

Refereed papers

Design and implementation of a web-based patient portal linked to an electronic health record designed to improve medication safety: the Patient Gateway medications module

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ABSTRACT

In this article we describe the background, design, and preliminary results of a medications module within Patient Gateway (PG), a patient portal linked to an electronic health record (EHR). The medications module is designed to improve the accuracy of medication lists within the EHR, reduce adverse drug events and improve patient–provider communication regarding medications and allergies in several primary care practices within a large integrated healthcare delivery network. This module allows patients to view and modify the list of medications and allergies from the EHR, report non-adherence, side effects and other medication-related problems and easily communicate this information

to providers, who can verify the information and update the EHR as needed. Usage and satisfaction data indicate that patients found the module easy to use, felt that it led to their providers having more accurate information about them and enabled them to feel more prepared for their forthcoming visits. Further analyses will determine the effects of this module on important medication-related outcomes and identify further enhancements needed to improve on this approach.

Keywords: adverse drugs event, electronic health record, patient portals

Introduction

Drug-related morbidity and mortality is an epidemic patient safety problem, estimated to result in \$76 billion dollars in total costs annually.¹ One drug-related problem, adverse drug events (ADEs), broadly defined as injuries due to medications,² is estimated to occur in 25% of ambulatory patients. Approximately 11% of ADEs are considered preventable and an additional 28% are amenable (i.e. their severity or duration could be decreased if proper action were taken).³ Equally problematic is undertreatment of chronic diseases, where patients are estimated to receive approximately half of all recommended care.⁴

The causes of ambulatory ADEs and undertreatment often stem from one of three problems: medication discrepancies, non-adherence and inadequate monitoring and follow-up (e.g. regarding discrepancies, non-adherence or the development of symptoms that could be ADEs). Medication discrepancies are unexplained differences between the medication regimen a patient thinks he should be taking and the regimen collectively prescribed by his physicians, or between documented regimens across different sites of care.⁵ For example, a patient might think he is supposed to take both atenolol 100 mg po qd as well as metoprolol XL 200 mg po qd because he did not understand (or was never explicitly told) that one medication had been substituted for the other during a previous hospitalisation. Discrepancies can have serious consequences, including prolonged periods of overtreatment or undertreatment. Of the 350 medication errors resulting in serious injury in the Joint Commission's sentinel event database, approximately 30% could be attributed to unintentional medication discrepancies.⁶ Causes of discrepancies include lack of communication among multiple outpatient providers, the lack of one provider responsible for maintaining a

complete and accurate medication list (even within an electronic health record (EHR)),^{7,8} inadequate health literacy among patients⁹ and changes in medications, discontinuity of care and inadequate patient education during transitions in care.^{10–13}

Medication non-adherence, or differences between the regimen a patient thinks he should be taking and what he is actually taking, is estimated to occur in approximately 50–75% of patients.^{14–16} (Note that this definition of adherence is different than the one used by Osterberg and colleagues, 'the extent to which patients take medications as prescribed by their health care providers'.¹⁵ This latter definition does not distinguish between medication discrepancies and non-adherence, a distinction that is crucial to any intervention designed to improve the accuracy of a medication list in an EHR shared by patients and providers.) In one large survey, 30% of patients admitted to taking prescription medications less often than prescribed, 26% delayed filling a prescription, 21% stopped taking a prescription sooner than prescribed, 18% never filled a prescription and 14% took smaller doses than prescribed.¹⁷ Medication non-adherence can lead to poor control of chronic diseases such as hypercholesterolemia, diabetes, hypertension and heart failure.^{16,18–20} Causes of non-adherence include the high cost of medications, the inconvenience of taking daily medications and obtaining refills, and lack of appreciation for medication indications, especially for asymptomatic conditions such as hypertension.

Inadequate monitoring for medication discrepancies, non-adherence, or the development of ADEs is also extremely common. (A full discussion of monitoring, such as therapeutic drug monitoring (e.g. INR levels for patients prescribed warfarin) is beyond the scope of this article because the PG medication module does not address this issue in any direct way.) Medication discrepancies, by definition, will not be reported

by patients and can only be detected by active surveillance. Regarding ADEs, patients often are unaware that symptoms they are experiencing are due to medications. Even if they do suspect a medication effect, patients may not report it to their physicians and physicians may not actively solicit this information.^{3,21} Thus, physicians cannot take action to ameliorate the severity or duration of symptoms. Medication non-adherence is also underreported, and physicians do not actively solicit this information.²² Communication regarding drug-related problems may be completely absent between patient visits, but is often inadequate even during visits because of time constraints, clinical inertia, patient concerns about 'bothering' their physicians, and/or lack of patient involvement in their own care. As a result, ADEs and undertreatment remain undetected and the opportunity to prevent or ameliorate these problems is lost.

By empowering patients to become active participants in their own care, an interactive patient portal linked to an EHR has the potential to help address many medication safety and quality issues.²³ If designed properly, a patient portal module focused on medication safety would allow patients online access to the medication and allergy data from their ambulatory EHR, allow them to interact with the data and update it as necessary, identify discrepancies, report ADEs and non-adherence, then convey this information back to the patient's physician, who can discuss the information with the patient, update the EHR, document drug-related problems and take action as needed.

At Partners HealthCare (Massachusetts, USA), we have developed and deployed such a tool within Patient Gateway (PG), our patient portal, to address these medication issues as part of the *Prepare for Care* study.^{24,25} We hypothesised that the PG Medications Module would facilitate patient-provider communication, increase the detection and handling of discrepancies and ADEs, improve the documentation of medications and allergies within the Partners EHR, increase patient knowledge of and adherence with their medications and increase patients' satisfaction with care. The purpose of this manuscript is to describe the PG Medications Module, including the design and experience of the application from the patient's and provider's viewpoint, preliminary usage data, the evaluation plan and lessons learned to date.

Study setting

Partners HealthCare was formed in 1994 by Massachusetts General Hospital and Brigham and Women's Hospital. Since its inception, this integrated delivery network has grown to include five acute care

hospitals, four rehabilitation and long-term care facilities and a large network of primary care and specialty physicians. Clinical activities in the ambulatory setting are supported by the enterprise EHR – the Longitudinal Medical Record (LMR), which currently has over 7000 clinical users.

Patient Gateway

As part of a system-wide strategy to facilitate communication between patients and their physicians, Partners HealthCare began in 2000 to develop a secure patient portal PG. PG allows patients to update their contact information, renew their medication prescriptions, request appointments and referrals, communicate with their practice via secure web mail and access a licensed health information library.²⁶ As of July 2007, PG supported 35 680 patients (23 296 accounts used) across 30 primary care and specialty practices, with more than 4200 unique patients using it in any given month. The functionality described in the remainder of this manuscript was developed by adding further features to the base PG product for use in the *Prepare for Care* study.

Design of the PG Medications Module

As with other components of *Prepare for Care*,^{24,27} the Medications Module was designed so that patients could use it prior to a scheduled primary care physician (PCP) visit. During these sessions, patients can view information from the LMR, interact with it and create 'journals' that can then be sent to their PCPs. PCPs or their representatives can then view the contents of a journal, discuss it with the patient to verify the information and explore any underlying issues, use the journal to facilitate entry of information into the LMR and take other action as necessary.

User interface design process

A multidisciplinary team consisting of physicians, medication safety experts, information technology analysts, programmers and clinical researchers was assembled to develop the functional requirements for the Medications Module. The team then iteratively developed a series of paper-based and then electronic prototypes to refine the details of the design. We also solicited input from an advisory council comprised of primary care physicians from practices already using the basic PG product. Finally, we conducted a series of usability tests with volunteer patients going through mock scenarios to enhance the ease of navigation and clarity of the user experience.

Patient view

The patient interaction with the Medications Module systematically leads the patient from issues of medication accuracy to those of adherence and ADEs. First, the patient sees the current active medication list as it exists in the LMR. The Medications Module then asks the patient to compare this list with the list of medications the patient thinks he or she should be taking. The patient is then asked details regarding any discrepancies (differences in dose or frequency, additional medications, or missing medications; see Figure 1).

Patients are then specifically asked in a non-judgemental way about any problems they may be having with adherence. If problems exist, the reasons for non-adherence are explored using a menu of potential choices, such as cost, difficulty getting refills, or forgetting to take a medication regularly. Patients are then asked whether they are having possible side effects. If yes, the type, duration and confidence in the symptom being related to that medication are elicited, followed by whether the PCP is aware of the side effect. Lastly, the system asks whether the patient knows the indications for each medication, whether they think it's helping and if they need a prescription refill (see Figure 2). At any time, the patient can go directly to licensed health information (from Healthwise, Inc., Boise, ID) regarding any medication on their list.

Several key design decisions were made when creating the Medications Module. First, we had to balance the need for structured and coded information (which can drive decision support and facilitate entry of information

by the PCP into the LMR) with the convenience of free text entry (which is easier and faster for patients, especially if they are not familiar with medication names or terminology such as dose, strength and frequency). In the end, we decided to have structured (but not coded) information for most fields, with examples of how to enter the information, but allowed for free text when asking about additional medications in order to avoid patient confusion.

Second, throughout the system, we used patient-friendly language, drop-down menus and branching logic to make the system as fast and easy to use as possible. Finally, as mentioned above, we purposely addressed issues of discrepancies before addressing those of adherence or ADEs, since the latter two only apply to medications the patient thinks he or she should be taking.

Physician view

For PCPs, the major requirements were that the Medications Module fit into their workflow, present a concise overview of the information and facilitate efficient verification and documentation of information within the LMR. To that end, a visit-based medication journal only goes to the patient's assigned PCP (as designated by the patient at the time of PG enrolment) before visits that have been scheduled at least three weeks in advance (i.e. non-urgent visits) or are designated as an annual visit. If a patient has submitted a medication journal, then the clinician view of the

The screenshot shows a web-based interface for a patient's medication management. On the left, there is a sidebar titled 'Current Medications' with a list of items: 'Aspirin', 'Baclofen 90 (TRIM)', 'Carbamazepine 200 (R)', 'Lorazepam (POTOMAX)', 'Lorazepam', and 'Metoprolol AC (L)'. Below this list is a button labeled 'Add Medication'. The main area of the screen is titled 'ALCOLOPHANE (ALCOLOPHANE)' and contains a form for verification. The form has several sections: 'PLEASE ANSWER BELOW', 'Are you still taking this medication as shown above?', 'Please tell us how you took it here.', 'Is this a medication that you have experienced?', 'How often do you take it?', 'What is the form of the medication?', 'What is the strength of the medication?', 'How much do you take each time you take it?', and 'Who changed this medication?'. Each section has radio buttons or dropdown menus for selection. At the bottom right of the form is a 'Continue' button.

Figure 1 Verification of medication regimen accuracy

The screenshot shows a web-based interface for a patient's medication management. It contains a form titled 'Please tell us about any medication problems you might have.' with several questions: 'Are you having problems at all with the medication?', 'Are you having side effects from this medication?', 'Do you know what this medication is for?', 'Do you know what you are taking the medication for?', and 'Do you need to have this prescription?'. Each question has radio buttons for 'Yes', 'No', 'I don't know', or 'I don't take it'. At the bottom right of the form is a 'Continue' button.

Figure 2 Identification of non-adherence and adverse drug events

patient’s medication journal is displayed in the LMR in the place of the usual medications screen. This screen displays the usual medication information along with the information submitted by the patient (Figure 3), including medication discrepancies and reports of non-adherence, side effects or lack of understanding of medication indications. With a few mouse clicks, a PCP can move verified journal information into the LMR (e.g. delete a medication a patient is no longer taking and is no longer needed or tolerated, or change a dose). Additional medications taken by the patient can also be added; if the free text medication name supplied by the patient is recognised by the LMR medication dictionary, this process can be facilitated.

As with the patient view, several key design decisions were made when creating the physician view. First was the decision to essentially replace the usual LMR medications screen with the medication journal for applicable visits. Because the LMR incorporates electronic medication prescribing, PCPs almost always access the medications screen during a patient visit. Thus, this decision virtually guaranteed that physicians would interact with a submitted medication journal. Journal entries are no longer displayed on the medications screen once the journal is closed or expired.

Second, the system supports provider verification of patient journal information. It is very easy to delete medications from the LMR list in response to a patient journal, with a single click. Modifying or adding patient journal information to the LMR requires more steps, since patient journal entries might contain uncoded or unstructured information, and providers need to decide how the LMR should be updated. For modifications, a

user must click on the medication name to go to the electronic prescription pad, where they see the patient’s journal comments but have to enter the changes themselves. We felt that this struck the best balance between ease of use and patient safety (e.g. we did not want to make it too easy for unconfirmed medication information to be moved directly into the LMR).

Allergies

The Medication Module also allows for verification of allergy information in a manner completely analogous to the process for medications. Patients interact with their coded allergy information from the LMR (including drugs, foods and other allergens, as well as reactions to each), and can verify or update the information as needed and submit it along with their medications journal. PCPs or nurses can then communicate with patients, verify any new information and update the LMR allergy section with just a few clicks.

Deployment strategy

We relied on several approaches to deploy the Medications Module within the PG product platform as part of the *Prepare for Care* study. First, we identified physician champions in each practice and solicited their input for optimal ways to deploy the Medications Module within their practice. Second, we presented the Medications Module to physicians at practice meetings to introduce its functionality to the clinicians. Third, we provided onsite and online support and returned to practices to hear feedback about the

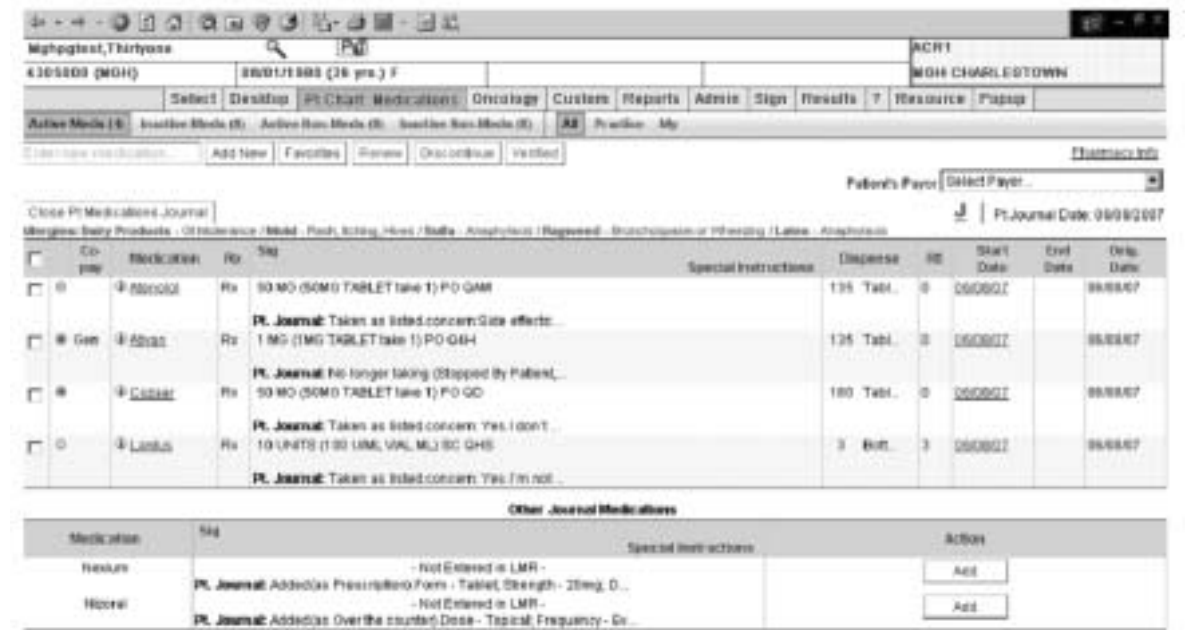


Figure 3 Clinician view of LMR med screen with added journal meds

Medications Module after rollout. Fourth, we provided marketing materials to practices so that patients became aware of this new feature. Fifth, we sent reminders through the base PG product to all patients who had consented to the study to prompt them to review and update their medication and allergy information in the Medications Module prior to an eligible upcoming visit.

Short-term evaluation plan

The Medications Module was implemented between September 2005 and March 2007 at four primary care practices within our integrated delivery network, in conjunction with a diabetes module.²⁴ Patients with an active PG account were invited to participate in the study. Enrolled patients with a forthcoming scheduled visit with their primary care physician were invited to complete a medication journal and therefore were eligible to participate in this part of the evaluation. To evaluate the usage of the Medications Module by patients and clinicians, we recorded the following: i) the number of consented and eligible patients who accessed the Medications Module to review their medications and allergies; ii) the number of patients who submitted their information in the form of a medication journal and iii) the proportion of patient-submitted journals that were electronically reviewed by providers.

To evaluate patient attitudes towards the use of the medication module, patients were invited to complete a short online survey three days after a scheduled visit for which a journal had been opened. On this survey, patients were asked to rate on Likert scales their experience in reviewing and updating their medical records online, including whether they found the medications module easy to use, whether they felt more prepared for the visit and whether the use of the module led their providers to have more accurate clinical information.

Short-term evaluation results

Table 1 presents the characteristics of all the patients in the primary care practices that used PG during the study period (in both arms of the *Prepare for Care* study), those patients with an active PG account invited to participate in the study, those who gave informed consent to participate and those who completed a visit-based journal. Moving from the first to the fourth group of patients, there is a trend for patients to be older, to be white, to live in less impoverished zip codes and to have more frequent physician visits per year.

During the study period, 12 278 patients with active PG accounts who sought primary care at one of the four Medications Module intervention practices were invited to participate in the study. Of them, 2273 (19%) completed the consent process. Of these, 1457

Table 1 Characteristics of patients in *Prepare for Care* primary care practices

	All patients in practices that use Patient Gateway	Patients with active Patient Gateway accounts invited to participate in study	Invited patients consented and enrolled in study	Study patients who submitted a visit-based journal
Number of patients	126 552	28 757	5298	1893
Mean age, y	46	45	48	51
Female, %	63	64	59	61
White race, %	68	80	83	85
Median income by zip code below federal poverty line, %	10.3	9.3	9.2	8.9
Mean annual number of visits to PCP	2.6	2.6	3.5	4.1
to other providers	6.0	6.1	7.8	8.1
Mean number of ways patients report using the internet			3.7	4.2

(64%) patients had a forthcoming scheduled primary care visit and were invited to complete a visit-based medication journal at least three weeks prior to the visit. Of these, 1131 patients (78%) opened a medications journal and 1053 (72%) completed the review and updating process and submitted a journal for review. Data were reviewed electronically within the LMR for 812 (77%) of these patients.

In addition, 687 consented patients who opened their invitation to complete a medication journal prior to a visit were further invited to complete a brief survey of their journal experience three days after their visit. Of these patients, 466 (68%) responded (Table 2). Overall, 70% of these patients found the journal very easy or easy to complete. Fifty-three percent either strongly agreed or agreed that the use of the journal led their providers to have more accurate information about them, while 39% felt neutral about the journal's impact in this area. Similarly, 56% of respondents strongly agreed or agreed that they felt more prepared for their visit with the use of the journal, while 35% reported that they felt neutral about the journal's impact on feelings of preparedness.

Discussion

Our preliminary findings demonstrate that a patient portal-linked tool designed to help improve medication safety has promise, at least for those who use it. Of the patients who chose to take part in the study and were asked to complete a medications journal, approximately 72% submitted a journal for review and about 77% of these were reviewed by physicians during the subsequent visit. Patient survey data showed that the majority

of patients who used a medication journal found it easy to use, and felt that it led to their providers having more accurate information about them and enabled them to feel more prepared for their forthcoming visit. However, only about 20% of eligible patients consented to be in the study in the first place, and these eligible patients made up less than a quarter of all patients in these practices, since most patients had never signed up to use PG. This lack of reach both limits the generalisability of our research findings and also represents a major barrier to be overcome if interventions such as these are to have effects on a broader patient population. That PG and Medications Module users tended to be white and less impoverished than non-users is particularly worrisome and it will likely require major outreach efforts to bridge the so-called 'digital divide'.

The development of the Medications Module illustrates several important lessons for others engaged in developing these kinds of applications:

- the critical importance of a multidisciplinary design team and iterative refinement of the application
- the need for usability testing at several points during the development cycle, including with patients
- the use of a judicious mix of free text, structured and coded data fields within the patient interface to optimise the usefulness of patient-entered data without confusing or overwhelming patients
- the need to give clinicians the ability to verify and correct patient-entered data while still facilitating entry of that data into the EHR
- the importance of integrating the clinician side of the application with clinicians' workflow to maximise use and usability
- the need to document both medication and allergy information within one application to avoid potential drug-allergy interactions.

Table 2 Patient satisfaction survey results

With use of journal	Patient response, % (n=466)				
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
My provider had more accurate info about me	17	35.5	38.6	7	1.8
I felt more prepared for my visit	18.3	37.4	35.1	7.2	1.9
	Very easy	Easy	Neither	Difficult	Very difficult
Patient experience of completing journal online	27.9	41.9	20.4	2.3	0.4

Long-term evaluation plan

We are currently studying the impact of the PG Medications Module on patient outcomes with a cluster randomised controlled trial (clinicaltrials.gov #NCT00251875). As part of the *Prepare for Care* study, we designed four new PG modules: medications/allergies, diabetes, health maintenance and family history. We randomised Partners primary care practices with PG to receive two of the four modules (medications and diabetes in one study arm versus health maintenance and family history in the other). In this way, patients who submitted a journal about medications/allergies could be compared to patients who submitted a journal unrelated to medications. Clinical outcomes to be evaluated include ameliorable and preventable ADEs, LMR medication list accuracy (i.e. unexplained discrepancies), self-reported medication adherence and patient-reported communication with PCPs regarding ADEs.

Conclusions

The PG Medications Module represents a major effort to engage the patient directly in medication surveillance in order to decrease serious medication errors in the outpatient setting. We believe that integration of this kind of intervention into a patient portal represents a novel and potentially powerful way to reduce ADEs and medication discrepancies. The effects of this intervention on a variety of outcomes are currently being tested. Expanding its use to a broader population will be a major focus going forward. Ongoing education of both physicians and patients regarding the prevalence and seriousness of medication discrepancies and ADEs and the importance of communication about these issues will also be needed to produce the culture change necessary to improve medication safety.

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CONFLICTS OF INTEREST

None.

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