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Design and Implementation of a Web-Based Patient Portal Linked to an Ambulatory Care Electronic Health Record: *Patient Gateway* for Diabetes Collaborative Care

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Abstract

Background—Despite the availability of expert guidelines and widespread diabetes quality improvement efforts, care of patients with diabetes remains suboptimal. Two key barriers to care that may be amenable to informatics-based interventions include (1) lack of patient engagement with therapeutic care plans and (2) lack of medication adjustment by physicians (“clinical inertia”) during clinical encounters.

Methods—The authors describe the conceptual framework, design, implementation, and analysis plan for a diabetes patient web-portal linked directly to the electronic health record (EHR) of a large academic medical center via secure Internet access designed to overcome barriers to effective diabetes care.

Results—Partners HealthCare System (Boston, MA), a multi-hospital health care network comprising several thousand physicians caring for over 1 million individual patients, has developed a comprehensive patient web-portal called *Patient Gateway* that allows patients to interact directly with their EHR via secure Internet access. Using this portal, a specific diabetes interface was designed to maximize patient engagement by importing the patient's current clinical data in an educational format, providing patient-tailored decision support, and enabling the patient to author a “Diabetes Care Plan.” The physician view of the patient's Diabetes Care Plan was designed to be concise and to fit into typical EHR clinical workflow.

Conclusions—We successfully designed and implemented a Diabetes Patient portal that allows direct interaction with our system's EHR. We are assessing the impact of this advanced informatics tool for collaborative diabetes care in a clinic-randomized controlled trial among 14 primary care practices within our integrated health care system.

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Introduction

TYPE 2 DIABETES is a complex chronic disease that requires effective collaboration between physicians and patients to achieve evidence-based goals of care. Despite the availability of expert guidelines and widespread diabetes quality improvement efforts, however, care of patients with diabetes remains suboptimal.[1] Shortfalls in diabetes care have been documented in the areas of testing frequency, preventive services, medication initiation and adjustment, medication adherence, and control of glycosylated hemoglobin (HbA1c), low-density lipoprotein (LDL)-cholesterol, and blood pressure levels.[2–7]

Given the clinical complexity and data-intensive nature of diabetes management, informatics applications have been heralded as a means to improve diabetes care.[8,9] In medical systems with advanced informatics infrastructures, much work to date has focused on physician-oriented electronic health records (EHRs) with computerized clinical decision support and/or clinical care reminders[10–12] and on population management using computerized disease registries.[13,14] Patient-focused web applications for education, peer-to-peer support, and medical advice have also been developed. However, these patient portals have generally not been linked directly to the EHRs used by the patients' physicians and have had a relatively modest impact on care.[15–19]

A patient web-portal that can draw the patient's clinical data directly from the ambulatory EHR and, in turn, link the patient back to his or her primary care physician (PCP) via the EHR represents a novel mechanism for engaging patients in their care and augmenting traditional visit-based medicine.[20] Such a system also has the potential to overcome many of the current barriers to effective diabetes care. Partners HealthCare System, a large integrated health delivery system in Boston, MA, comprising several thousand physicians caring for over 1 million individual patients, has developed a comprehensive patient web-portal called *Patient Gateway* that allows patients to interact in a limited manner with their electronic medical record via secure Internet access.[21,22] *Patient Gateway* is currently available to over 150,000 patients in 14 primary care clinics within our system. In this report, we describe the conceptual framework, design, implementation, and evaluation plan for a Diabetes Module to be integrated into *Patient Gateway*.

Conceptual Framework

Wagner et al.[23] and Bodenheimer et al.[24] have proposed the Chronic Care Model as a framework for interventions directed towards chronic diseases such as diabetes. In this model of care, an informed and prepared patient is the central figure of the care team. Based on this model, we designed our Diabetes Collaborative Care module to directly address two key barriers to care: (1) lack of patient engagement with therapeutic care plans and (2) lack of medication adjustment by physicians (“clinical inertia”) during clinical encounters.

Lack of patient engagement

A central theme of chronic disease management is the critical role of patient self-care.[25,26] Prior research has shown that increased diabetes education results in improved self-care behaviors and improved disease-related outcomes.[27,28] In one seminal study, Greenfield et al.[29] used “pre-visit activation” (e.g., personally coaching patients with diabetes on how to address care issues with their physician) to improve diabetes-related outcomes. Similarly, in a 4-year randomized controlled trial, Rachmani et al.[30] found that actively encouraging intervention patients to participate in their care by providing detailed clinical data resulted in significantly lower HbA1c, blood pressure, and lipid levels compared with control patients. While these studies are encouraging, the sustainability of such labor-intensive interventions is uncertain.

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Other studies have found that patients are often unaware of their diabetes control. One survey of 686 health plan members with diabetes who had an HbA1c test in the prior 6 months found that 66% of respondents did not know their result and another 10% were incorrect in their estimate.[31] A similar study of patients with hypertension found that 41% of respondents did not know their blood pressure level.[32] We found similarly low levels of HbA1c, cholesterol, and blood pressure result awareness in a survey of current *Patient Gateway* users in our system.[33] Thus, there is evidence both for better diabetes control among patients with greater knowledge of their current management status and for the broad opportunity to improve diabetes knowledge given the current low prevalence of patient awareness.

Lack of medication adjustment

Medication prescription is a key component of effective diabetes control. However, medication changes are often not made during clinic visits despite the presence of elevated risk factor levels. In a survey of 32 U.S. academic health center practices, we found that dose or regimen changes were made at fewer than half of clinic visits among medically treated patients with elevated HbA1c.[3] For untreated patients with elevated blood pressure or lipid levels, corresponding medications were initiated in fewer than 15% of visits. Others have found similar evidence for clinical inertia in the management of diabetes.[34–39]

Although published trials of interventions to overcome clinical inertia are limited, one study found that individual encouragement from other physicians reduced inertia.[40] Another recent study that compared computerized versus patient-delivered reminders to screen for diabetes provided evidence that—if properly prepared and engaged in care—patients themselves may be effective catalysts for changing clinical care processes.[41] We hypothesized that a patient web-portal designed to encourage patients with elevated risk factor levels to discuss corresponding medication initiation or dose adjustment would help reduce clinical inertia and thereby improve diabetes-related clinical outcomes.

Key Design Elements: Form

In designing the Diabetes Collaborative Care web-portal, we sought to specifically address the problems of patient engagement and clinical inertia by providing an interactive, algorithm-driven interface with which an individual patient could review all elements of ideal, evidence-based diabetes care as it applied to him- or herself. In going through this interface, the patient would be able to “self-audit” his or her care and to specifically identify areas of inadequate adherence and opportunities to modify his or her treatment plan. The results of this self-audit would subsequently be shared with the patient's PCP at the next (upcoming) appointment, thereby allowing an opportunity for the patient and PCP to discuss the current care plan. More than simply educating patients, this process would also empower them to understand and contribute to making changes in their care plan.

In this section we describe the design of (1) the patient interface within the web-portal and (2) the physician's view of patient activities. In Key Design Elements: Function we discuss the integration of the web-portal into our health system's EHR.

The patient's view

Two key goals of the design for the patient interface were (1) to organize the clinical data in an educational format and (2) to enable patients to author a detailed, tailored Diabetes Care Plan to share with their PCP.

The first major organizational division was to separate the three core diabetes-related medically managed conditions (glucose control, blood pressure control, and cholesterol

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control) from the six behavioral or referral-associated goals (diet and exercise, smoking cessation, anti-platelet agent, and eye and foot exam referrals) using a “tab” format (Fig. 1).

The three diabetes-related conditions were grouped into the “condition management” page, which was organized using left-side markers for control of blood sugar, blood pressure, and cholesterol. As the patient clicks on each of these three links, he or she is presented with all the key data related to that condition on the central area of the page. For example, choosing “Blood Sugar Control” brings together the patient's data regarding: HbA1c test result, test date, HbA1c goal, and corresponding medication for HbA1c control. Coupled to each result is “patient-centered decision support”—recommendations of what actions should be taken (e.g., for out-of-date or elevated result). Finally, beneath each decision support item, patients have the opportunity to check a box or fill in free text to add a concern or suggested management change to their Diabetes Care Plan. The Diabetes Care plan authored by the patient is the primary product of the module (Fig. 2).

Because medication management is key to risk factor control (and underlies the problem of clinical inertia), we created a “Medication Module” to allow patients to view their EHR medication list in order to make corrections, add new medicines, and report any medication-specific adherence barriers or side effects. We then created a diabetes-specific medication library that imported from the Medication Module to the Diabetes Module any medication (and associated patient comments) used to treat each of the three diabetes-related conditions. This organizational framework allowed us to specifically link medication names to their corresponding treatment targets and to provide patients with a tailored view of their own current care for a given condition (Fig. 1), thereby enabling tailored “patient-centered decision support” focused on medication management. Thus, for patients with elevated risk factor levels, the link with corresponding medications permits specific decision support regarding medication increase (or initiation).

The behavioral/referral-related page was organized in a similar format, with the six areas (diet and exercise, smoking cessation, antiplatelet agent, and eye and foot exam referrals) listed along the left-hand panel of Figure 3. For each area, clinical data are imported from the EHR where available, and decision support is provided to enable the patient to add to his or her Diabetes Care Plan. Throughout both divisions of the module, individual “Information Icons” link specific terms and concepts on the web page to corresponding explanations provided by a commercial patient education content provider (Healthwise®, Boise, ID).

Thus, as the patient works through the various sections of the diabetes module, he or she learns about the current status of each element of his or her diabetes care and has the opportunity to request that specific areas be addressed at the next clinical visit through the mechanism of the semiautomated, self-authored Diabetes Care Plan.

The physician's view

In contrast to the patient view of the diabetes *Patient Gateway*, where the goals were to be educational, explicit, and detailed, the priorities for the physician view in the EHR were to be concise and to fit into existing workflow. To achieve these priorities, invitations for patients to open a diabetes module are limited to those patients with an upcoming (within 3 weeks) appointment with their designated PCP. This approach ensured that physicians (who receive no payment for non-visit care) would be able to address concerns raised by patients in the context of a clinic visit rather than as “additional work” through a phone call or other correspondence. Moreover, as part of registering for the *Patient Gateway* and consenting to the research study, patients were required to specifically identify their PCP, which served to

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avoid sending completed Diabetes Care Plans to other physicians not directly involved in the patients' diabetes care.

PCPs are made aware when a patient transmits a completed Diabetes Care Plan by the presence of an alerting icon in the EHR. PCPs can then open the Diabetes Care plan—which is reformatted as a concise list of specific management decisions and patient concerns (Fig. 4)—to review the contents, add physician comments, and save as a "Letter" in the EHR. PCPs also have the option of importing the concise Diabetes Care Plan directly into a physician progress note, thereby facilitating documentation.

Key Design Elements: Function

Patient Gateway, the basic patient portal that provides the infrastructure for the Diabetes Module, is implemented using the Caché programming platform (InterSystems, Cambridge, MA) and redundant Microsoft® (Redmond, WA) Internet Information Servers utilizing HTML and Javascript-based page rendering. Realizing our design goals for a patient diabetes portal within *Patient Gateway* required a system that could (1) read clinical data from multiple sources (e.g., the hospital data repository, administrative demographic data, clinic scheduling, the EHR), (2) store data entered by patients, and (3) interface directly with the EHR for data capture (e.g., medications, problem lists), data transfer (e.g., patient-generated Diabetes Care Plans), and shared clinical decision support and application logic. A schematic overview of this information infrastructure is presented in Figure 4.

To effectively implement our diabetes portal application within our existing EHR, we needed to effectively integrate (1) EHR and patient portal data, (2) EHR and patient portal decision support, and (3) patient and clinician workflow.

Integration of EHR and patient portal data

Our design goal was to provide patients' control over their diabetes portal entries while retaining clinicians' control over EHR data entries. Clinical data such as the medication list and the most recent HbA1c and cholesterol results are displayed in the patient portal using a real-time lookup service from the EHR, ensuring that patients have access to the same information as the clinician. Patients are encouraged to correct any inaccuracies or omissions they see, and are reminded that clinicians will review their Diabetes Care Plan at (but not before) their next scheduled visit in the office.

When a patient accesses his or her Diabetes Module, an "EHR snapshot" of relevant clinical data is copied into the module, which ignores any subsequent changes in EHR data while it is being edited by the patient. The patient may determine if EHR data have changed since they were copied into the diabetes module, and may elect to "refresh" the module with a current EHR data snapshot if desired. This assures that a clinician can update clinical data in the EHR regardless of patient portal activity.

Patient-submitted data are not stored in the EHR without clinician approval. Since clinical judgment determines which information is accurate, relevant, and important to document, clinicians are encouraged to review patient-submitted Diabetes Care Plan information. They can document that information using new shortcuts placed in the EHR that permit clickable updates to the medication list and allow the user to save a diabetes care plan as a note. Or, they can type or dictate a note. Documentation is completely determined by the clinician, since the EHR is not only the provider's record of care, but also serves financial, legal, and administrative purposes as well. Certain diabetes module information is visible to the patient after it has been updated in the EHR (such as medication lists), while other data are not

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(such as a diabetes progress note). Future system enhancements may make it possible to release more chart information to the patient.

Integration of decision support services

Displaying EHR decision support directly to the patient was an important aim of the patient diabetes portal design. Patients are offered a web page (available at any time) that relies on EHR decision support services to determine if they have reached their goal in controlling cholesterol, blood sugar, and blood pressure. Advice intended for the clinician is rewritten for a less technical reader, the patient. Since EHR decision support systems are imperfect, patients may be presented with information that disagrees with their clinician's judgment. This was judged to be better than the alternative— avoiding showing the patient the same decision support seen by his or her clinician. Decision support services from the EHR were used with slight modifications for the patient portal [e.g., calculation for due/overdue status of a test (HbA1c) was based on the future appointment date rather than the current date, as is done in the EHR for the clinician].

Patient and clinician workflow

The system was designed with the following workflow parameters: (1) only one diabetes module at a time can be open per patient; (2) a Diabetes Care Plan can only be submitted if the visit still appears in the scheduling system; (3) once submitted, a Diabetes Care Plan link appears near the patient's name on the provider schedule, even if the appointment time was changed; and (4) patient submissions autoclose after 21 days of inactivity to permit future Diabetes Care Plan creation. These rules were established to avoid having physicians receive multiple care plans from a single patient, or care plans submitted without an appointment. Our overarching goal was to be sensitive to physician concerns when introducing new technology into routine clinical care in order to maximize ongoing physician participation.

Evaluation Plan

Because of ongoing quality improvement efforts within our institution that affect various aspects of diabetes care, we felt that it was imperative to evaluate the impact of the diabetes *Patient Gateway* in a randomized controlled trial (ClinicalTrials.gov identifier NCT00251875). This study design allows us to measure the impact of the intervention above and beyond temporal trends in care. Randomization will occur at the clinic level and will involve 14 primary care practices across our health care system.

Identification of patients with diabetes is based on an algorithm using problem lists, diabetes-specific medications, and HbA1c results >7.0%. Prior work has found 98% specificity and sensitivity for this algorithm compared with a manual chart review gold-standard (authors' unpublished data). The subset of eligible patients randomized to receive the Diabetes Module will be invited via the *Patient Gateway* portal to sign a consent form, specify the name of their PCP, and complete a baseline questionnaire. Clinical outcomes in these patients will be compared with those in patients in the control clinics who have registered for a *Patient Gateway* account but have not been provided access to the Diabetes Module. Control patients will serve as active comparators in that they will receive a non–diabetes-related intervention involving family medical history and (nondiabetes) preventive services screening.

Diabetes-related study outcomes that we will be measuring include changes in the proportion of patients with up-to-date testing for HbA1c, blood pressure, and LDL-cholesterol; changes in HbA1c, blood pressure, and LDL-cholesterol levels; changes in proportion of patients prescribed medications (or with increased doses of existing medications) to treat the three conditions; and changes in proportion of patients prescribed

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anti-platelet agents, provided eye or foot exam referrals, or prescribed medications for smoking cessation. We plan to perform an intention-to-treat analysis of all patients with diabetes at study inception to compare changes between such patients in each of the two study arms. Patients will be stratified by baseline treatment modality (diet-only, oral medications only, any insulin). To address the clustering effects of clinic-level randomization and of individual providers caring for multiple study subjects, we will use a hierarchical statistical modeling technique when analyzing outcomes.

Implications

In this report we describe a web-based patient portal for diabetes management linked directly to our system's ambulatory EHR that enables patients (1) to review detailed clinical information in an educational context related to their own diabetes care, (2) to prepare for upcoming scheduled visits with their PCPs by authoring a Diabetes Care Plan, and (3) to interact in a controlled manner with their PCPs via the portal. Key elements of our project have been (1) to begin with a sound conceptual framework for action, (2) to design the web-portal based on our hypothesized mechanism of action, (3) to integrate the web-portal with physician work flow, and (4) to test the impact of this system in a rigorous, randomized controlled trial.

One of the major challenges of this project has been to create a mechanism that provides patients with access to their own selected medical record information and access to their PCPs that fits into the current model of care. Physicians have reported concerns that permitting patients to view elements of their medical records could engender patient confusion, worry, and misinterpretation.[21] Moreover, many physicians resist permitting patients to contact them directly outside of planned clinical encounters. Our solution has been to carefully link patients to specific PCPs, limit transmission of completed Diabetes Care Plans to the 2-week period preceding a scheduled visit with that PCP, and engineer the physician-side to reduce time delays. In the initial rollout phase, we have also found that significant time must be invested in training physicians to use the new system, a process that includes educational e-mails, a help line, links to a web-based educational module, discussion with practice leaders, and one-on-one demonstrations.

A significant limitation of this intervention that must be addressed is the current disparity in patient access to and comfort with on-line technology, with older, poorer, and less educated people less likely to adopt the web-based system described here.[42] The consequence of this disparity is that our study population will likely consist of younger and more affluent patients and thus may not be immediately generalizable to other patient groups. A second potential concern is that some patients may receive elements of their care outside of our hospital system. Ideally, these outside services will come to light when the patient presents to his or her PCP for care and brings the Diabetes Care Plan to review at the clinic visit.

Despite current physician reservations, innovations in information technology will ensure that the practice of medicine will continue to change. The challenge remains to develop integrated systems of care that permit transparency, enhance collaboration between clinicians and patients, and emphasize a patient-centered approach to care.[43] Extension of the EHR from the clinic to the home via web-portals represents one such new paradigm of care. Results from our study will provide clinical trial evidence for the clinical impact of one such system. Moreover, the diabetes portal described here represents a first step towards such future innovations as web-based visits and serves as a model for continuous collaborative care.

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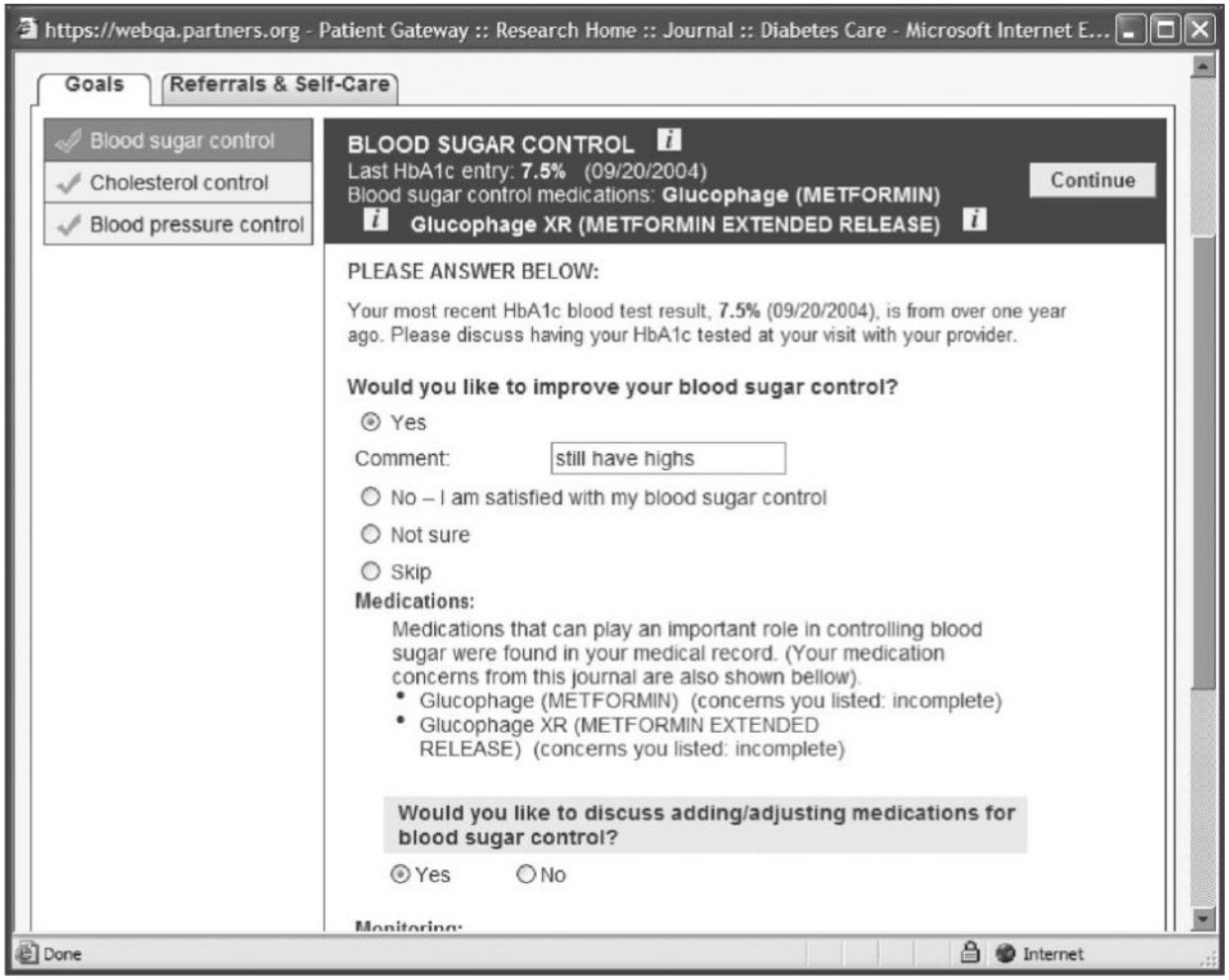

Fig. 1.

Screen shot of the Diabetes Patient Portal shows the three core diabetes-related medically managed conditions (glucose control, blood pressure control, and cholesterol control) and patient decision support related to glucose control.

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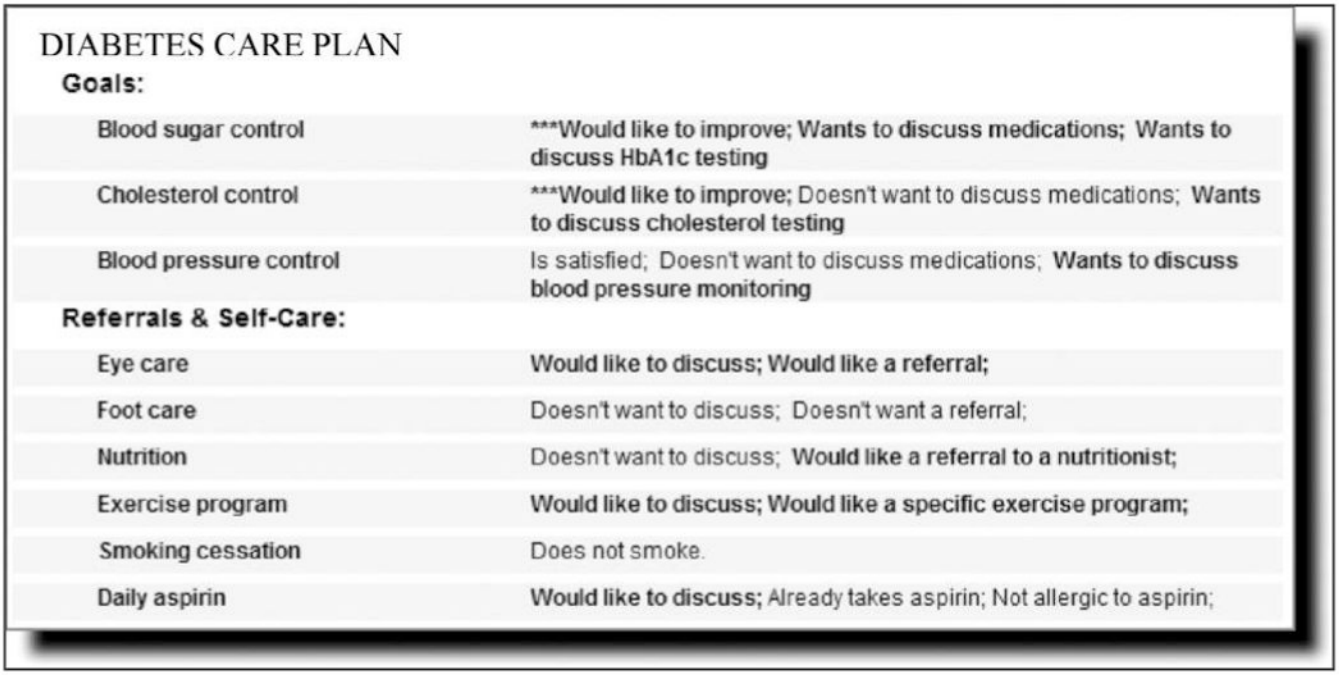

DIABETES CARE PLAN

Goals:	
Blood sugar control	***Would like to improve; Wants to discuss medications; Wants to discuss HbA1c testing
Cholesterol control	***Would like to improve; Doesn't want to discuss medications; Wants to discuss cholesterol testing
Blood pressure control	Is satisfied; Doesn't want to discuss medications; Wants to discuss blood pressure monitoring
Referrals & Self-Care:	
Eye care	Would like to discuss; Would like a referral;
Foot care	Doesn't want to discuss; Doesn't want a referral;
Nutrition	Doesn't want to discuss; Would like a referral to a nutritionist;
Exercise program	Would like to discuss; Would like a specific exercise program;
Smoking cessation	Does not smoke.
Daily aspirin	Would like to discuss; Already takes aspirin; Not allergic to aspirin;

Fig. 2.
Screen shot of a completed Diabetes Care Plan.

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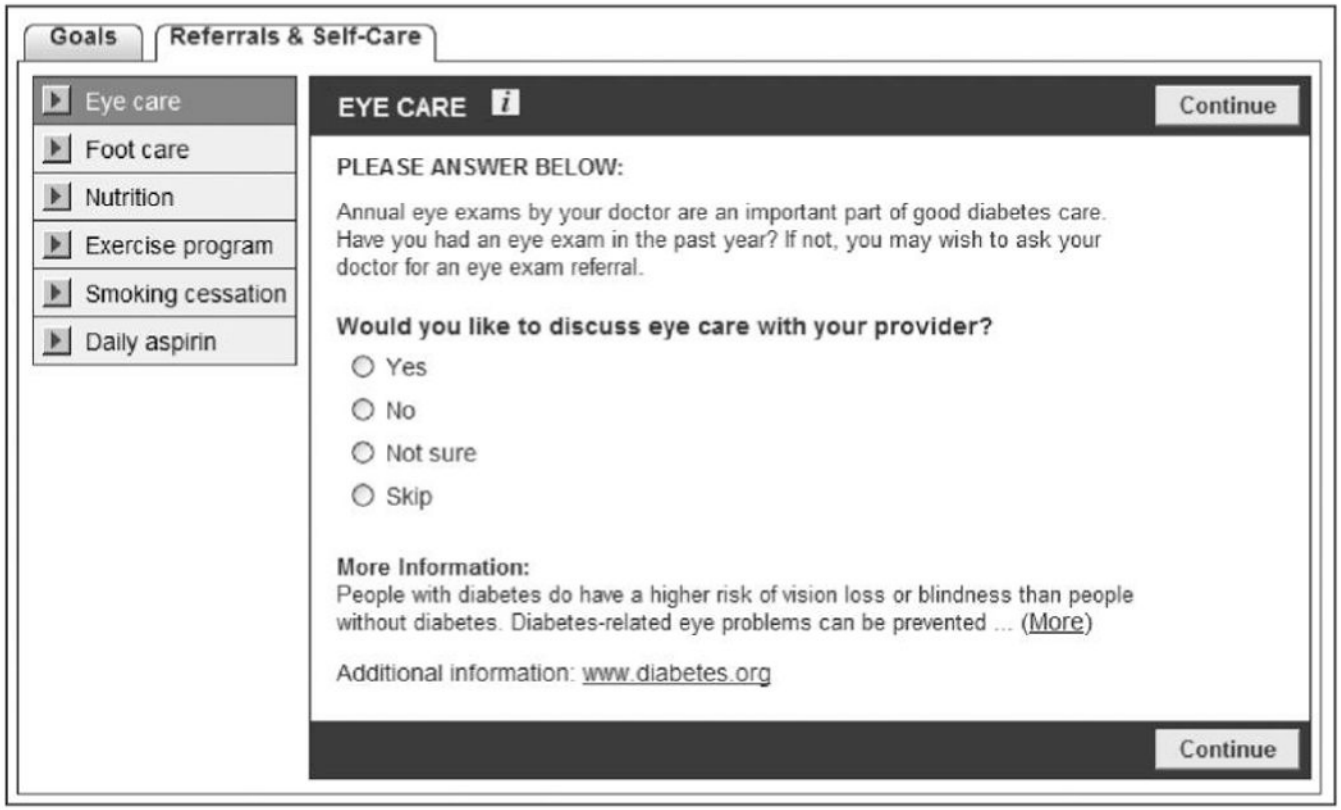

Fig. 3.

Screen shot of the Diabetes Patient Portal shows the six behavioral/referral-related areas (diet and exercise, smoking cessation, anti-platelet agent, and eye and foot exam referrals) and patient decision support related to eye care.

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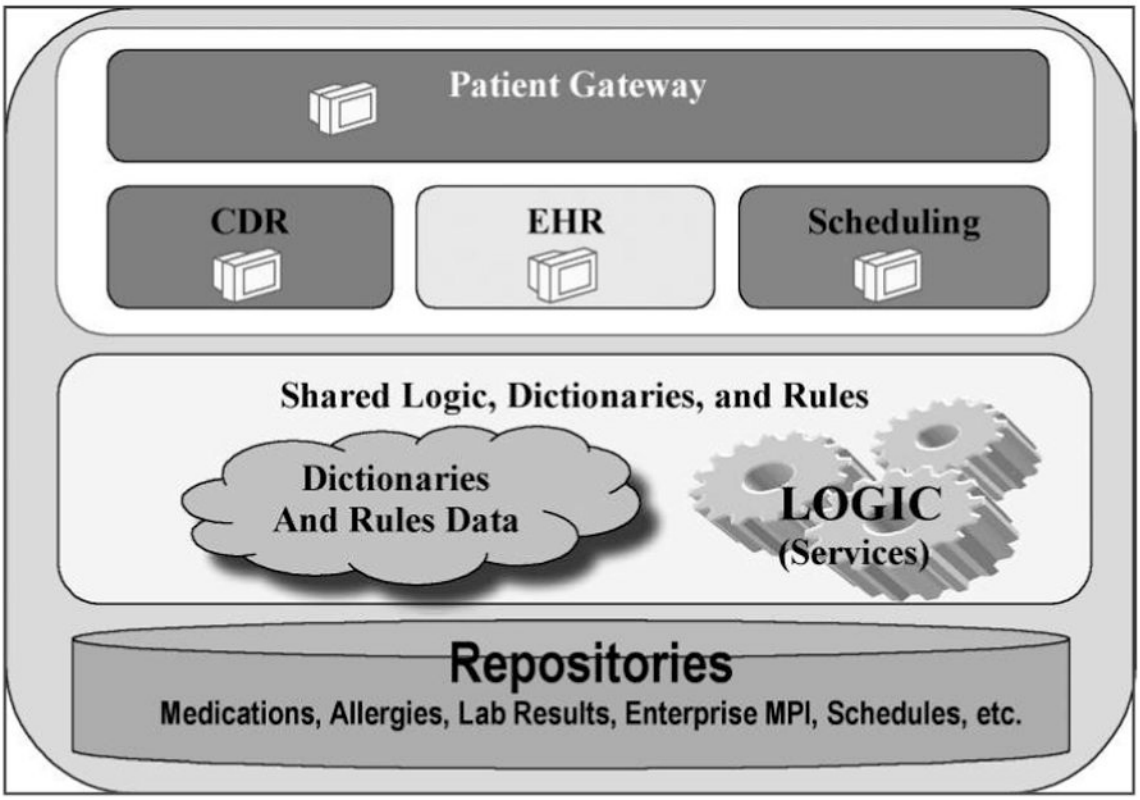

Fig. 4.

Schematic diagram shows the integration of the *Patient Gateway* patient portal with the clinical data repository (CDR), EHR, scheduling systems, and underlying decision support tools. MPI, Message Passing Interface.