (push and pull models)
• An overview of the impacts of second-generation eRx on the different stages of the medication management process
• The findings that little empirical data demonstrate the actual impacts of second-generation eRx technologies, and that a full description of context, type of technology and intensity of use has to be provided

Authors’ contributions

A.M. contributed to the search, the selection, the analysis and the main writing of this paper. C.S. and L.L. respectively participated as the second and the third reviewer in the selection step. L.L. and C.S. both assisted with the reading and the analyzing of the included studies, and the writing of the whole paper.

Conflict of interest

None.

Appendix.

Table A1

REFERENCES
<table>
<thead>
<tr>
<th>Authors</th>
<th>Data collection period</th>
<th>Location of the study (P: prescriber sites; D: dispenser sites)</th>
<th>Technology used (model)</th>
<th>Study design (D), sample size (S) (data collection method)</th>
<th>Utilization of the technology</th>
<th>Outcomes evaluated and/or variables reported</th>
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</thead>
<tbody>
<tr>
<td>Astrand et al. [20]</td>
<td>February–March 2006</td>
<td>Sweden P: multiple D: 3 mail order pharmacies</td>
<td>Heterogeneous (Pull)</td>
<td>D: Level III; observational with control (e-prescriptions or not) S (direct observation of pharmacist): 7532 new ETP and 6833 new non-eRx</td>
<td>52.4% of new Rx were ETP (range of 38.0–74.6%)</td>
<td>Numbers and frequencies of prescriptions necessitating a clarification contact, causes of clarification contacts, time and results of interventions</td>
</tr>
<tr>
<td>Ax and Ekedahl [21]</td>
<td>(a) January–March 2002 (b) 2003</td>
<td>Sweden P: multiple D: 21 pharmacies</td>
<td>NA (Push)</td>
<td>D: 2 study designs: (a) Level III; cross-sectional study (e-prescriptions or not, type of drugs, patient age and gender) (b) Level IV: observational study without control Sa (pharmacy computer data; National Prescription Survey for data on dispensed prescriptions; Apoteket AB for data on dispensed e-prescriptions): 44,607 ETP; 1123 unclaimed prescriptions Sb (postal survey): 340 patients</td>
<td>NA</td>
<td>(a) Rate of unclaimed prescription 3 months after transmission; (b) reasons for prescriptions not being picked up by patients</td>
</tr>
<tr>
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<td>Craghead and Wartski [12]</td>
<td>February–March 1988</td>
<td>USA (Kentucky) (Ireland Army Community Hospital) P: one community hospital D: one outpatient pharmacy</td>
<td>Homogeneous (Push)</td>
<td>D: Level III; observational before–after study (retrospective) S (pharmacy computer data; noncompliance report – report sent to the provider if the prescription remained unclaimed after 5 days): 15,945 ETP; 293 unclaimed prescriptions</td>
<td>NA</td>
<td>Rate of unclaimed prescriptions 5 days after transmission</td>
</tr>
<tr>
<td>Ekedhal et al. [23]</td>
<td>August–September 1997</td>
<td>Sweden P: multiple D: 10 pharmacies</td>
<td>NA (Push)</td>
<td>D: Level III; cross-sectional study (e-prescriptions or not, type of drugs, patient age) S (copy of prescriptions from pharmacy; National Prescription Survey for data on dispensed prescriptions): 8054 ETP; 155 unclaimed prescriptions</td>
<td>17% of Rx were ETP</td>
<td>Rate of non-redeemed prescription</td>
</tr>
<tr>
<td>Ekedhal and Manson [22]</td>
<td>(a) March–May 2000 (b) October 2001</td>
<td>Sweden P: multiple D: 21 pharmacies</td>
<td>Homogeneous (Push)</td>
<td>D: 2 study designs: 21.7% of Rx were ETP</td>
<td></td>
<td>(a) Rate of non-redeemed prescription 4–7 months after transmission</td>
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</table>
Table A1 – Description of the included studies.

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<td>(a) Level III; cross-sectional study</td>
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<td>(b) Reasons for not claiming a prescription 10 to 40 days after its transmission</td>
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<td>(e-prescriptions or not, type of drugs, patient age and gender)</td>
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<td>(b) Level IV; observational study without control</td>
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<td></td>
<td>So (pharmacy computer data and manual archives; National Prescription Survey for data on dispensed prescriptions; Apoteket AB for data on dispensed e-prescription): 89,533 ETP; 2171 unclaimed e-prescriptions</td>
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<td>Sb (telephone interviews): 87 patients</td>
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<td>Grossman et al. [13]</td>
<td>November 2005–March 2006</td>
<td>USA (New Jersey) P: 15 practices with eRx and 6 practices without eRx</td>
<td>Heterogeneous (Push)</td>
<td>D: Level IV, observational without control (few methodological details) S (interviews, observations): 44 discussions with respondents from 26 organizations</td>
<td>Practices with eRx: The majority of practices had fully implemented e-prescribing, with about half of the practices’ systems in place for more than two years. Only the practices with stand-alone e-prescribing systems were using electronic data interchange (EDI), which allows electronic transmission between physician practice computers and pharmacy computers. Practice estimates of the percentage of prescriptions printed ranged from only 10% to close to 100%.</td>
<td>Facilitators and barriers to e-prescribing adoption and use; perceptions of the effects of e-prescribing on practice operations, prescribing patterns, and patient satisfaction</td>
</tr>
<tr>
<td>Hellstrom et al. [24]</td>
<td>September–October 2007</td>
<td>Sweden P: 7 health care regions</td>
<td>Heterogeneous (Pull)</td>
<td>D: Level IV, observational without control S (survey): 180 physicians</td>
<td>Between 50% and 86% of dispensed e-prescriptions in each health care region studied. Fifteen percent of the respondents had used an electronic system for two months to one year, and 85% for more than one year.</td>
<td>Physicians’ attitudes toward e-prescribing</td>
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<td>Kinnaird et al. [28]</td>
<td>April–July 1998</td>
<td>Italy (United States Army Health Clinic) P: 1 health clinic D: 1 outpatient pharmacy</td>
<td>Homogeneous (Push)</td>
<td>D: Level IV; observational without control S (phone interviews): 124 patients (461 unclaimed ETP)</td>
<td>100% of Rx were ETP</td>
<td>Reasons for not claiming prescriptions</td>
</tr>
<tr>
<td>Lapane et al. [9]</td>
<td>July–September 2006</td>
<td>USA (Florida, Massachusetts, New Jersey, Nevada, Rhode Island, Tennessee) P: 35 practices</td>
<td>Heterogeneous (Push)</td>
<td>D: Level III; cross-sectional study (patients who had or who had not received an e-prescription) S (survey): 244 patients aged 65 or older</td>
<td>53% of patients reported ever receiving e-prescriptions</td>
<td>Patients’ perceptions and attitudes regarding expectations about and satisfaction with e-prescribing</td>
</tr>
<tr>
<td>Motulsky et al. [25]</td>
<td>2006</td>
<td>Canada P: multiple D: 8 pharmacies</td>
<td>Homogeneous (Pull)</td>
<td>D: Level IV; observational without control S (interviews): 12 pharmacists</td>
<td>Six of the pharmacists downloaded 15% of all eRx (total 458 ETP) generated during the entire 6-month pilot project, the other six pharmacists tried the system but executed a fewer e-Rxs, with two pharmacies unable to receive electronic transmissions because of technical problems with the network</td>
<td>Pharmacists’ perceptions of the ways in which eRx technology could transform their role</td>
</tr>
<tr>
<td>Murray et al. [14]</td>
<td>December 1993–April 1994</td>
<td>USA (Indiana) P: 1 Health Center (General Medicine practice GMP) D: 1 outpatient pharmacy</td>
<td>Homogeneous (Push)</td>
<td>D: Level III; observational before-after study (prospective) S (self-recorder work sampling by pharmacists): 9422 observations recorded by pharmacists during the study (before: 4687 observations; after: 735 observations)</td>
<td>Before: 926 Rx handled per day After: 1007 Rx handled per day; 64% were ETP</td>
<td>Type of work performed by pharmacists, reason for their work and people they contacted</td>
</tr>
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<tr>
<td>Pizzi et al. [15]</td>
<td>February 2003</td>
<td>USA (Florida, Massachusetts, New Jersey, Nevada, Rhode Island, and Tennessee) P: multiple</td>
<td>Heterogeneous (Push)</td>
<td>D: Level III; cross-sectional study (e-prescribers or not) S (survey): 164 e-prescribers and 842 traditional prescribers (physicians)</td>
<td>14.85% of respondents were eRx users</td>
<td>Perceived benefits and barriers to adoption and use of eRx systems</td>
</tr>
<tr>
<td>Rupp et al. [37]</td>
<td>April–July 2006</td>
<td>USA (Florida, Massachusetts, New Jersey, Nevada, Rhode Island, and Tennessee) P: multiple</td>
<td>Heterogeneous (Push)</td>
<td>D: Level III; cross-sectional study (e-prescription or not) S (survey): 1094 pharmacy personnel</td>
<td>Pharmacies included in the sample had to meet a minimum dispensing volume of 5 ETP per day</td>
<td>Attitudes, beliefs and satisfaction with e-prescribing (compared with conventional prescribing)</td>
</tr>
<tr>
<td>Sugden and Wilson [26]</td>
<td>2002–2003</td>
<td>UK 3 pilots, including P: 34 practices D: 23 pharmacies</td>
<td>Heterogeneous (Push-2 pilots; Pull-1 pilot)</td>
<td>D: Level III; observational before–after study (few methodological details) S (interviews, focus group, observations): NA</td>
<td>Take up of ETP was much slower than anticipated. In the last two months of 2002, it reached significant volumes (an aggregate of nearly 15,000 dispensed prescriptions)</td>
<td>Content of information, changes in processes of communication, service and quality of care, workload and work practices of stakeholders, stakeholders’ attitudes to ETP, use of ETP</td>
</tr>
<tr>
<td>Tan et al. [29]</td>
<td>October 2007</td>
<td>Singapore P: 9 polyclinics D: 9 pharmacies (one polyclinic can transmit prescriptions to only one pharmacy)</td>
<td>Homogeneous (Push)</td>
<td>D: Level IV; observational study without control S (survey): 118 physicians and 61 pharmacy staff</td>
<td>7.3% of respondents had been using eRx for less than a month, 23.6% for 1–3 months, 41% for more than 6 months.</td>
<td>User satisfactions; perceptions regarding the impact of the use of electronic prescriptions on prescription errors and interventions</td>
</tr>
<tr>
<td>Authors</td>
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<tr>
<td>van der Kam et al. [27]</td>
<td>February-May 1998</td>
<td>Netherlands P: 5 General practitioners in the electronic group and 5 general practitioners in the paper-based group D: multiple</td>
<td>Homogeneous (Push)</td>
<td>D: Level III; longitudinal study with control (electronic vs. paper-based group) S (interview): electronic group: 65 patients on admission day; paper-based group: 74 patients on admission day</td>
<td>100% of Rx were ETP in the electronic group</td>
<td>Quality of patient data: current medication of the patient, according to the GP, the pharmacist and the patient on the day of admission (and 10 days after discharge)</td>
</tr>
<tr>
<td>Wang et al. [17]</td>
<td>October-December 2006</td>
<td>USA (New Jersey) P: multiple</td>
<td>Heterogeneous (Push)</td>
<td>D: Level III; cross-sectional study (e-prescribers or not) S (survey): 139 e-prescribers; 89 non-e-prescribers</td>
<td>Among e-prescribers, 37% reported using the system to write all their prescriptions (average 178 eRx per month), 46% reported using the system for some prescriptions (average 119 eRx per month), and 17% reported they were no longer using the system for any prescriptions (average 51 eRx per month prior to quitting).</td>
<td>Prescribers’ perceptions regarding various aspects of the prescribing process: information (including its accuracy and usefulness), office workload, and prescribing safety and quality</td>
</tr>
<tr>
<td>Warholak and Rupp [18]</td>
<td>July-September 2006</td>
<td>USA (Massachusetts, New York, Pennsylvania, Maryland, and Nevada) P: multiple D: 68 chain pharmacies</td>
<td>Heterogeneous (Push)</td>
<td>D: Level III; cross-sectional study (e-prescription type-new or refill-type of drugs) S (self-reported observations by pharmacists): 312 observation periods (pharmacist shifts); 2690 ETP</td>
<td>Pharmacies in the sample had to meet a minimum dispensing volume of 5 ETP per day.</td>
<td>Number, type and reason for pharmacist interventions on e-prescriptions</td>
</tr>
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</table>
Table A1 – Description of the included studies.

<table>
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<th>Utilization of the technology</th>
<th>Outcomes evaluated and/or reported variables</th>
<th>Peersactions regarding the use of e-prescribing in general and medication safety alerts in particular</th>
<th>Notes</th>
</tr>
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<tbody>
<tr>
<td>Weingat et al [19]</td>
<td>Summer 2007</td>
<td>Homogeneous (Push)</td>
<td>USA (Massachusetts)</td>
<td>D-Level IV: observational control, 3 focus groups, 21 sites; P: multiple</td>
<td>D: electronic transmitted prescription; ETP: electronically transmitted prescription</td>
<td>NA, not available, Rx: prescription.</td>
<td>Client had used e-prescribing for 2.5 years (range 1.0–5.5), wrote the majority (89%) of their prescriptions electronically</td>
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</table>


