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An effort to improve electronic health record medication list accuracy between visits: Patients' and physicians' response

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ABSTRACT

Objective: To evaluate the efficacy of a secure web-based patient portal called *Patient Gateway* (PG) in producing more accurate medication lists in the electronic health record (EHR), and whether sending primary care physicians (PCPs) a clinical message updating them on the information their patients provided caused physicians to update the EHR medication list.
Methods: We compared the medication list accuracy of 84 patients using PG with that of 79 who were not. Patient-reported medication discrepancies were noted in the EHR in a clinical note by research staff and a message was sent to the participants' PCPs notifying them of the updated information.
Results: Participants were taking 665 medications according to the EHR, and reported 273 additional medications. A lower percentage of PG users' drug regimens (54% versus 61%, $p = 0.07$) were reported to be correct than those of PG non-users, although PG users took significantly more medications than their non-user counterparts (5.0 versus 3.1 medications, $p = 0.0001$). Providing patient-reported information in a clinical note and sending a clinical message to the primary care doctor did not result in PCPs updating their patients' EHR medication lists.
Conclusions: Medication lists in EHRs were frequently inaccurate and most frequently overlooked over-the-counter (OTC) and non-prescription drugs. Patients using a secure portal had just as many discrepancies between medication lists and self-report as those who did not, and notifying physicians of discrepancies via e-mail had no effect.

1. Introduction

Having accurate records of the medications a patient is taking is central to delivering safe, effective clinical care. Knowing exactly which medications and regimens patients use can help physicians to avoid drug interactions, manage side effects, and more effectively direct the patient's treatment. Furthermore, in emergency situations, medical records may serve as the only source of information on a patient's medications, thereby performing a critical function in that person's care.

Increasingly, electronic health records (EHRs) are being used to track patients' medical histories. Computerized

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records have the virtue of being more legible than paper and are probably also more easily shareable and updateable by providers [1]. However, patients receive their care in a variety of settings and recent studies suggest that less than 18% of physicians in the U.S. use an EHR [2–5]. Furthermore, because of low levels of EHR interoperability and a lack of data exchange between providers, EHRs today tend to have incomplete information, which limits their usefulness for clinical care, research studies, and quality of care initiatives [6]. Since universal EHR use with complete data exchange between providers may take years to accomplish, other methods of compiling accurate clinical information must be explored.

Medication lists represent one of the most important components of the EHR since they are used for filling refill requests, assessing quality, performing research, and for informing computerized clinical decision support. As Wagner and Hogan point out, it is especially important to maintain accurate structured lists in the presence of automated decision support because medication information presented in free-text format or in any other non-standard part of the medical record would be unreadable and unusable by the automated decision support system, resulting in loss of many potential benefits of the system [7].

In addition to the difficulties of maintaining a complete overall health record, there are specific challenges to maintaining accurate medication lists. Patients may discontinue their medications or change their regimens as their symptoms improve or if they experience side effects, and they often do not report these changes to their physicians [8–10]. Also, other providers, such as specialists, may prescribe new medications or change patients' regimen without notifying the primary care physician (PCP) [11,12]. Because patients are the end-users of medications, they are often the only source of information regarding which drugs they actually take and how they take them. Providing patients with mechanisms that allow them to review their medication lists and provide corrections or modifications may be beneficial in improving patient-physician communication and EHR medication documentation.

In this study, we sought to evaluate the efficacy of a secure web-based patient portal in producing more accurate medication lists in an electronic health record. The EHR medication lists of patients who did not use the portal were compared to those of portal users to see whether providing patients continual, electronic access to their medication lists encouraged them to update their physicians on their actual medication use. Furthermore, we evaluated whether entering a note into the EHR with patient provided information and sending doctors a secure e-mail clinical message notifying them of the updated information increased the likelihood that physicians would add this information into the EHR medication list for all patients, including both users and non-users of the portal.

2. Methods

2.1. Study site

Partners Healthcare System is an integrated healthcare delivery system in Eastern Massachusetts that uses an ambulatory care EHR called the Longitudinal Medical Record [13]. Features of this EHR include the ability to store provider notes from patient ambulatory care encounters, results of labs and diagnostic tests, family history, medication lists and other data along with automated physician reminders for preventive tests and procedures.

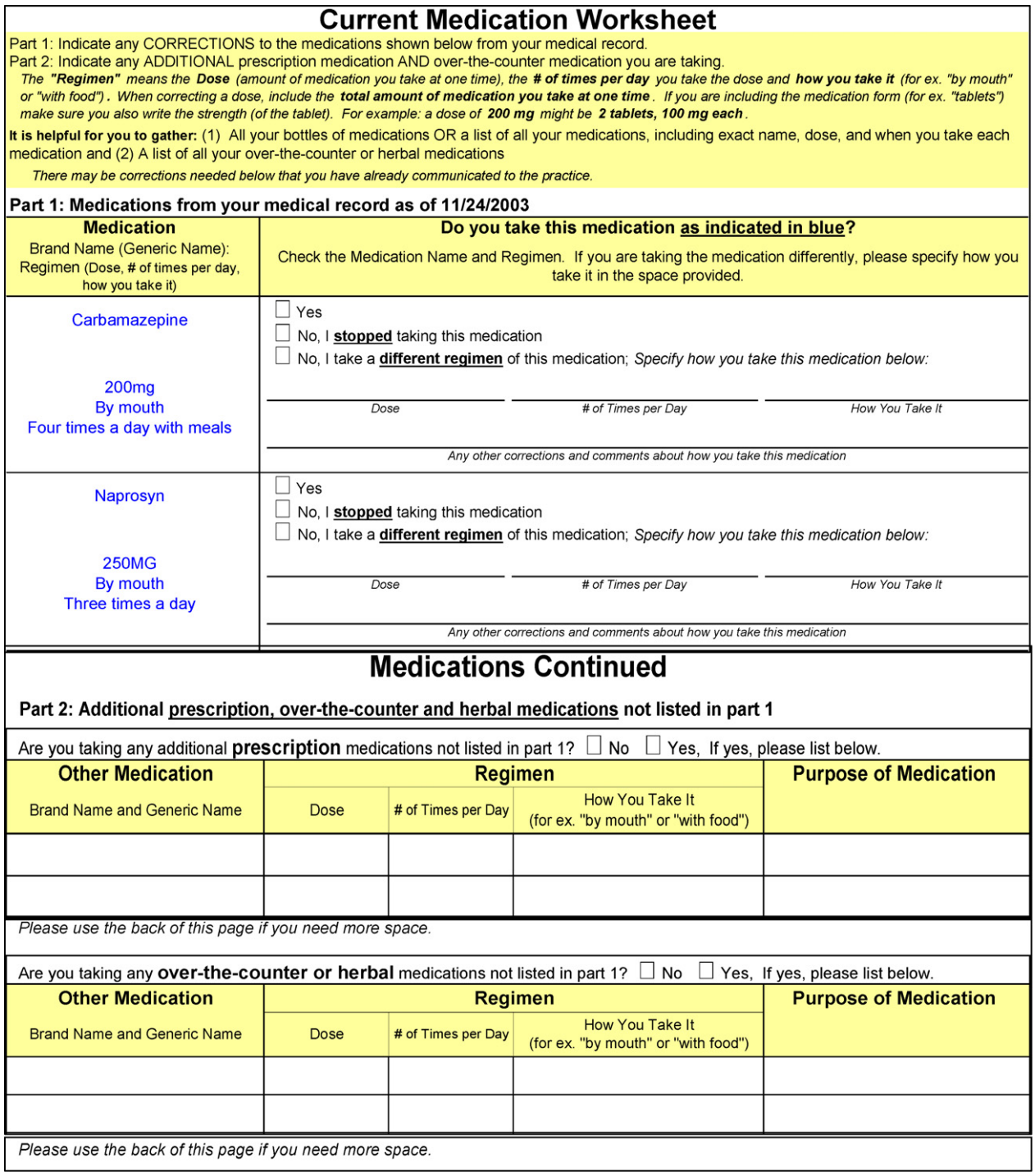
Recognizing the need for patient access to their records and the importance of patient participation in their care, Partners has implemented Patient Gateway (PG), a secure web-based patient portal designed to facilitate communication between patients and their doctors' offices as well as to allow patients easier access to their health records [14]. By signing up and logging on, patients can view their medication and allergy lists, as well as perform administrative tasks such as scheduling appointments or requesting referrals. Patients may not update the medication or allergy lists directly since these derive from the EHR. A patient may request correction of inaccurate or incomplete information by contacting their doctors' office to notify the office staff about the issue, ensuring that changes are approved by the physician as appropriate. A patient may also use PG to send the office a message regarding the correction.

2.2. Recruitment

Patients were recruited by postal mail from a Partners-affiliated primary care practice in a suburb of Boston that offers PG to all patients. Only patients with at least one visit to the office in the previous year were eligible for the study. Equal numbers of patients who were signed up for PG and those who were not signed up were sent a cover letter, consent form, privacy notice, an opt-out card, and a return envelope in the first study mailing. Those who chose to participate and returned a signed consent form were mailed a paper-based survey, pre-populated with current medication information from their electronic health records including a complete list of active medications, dosages and regimens (Fig. 1). The Partners Human Research Committee approved the study and the survey was administered November 2003–February 2004.

The participants were asked to review the information and indicate for each medication on the list whether they were taking it as indicated, if they had stopped taking it, or if they had changed the regimen. They were also asked to add any new prescription and/or over-the-counter (OTC) drugs they were currently taking. They were informed that the updates and corrections reported in the survey would be shared with their PCP and may become part of their medical record.

After making corrections to the pre-populated data, participants mailed the survey back to researchers. Non-responders were sent up to two reminders to encourage them to return their consent forms or their completed surveys if they had already consented. Patients were sent a photocopy of the survey for their records. In addition to medication information, the survey also included questions on family history and health maintenance. Results of these other survey sections are published elsewhere [15–17].



Current Medication Worksheet

Part 1: Indicate any CORRECTIONS to the medications shown below from your medical record.
Part 2: Indicate any ADDITIONAL prescription medication AND over-the-counter medication you are taking.

*The **"Regimen"** means the **Dose** (amount of medication you take at one time), the **# of times per day** you take the dose and **how you take it** (for ex. "by mouth" or "with food"). When correcting a dose, include the **total amount of medication you take at one time**. If you are including the medication form (for ex. "tablets") make sure you also write the strength (of the tablet). For example: a dose of **200 mg** might be **2 tablets, 100 mg each**.*

It is helpful for you to gather: (1) All your bottles of medications OR a list of all your medications, including exact name, dose, and when you take each medication and (2) A list of all your over-the-counter or herbal medications

There may be corrections needed below that you have already communicated to the practice.

Part 1: Medications from your medical record as of 11/24/2003

Medication Brand Name (Generic Name): Regimen (Dose, # of times per day, how you take it)	**Do you take this medication as indicated in blue?** Check the Medication Name and Regimen. If you are taking the medication differently, please specify how you take it in the space provided.
Carbamazepine 200mg By mouth Four times a day with meals	☐ Yes ☐ No, I **stopped** taking this medication ☐ No, I take a **different regimen** of this medication; *Specify how you take this medication below:* *Dose* / *# of Times per Day* / *How You Take It* *Any other corrections and comments about how you take this medication*
Naprosyn 250MG By mouth Three times a day	☐ Yes ☐ No, I **stopped** taking this medication ☐ No, I take a **different regimen** of this medication; *Specify how you take this medication below:* *Dose* / *# of Times per Day* / *How You Take It* *Any other corrections and comments about how you take this medication*

Medications Continued

Part 2: Additional prescription, over-the-counter and herbal medications not listed in part 1

Are you taking any additional **prescription** medications not listed in part 1? ☐ No ☐ Yes, If yes, please list below.

Other Medication Brand Name and Generic Name	**Regimen** Dose	# of Times per Day	How You Take It (for ex. "by mouth" or "with food")	**Purpose of Medication**

Please use the back of this page if you need more space.

Are you taking any **over-the-counter or herbal** medications not listed in part 1? ☐ No ☐ Yes, If yes, please list below.

Other Medication Brand Name and Generic Name	**Regimen** Dose	# of Times per Day	How You Take It (for ex. "by mouth" or "with food")	**Purpose of Medication**

Please use the back of this page if you need more space.

Fig. 1 – Medication pages of the patient survey with pre-populated medication information.

2.3. *Surveys*

Patient surveys were tracked and analyzed using Microsoft Access. All patient changes to their medications were reviewed upon survey receipt to determine whether there was any need for urgent contact to the patient's physician. When a patient reported new or different information about their medications, researchers created a note in the patient's medical record containing the new information and identifying it as patient-provided via a survey. Once a note was created in the chart, a clinical message was also sent via the EHR messaging system to the primary care physician to alert them to the presence and nature of the new information in the patient's EHR. The clinical message did not indicate the specific patient provided information, only its presence as an EHR-note. The notification message to the physician was sent within 90 days of receiving the survey from the patient.

p Values were calculated for the comparison tests between PG users and non-users using chi-square test for proportions and Wilcoxon rank-sum test for means.

3. Results

Among 1098 patients initially recruited, 189 consented to the survey and 163 completed the study. Respondents and non-respondents were similar in the proportion that were female (66% and 67%, respectively), in their average number of medications listed in the EHR (3.5 for both), and average number of problems on their EHR problem list (4.8 and 4.4, respectively). Respondents were significantly older on average (50.6 years) than non-respondents (46.8 years) ($p = 0.001$).

Respondents were divided into two groups: those who had logged on to PG (users) and those who had not (non-users) (Table 1). The non-user group was comprised of both those patients who had never enrolled in PG and those that had enrolled but never logged on to the patient portal.

PG users and non-users were similar in their average age (50.9 years old versus 50.1 years for non-users), however a higher percentage of users were female (70% female in the user group, 58% female among the non-users) although the difference was not significant ($p = 0.1$). Users did, on average, have significantly more medications recorded in the EHR than non-users averaging five medications on their medication lists compared to 3.1 medications for non-users ($p = 0.0001$). There were no significant differences in the proportion of medications that users and non-users reported they had stopped taking without this change being recorded in the EHR (users 32% versus non-users 26%, $p = 0.1$), were taking with a different regimen (users 14% versus non-users 12%, $p = 0.4$), or were accurately listed on the EHR medication list (users 54% versus non-users 61%, $p = 0.07$).

PG users and non-users were equally likely to report taking additional prescription medications beyond those listed in the EHR (30% of patients for both users and non-users). A higher percentage of users report at least one additional over-the-counter (OTC) drugs than non-users (54% and 43% of patients, respectively, $p = 0.2$) with an average of 1.5 new OTC drugs per user compared to 0.9 per non-user ($p = 0.08$). In this study, accessing a patient portal alone was not associated overall with more accurate medication list information in a patient's electronic health record.

We evaluated whether more frequent access to their medication list information through PG would result in patients reporting a greater degree of accuracy. Overall, patients in the group with 10 or greater accesses to their medication information did not have a significantly different percentage of accurate medications than the group accessing this information less than 10 times (56% versus 51%, respectively, $p = 0.3$) even though the frequent use group had a significantly higher average number of medications per patient (6.1 versus 4.2, respectively, $p = 0.01$). In addition, the frequent use group reported a significantly lower percentage of medications they had stopped taking but that were still listed in the EHR than did the group of patients with less than 10 accesses (27% versus 37%, respectively, $p = 0.03$). The difference between the access groups with respect to reporting taking a different regimen and additional prescriptions was not significant.

3.1. *Physician response*

In the second portion of the study, we analyzed physicians' responses to clinical e-mail messages informing them that a clinical note had been written in the EHR containing updated medication information from their patient. A total of 938 medications were reviewed, a combination of EHR-recorded and patient-reported medications from all 163 study respondents (Fig. 2). Of the 665 (71%) EHR-recorded medications, patients indicated that 371 (56%) were accurately recorded, 191 (29%) were reported as stopped and 91 (14%) were reported as being taken with a different regimen from the one indicated in the EHR. Twelve respondents (2%) did not provide answers to this portion of the survey.

Of the 191 medications that patients reported as stopped in the survey, 23 medications were discontinued between when the patient filled out the survey and the researchers sent out a clinical message to the physicians. This suggests that either the patients contacted the physician after viewing their

Table 1 – Medication list accuracy by patient gateway usage status

	PG users ($n = 84$)	Non-PG users ($n = 79$)	Total ($n = 163$)	p-Value
EHR medications				
Average number of HER medications per patient	5.0	3.1	4.1	0.0001
% Medications (yes, accurate. Taking with same regimen)	54%	61%	56%	0.07
Average number of medications taking with same regimen	2.7	1.9	2.3	0.003
% Medications (no, not accurate. Stopped taking)	32%	26%	29%	0.1
Average number of medications stopped taking	1.6	0.8	1.2	0.002
% Medications (no, not accurate. Taking with different regimen)	14%	12%	14%	0.4
Average number of medications taking with different regimen	0.7	0.4	0.6	0.02
% Medications (patient had no response)	0.5%	1.6%	0.9%	0.1
Additional medications				
% Patients with additional prescriptions	30%	30%	30%	0.9
Average number of additional prescriptions per patient[a]	0.4	0.5	0.5	0.8
% Patients with additional OTC/herbals	54%	43%	48%	0.2
Average number of additional OTC/herbals[a]	1.5	0.9	1.2	0.08

[a] Denominator is the total number of patients in the study, not just those reporting new drugs.

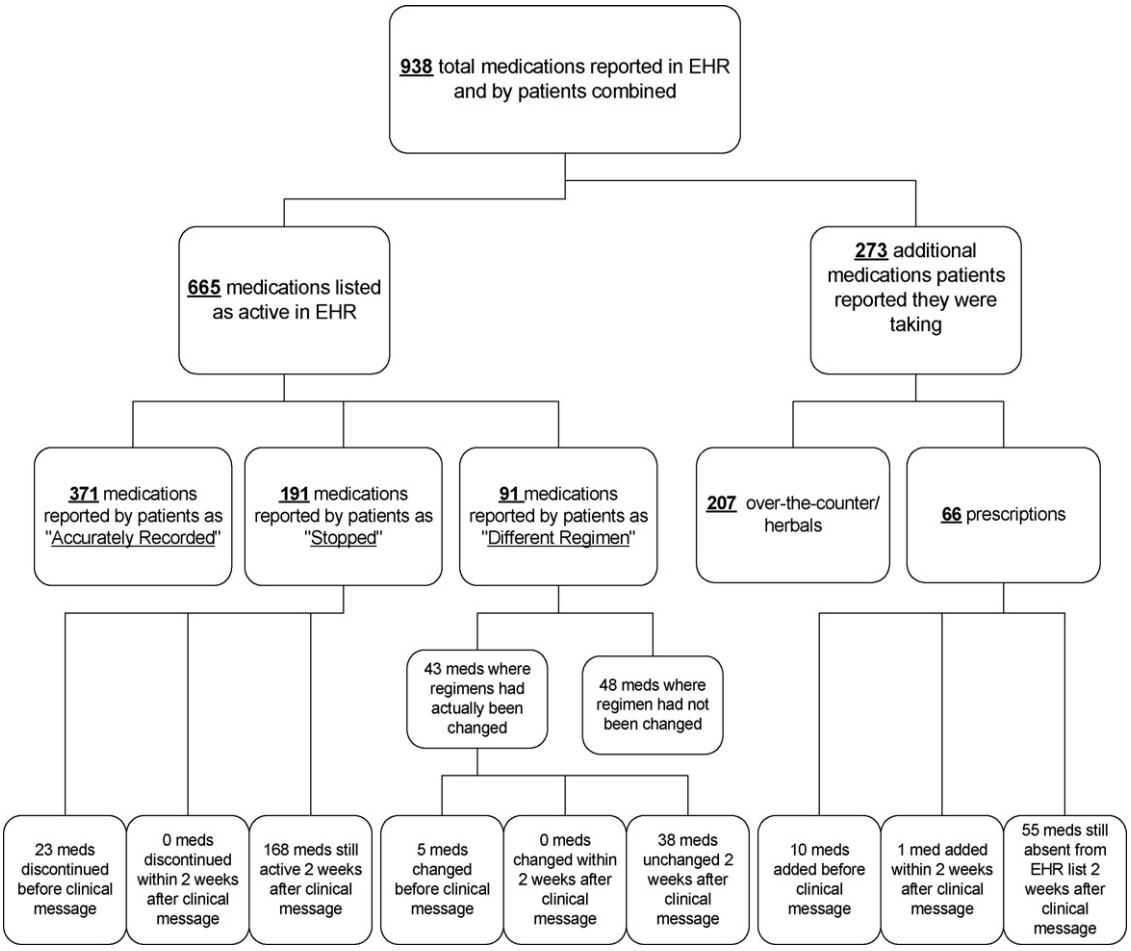


Fig. 2 – Status of medications listed in the EHR and reported by patients.

medication list in the survey, thus resulting in the physician correcting the record, or that the need to update the list was identified through the course of other clinical activities such as refill requests or visits prior to when the clinic message was sent. Eighty-eight percent ($n = 168$) of the stopped medications were still reported as active in patients' records 2 weeks after a clinical message was sent to the patient's primary care physician informing them of the patient-provided information, and just 38 of these were discontinued within 10 weeks of the clinical message, a time-frame suggesting the influence of other factors than the clinical message.

Of the 130 medications that remained on the EHR list after 10 weeks, 41 (32%) were "as needed" or allergy medications that physicians tend to leave on medication lists even if a patient is not actively taking them. Seventy-three medications (56%) were those typically used to treat acute conditions and would likely be recognized upon physician review as not currently relevant. However, 51 (39%) of the medications patients reported as having stopped were those typically used to treat chronic conditions and could represent serious care concerns.

Analysis of the 91 different-regimen medications showed that for 48 of these medications (53%) a true difference in regimen did *not* exist. Of those 48 medications, 11 different-regimen medications were due to transmission errors from EHR to the survey (termed "EHR error"), 16 medications were due to patients misunderstanding the directions on the survey (termed "Pt error"), and 21 medications were due to what we called "PRN errors". PRN errors were times when physicians prescribed medications "as needed" with a maximally suggested dose, and patients took less than or an equivalent of that dosage on an as-needed basis; or, times when physicians prescribed medications that were deemed by the study pharmacist as "as-needed meds," thus not requiring the physician to indicate a PRN status (e.g., seasonal allergy medications, certain pain meds, etc.).

Of the 43 medications ($91 - 48 = 43$) for which the medication regimen had actually been changed, the majority (28 meds, 65%) were chronic-use medications. Despite sending a clinical message to the PCP that his or her patient had provided updated information, 38 of the 43 medications (88%) that represented actual different medication regimens remained the same in the EHR medication list more than 2 weeks after the clinical message was sent.

Although not changed on the medication list and therefore not readily available for other clinicians' review or clinical decision support, 5 of these 38 medications were mentioned

by the physician in EHR notes subsequent to the patient survey. It is important to note that the EHR medication list may represent the physician's intended prescription and that the patient report may reflect a patient's lack of understanding or non-compliance. In these cases, one would not expect the medication list to change, but rather that a physician would indicate the discrepancy and note any intervention attempted.

Of the 273 medications that patients added to their pre-populated medication lists only 66 (24%) were prescription medications. Of these 66 prescriptions, 37 (56%) were medications typically used to treat chronic health problems, and thus represented a continuing source of inaccurate information in patient treatment. The study pharmacist deemed 16 of the unlisted 66 prescriptions as "high/moderate risk" meaning they had a greater potential to cause problems if not available for clinical care. Of these 16 medications, 10 were still not added to the EHR medication list more than 2 weeks after the clinical message was sent.

4. Discussion

The accuracy of the medication list is important for patient safety, clinical care, electronic decision support, quality assessment, and research. This study confirms earlier reports that it is common for medication list information in an electronic health record to have inaccuracies. Overall, patients reported that 43% of the medications listed in the EHR were inaccurate—with 29% having been stopped and 14% having been changed.

We had hypothesized that having electronic access to their medical records would result in PG users having more accurate medication lists. Instead, patient-reported rates of medication list accuracy were generally similar whether patients had ever used PG or not. On average, users took significantly more medications than non-users, perhaps making maintaining accuracy more challenging. Only about half of the medications for which patients indicated they were taking a different regimen turned out to represent actual differences from the EHR medication list. The majority of these false positive reports were related to interpreting the meaning of "PRN". This finding underscores the importance of creating patient-friendly terminology when translating medical record information to patients.

Prescriptions and many over-the-counter medications that were not on their medication lists were identified by both PG users and non-users. Fifty-four percent (54%) of users and 43% of non-users reported additional OTC therapies and 30% of both groups reported additional prescriptions.

Overall, more than three times as many OTC drugs (207 versus 67) than prescription medications were missing from the EHR according to patients. From one perspective, this is good news, because it suggests that the EHR is more accurate in recording the presence of prescription medications than OTC drugs. The absence of some moderate to high-risk prescriptions and the high rate of missing OTC medications, however, are of concern because of the potential for drug-drug interactions that may reduce medication efficacy or create side effects [18–20]. Thus, it is important that physicians ask about other prescriptions and OTC drug use and record it in the EHR in order to minimize potentially harmful drug interactions.

Providing patients the ability to view their EHR medication lists through the patient portal was not by itself associated with greater accuracy of the medication list. Asking patients to annotate their medication list results in more accurate capture of current medication and OTC information than what is recorded in the EHR. These findings support the potential utility of patients providing information on their medications to physicians who frequently do not ask about OTC drug use or patient compliance during appointments, and may not know about additional prescriptions between visits. However, this information must be provided in the context of care delivery and in a format that physicians will accept and use. In our study, e-mailing providers a link to a note containing patient-provided medication updates was ineffective at prompting physicians to update the medication list outside of a clinic visit.

The negative results of this study highlight the importance of aligning information management tools to the workflow and care delivery priorities that exist. We continue to believe that patient portals are a viable way of increasing medication list accuracy with some modifications to the approach. If patient-provided information is to be added into the record, a more efficient way must be found for the physician to process this information, and the care benefits must be clear. Further studies are needed to determine the most effective way of engaging patients in reviewing their electronic medication lists and activating physicians to update the medication lists when appropriate to increase their accuracy and usefulness.

A study is currently underway at Partners HealthCare System that involves electronically inviting patients through the PG patient portal to comment on their health care records before upcoming visits and to submit this information to physicians within the EHR. Physicians will then be able to review the information during the visit and simply click a button to update the patient's electronic record. With this process, it is hoped that some of the barriers preventing more accurate medication lists will be addressed by tying the receipt of patient updated information to a scheduled visit and streamlining the physician's process to enter the data into the electronic record.

This study has a number of limitations. It was performed at a single suburban academically affiliated clinic outside of Boston, so that the results may not be generalizable to other environments. The low response rate may also have affected the results, as respondents may have been different from non-respondents in ways that were not measured. We could not validate patient reports so we do not know the extent to which patients' reports were accurate. We do not know whether the physician looked at the note in the EHR and do not know exactly why the change was not made to the medication list. A physician's response to a reported change in medication regimen may differ based on knowledge of the patient, the implications or the change, and the ability to document the change in the best format within a particular EHR.

Researchers had already placed a free-text note into the patients' EHR reflecting the updated information. Physicians may have felt this to be sufficient documentation and did not feel it necessary to change the structured medica-

tion list as well. Also, physicians may have perceived the patient-provided changes as unimportant to clinical care and therefore did not spend the time to update the medication list.

As we did not determine the clinical importance of the patient-provided information with the exception of unlisted prescriptions, it is difficult to say how big a role this played in the physicians' lack of action on the clinical messages they received. Physicians may have also decided to postpone updating the medication list until the patients' next appointment, as it is common practice to update the medication list at each office visit and, at that time, the physician would have an opportunity to discuss the medication changes with the patient and would have been reimbursed for the time they spent doing so. Furthermore, discrepancies between the EHR and patient-report could have been due to noncompliance on the part of the patient. There could be instances where the prescription on the medication list would not change even though the physician became aware that the regimen actually followed by the patient was different. Although potentially valuable information, typically EHRs do not have mechanisms to augment medication lists with compliance information or patient reported medication changes.

While the lack of physician action may not have been clinically significant in the majority of cases, some patients may have benefited from follow-up between visits. For example, there were instances where patients reported medications not documented on the medication list and could pose harm if clinicians are unaware of them. The patient-reported regimen change for chronic-use medication may have also represented an opportunity to address compliance problems, side-effects, growing tolerance, a worsening condition or lack of progress on the current dose.

We conclude that medication lists in this electronic health record were frequently inaccurate, mostly due to undocumented OTCs although some chronic prescription medications were also missing. Patient access to a secure web-based patient portal was not, by itself, associated with more accurate medication lists in the electronic health record. Clinical messages to physicians containing links to chart notes documenting patient-provided medication updates did not result in physicians updating the medication list in the EHR. A better solution is needed to support patients' review of their medication information and integration into a physician's workflow to facilitate accurately maintaining this vital information. EHR medication data needs to evolve to support the complexities inherent in prescriptions, medications use and its documentation. More research is needed to identify when a discrepancy between medication list and patient-report is important and when to appropriately notify someone, so as not to create a burden of unnecessary activity.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.ijmedinf.2007.03.001.

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