An informatics approach to medication adherence assessment and improvement using clinical, billing, and patient-entered data

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ABSTRACT

The aim of this study was to describe an integrated informatics approach to aggregating and displaying clinically relevant data that can identify problems with medication adherence and facilitate patient–provider communication about strategies to improve medication use. We developed a clinical dashboard within an electronic health record (EHR) system that uses data from three sources: the medical record, pharmacy claims, and a personal health record. The data are integrated to inform clinician–patient discussions about medication adherence. Whereas prior research on assessing patterns of medication adherence focused on a single approach using the EHR, pharmacy data, or patient-entered data, we present an approach that integrates multiple electronic data sources increasingly found in practice. Medication adherence is a complex challenge that requires patient and provider team input, necessitating an integrated approach using advanced EHR, clinical decision support, and patient-controlled technologies. Future research should focus on integrated strategies to provide patients and providers with the right combination of informatics tools to help them adequately address the challenge of adherence to complex medication therapies.

BACKGROUND AND SIGNIFICANCE

Type 2 diabetes mellitus (T2DM) is a major public health crisis. Over 28 million adults have T2DM, and an additional 79 million are at risk of developing the disease.[1] Moreover, these numbers are expected to increase rapidly.[2] Direct and indirect healthcare costs attributable to T2DM exceeded US $245 billion in 2012, which accounted for almost 20% of the healthcare costs incurred by the entire US population.[3] The prevalence and costs of T2DM continue to rise at nearly epidemic rates globally as well, driven by urbanization, growing increases in obesity, and aging of populations.[4]

A key finding of major studies investigating the quality of T2DM care being delivered is the discrepancy between available management strategies and outcomes.[5–9] Many persons with T2DM do not reflect the quality of management that would be expected given their access to appropriate therapeutics. One factor that may account for this discrepancy is that patients with T2DM may not be adhering to their pharmacologic therapy. Indeed, increasing evidence indicates that patients with T2DM often show poor adherence to prescribed medication therapies.[10 11]

Even though persons with T2DM often show poor adherence to medication regimens, the reasons why patients do not take their medications as prescribed are poorly understood.[12] Previous studies on adherence have relied on patient self-report data on medication use, or they have used more 'objective' measures such as gaps in prescription coverage or technologies to determine if patients are taking their medications. An example of a technology to measure adherence is the electronic medication event monitoring system (MEMS) cap, which documents when a pill bottle is opened.[13–15] Such approaches have limitations, such as accuracy, reporting and response bias, and limited effect size.[16]

It is often assumed that the number of medications, and the complexity associated with their appropriate use, is a contributing factor.[17 18] However, a polypharmacy regimen, while common among patients with T2DM, is not the only cause of poor adherence.[11 15] A wider range of factors, including social, psychological, and economic situations, have also been implicated and should therefore be considered by clinicians when working with patients to manage medication therapy.[19] Unfortunately, it is not common for primary care providers to routinely assess whether their patients are having difficulty in following a medication regimen.[20] Indeed, few have assessed the role of barriers perceived by patients to medications use and how perceived barriers may be addressed by intervention.

To address medication adherence problems facing individuals with complex medication regimens, we have developed an integrated dashboard to help clinicians identify which patients with T2DM may have low adherence and face barriers that inhibit them from taking their medications as prescribed. The dashboard combines objective data on medication possession ratios with laboratory and point-of-care testing data, as well as patient-entered data on perceived barriers to adherence. By integrating information and presenting it through the electronic health record (EHR) at the point of care, we seek to better inform T2DM therapy decision-making processes and increase the communication between patients and their providers about appropriate medication use.

MATERIALS AND METHODS

System description

The clinical dashboard (figure 1) is a Java-based module that plugs into the Regenstrief CareWeb framework, an open-source EHR platform developed by the Regenstrief Institute Center for Biomedical Informatics. When the clinician selects a patient in CareWeb, the dashboard refreshes with

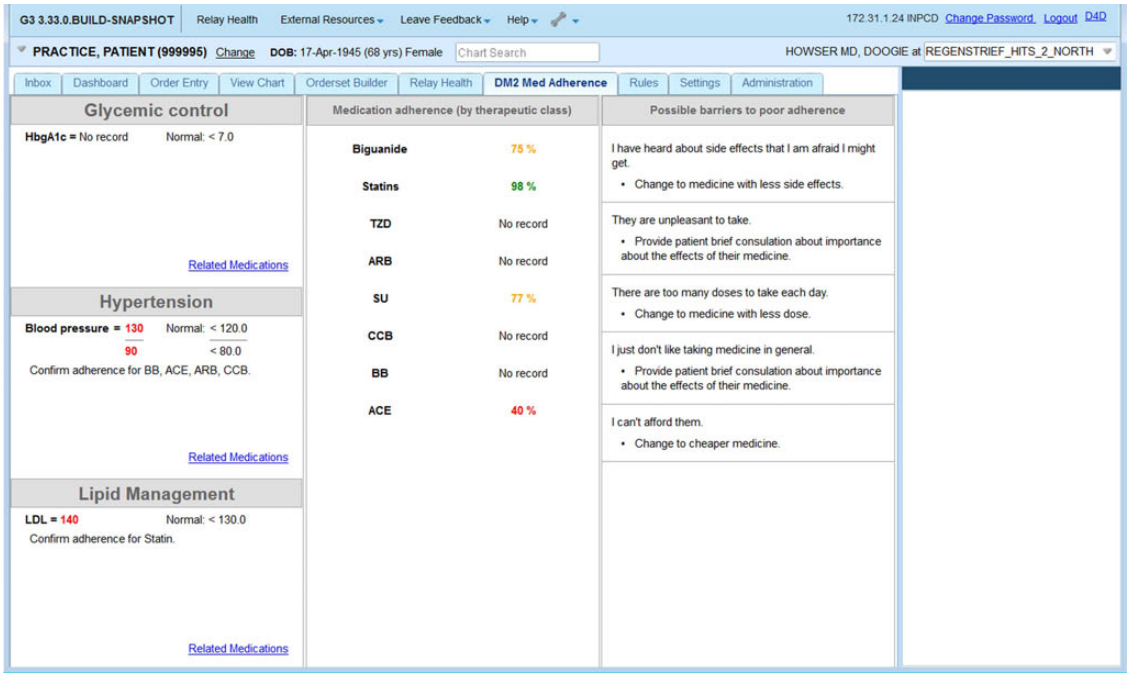

Figure 1 Screenshot of a clinical dashboard for reviewing key medication adherence information from three integrated sources: electronic health record, pharmacy claims, and personal health record.

content from three distinct sources (figure 2). First, the dashboard requests blood pressure, the latest low-density lipoprotein cholesterol value and latest hemoglobin A_{1c} (HbA_{1c}) value from the patient's medical record. Next, the dashboard calls the clinical decision support system (CDSS) for information about the patient's medication-dispensing events. Finally, the dashboard queries the patient's personal health record (PHR) for data on perceived barriers to medication adherence. The dashboard displays the data from all three sources in distinct areas on the screen.

The CDSS, an independent web service in the Regenstrief infrastructure, provides the dashboard with information on current adherence to prescribed medications for treating T2DM and cardiovascular risk factors. The CDSS gathers medication refill data from the Indiana Network of Patients Care (INPC), one of the nation's largest and most tenured health information exchange networks with more than 55 hospitals as well as data sources such as Surescripts, a pharmacy benefits manager clearinghouse, and pharmacy claims-based dispensing data from payers including Medicaid.[21 22] Using pharmacy claims data available from the INPC, the CDSS calculates the proportion of days covered (PDC), which has been shown in numerous studies to accurately identify patients who fail to fill or refill their medications as directed by their physician or pharmacist for any number of reasons.[23]

The PHR was implemented on the Open Medical Record System (OpenMRS) platform,[24 25] although the dashboard could be integrated with any PHR. OpenMRS includes a forms module that allows collection of standardized data from patients. Using the forms module, we implemented a five-point Likert-style, validated questionnaire developed by researchers at the Diabetes Translational Research Center affiliated with the Indiana University School of Medicine.[26 27] The questionnaire uses 20 items to assess possible barriers to medication adherence. For example, valid responses as to why patients may not take their prescribed medications include 'I can't afford them' and 'I just forget to take them.' Individual items are grouped into categories and ranked on the basis of aggregate scores from patient responses. The three highest ranking categories are stored for retrieval by the dashboard.

System development

User-centered design principles were used to develop the system. Clinical and informatics experts outlined high-level system functions and goals. Then, with input from primary care physicians and T2DM educators, engineers and human-computer interaction specialists iteratively developed the dashboard and PHR interfaces. Multiple iterations were reviewed by the extended team of developers and practicing clinicians. For example, early iterations used a stoplight metaphor to represent medication adherence. Multiple stoplights were confusing to clinicians, who preferred to see numeric PDC values with abnormal values highlighted. The alternative approach also fits better with the general design of CareWeb and other projects, including the redesign of the Regenstrief Medical Gopher.[28]

System workflow

Lack of fit between a clinical informatics system and its users, as well as users' work environment, can create inefficiencies and facilitate unintended consequences, which can prevent achievement of the primary aims of the system and lead to a decrease in patient safety.[29–32] We implemented the dashboard so it would integrate into existing clinical workflows used in the pilot primary care clinics. Clinicians in these clinics are accustomed to opening patient charts before entering the exam room. Since the dashboard is populated upon patient selection, the data are available for review before the clinical encounter. Furthermore, we implemented a reminder to prompt clinicians that the dashboard is available when they select a diabetic patient whose data can be viewed. We further engineered the dashboard to support a variety of patient-centered medical home models being tested throughout the health system in

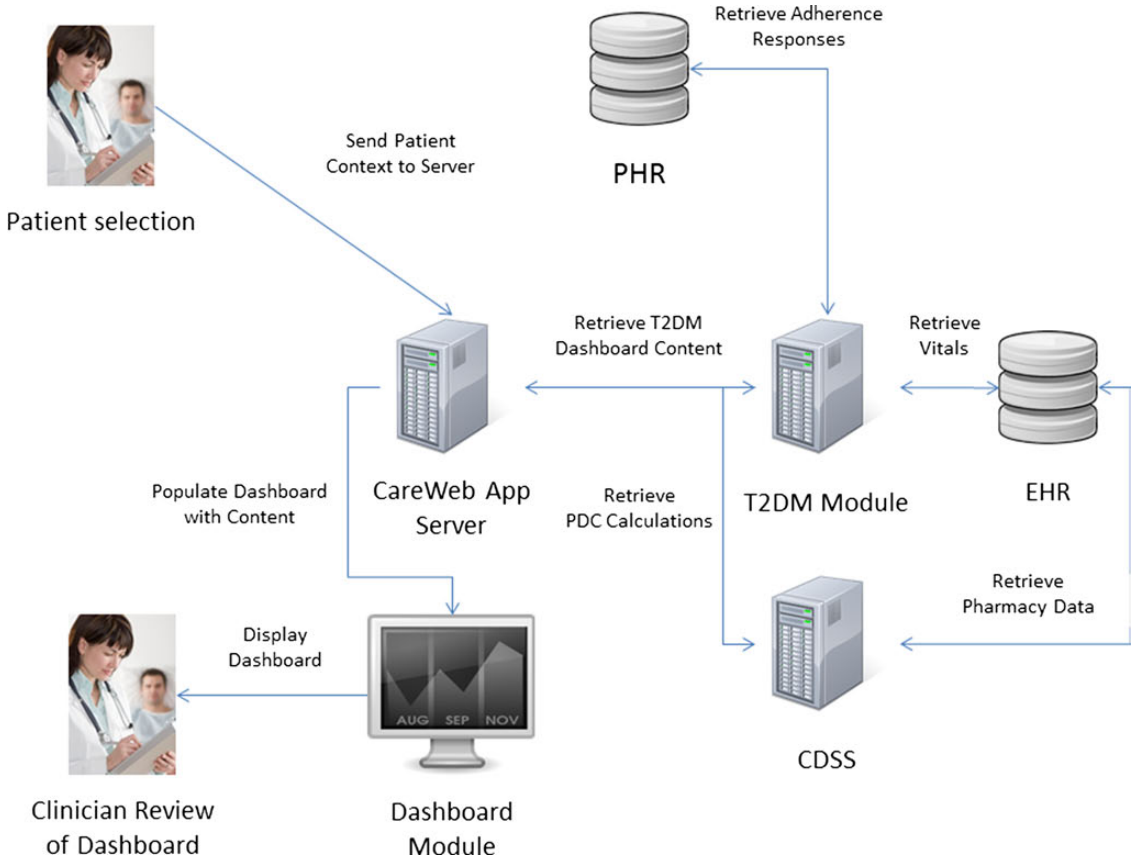

Figure 2 Information flow diagram outlining how the clinical dashboard for medication adherence retrieves and integrates data from the electronic health record, pharmacy claims, and personal health record. CDSS, clinical decision support system; EHR, electronic health record; PDC, proportion of days covered; PHR, personal health record; T2DM, type 2 diabetes mellitus.

which we are conducting the pilot. This will enable the dashboard to be used by a variety of clinicians on medical home teams in the future, including pharmacists and social workers, who play critical roles in helping patients address barriers to medication adherence.

Study design

The dashboard and PHR were released into production at the end of 2012. In early 2013, we started enrolling providers and their patients at three community health centers in metropolitan Indianapolis into a 6-month pilot demonstration of the dashboard. We seek to enroll 20–30 clinicians and 150–200 patients to examine the efficacy of the dashboard for improving patient–provider communications about medication adherence.

The pilot will be evaluated using a pre–post quasi-experimental design involving mixed methods[33 34] to assess providers' and patients' usage of the system, effects on T2DM control as well as medication adherence, and perceptions of providers and patients regarding clinician–patient discussions about medication adherence. Usage will be captured from system logs. CareWeb and the CDSS capture both logins and clicks as users navigate between the EHR, the dashboard, and other CareWeb components. Perceptions about and occurrence of adherence-related discussions will be captured in surveys of providers and patients before and after the demonstration period. In addition, we will collect demographic information about patients and providers to enable comparison across health center locations and socioeconomic data, which has been shown to affect patient access to the internet, impacting on PHR usage.[35 36] Patients will further be asked to complete the survey on medication barriers at least twice during the 6-month demonstration.

Analysis will principally focus on comparing PDC rates before and after the pilot (quantitative). Satisfaction and perceived impact on provider–patient conversations will be a secondary target of the analysis (qualitative). In addition, we will further compare medication barrier responses over time (quantitative) in relation to perceptions of the dashboard (qualitative), conversations (qualitative), and diabetic control (quantitative). Individual quantitative and qualitative analyses will be integrated[37] to inform our interpretation of the system's impact on process and health outcomes. Our hypothesis is that the dashboard will improve not only the volume and quality of conversations between providers and patients but also medication adherence rates and T2DM control.

DISCUSSION

In this paper we present a novel informatics approach to address the challenge of medication adherence in patients with chronic and complex diseases such as T2DM. The goal of our approach is to improve adherence by providing personalized assessment and facilitating meaningful discussion between patient and provider using an integrated informatics strategy. It is the first approach of which we are aware that combines objective and subjective data and integrates EHR with consumer-oriented technologies to address medication adherence. In this context, our approach increases the possibility of patient engagement and meaningful clinical discussion that may improve health outcomes.

In the traditional approach, physicians assess barriers to adherence by asking patients simple, straightforward questions about whether or not they are taking prescribed medications. This approach is not only subject to bias and fear of interpersonal confrontation, but lacks accuracy compared with the use of a validated set of questions. Unplanned, conventional conversations to assess medication adherence are therefore affected by clinicians' underestimating the unknown or uncommon barriers. Asking incomplete, uninformed questions will lead to inaccurate responses from patients and consequently to inaccurate clinical decisions.

In addition, conventional methods rarely maintain the consistency of checking the adherence at each visit. This enables the provider to capture issues affecting adherence that may be situational in nature. By integrating the tool into the EHR and incorporating the system into work practice, it will be more likely to continually maintain the assessment during each clinical visit. This continuous assessment is critical for long-term chronic diseases such as T2DM.

Several studies have investigated potential barriers to medication adherence. However, these studies often analyze the result of the recruited group and apply the sum of this result to each individual. In most cases, individuals are treated on the basis of the average of other groups where individual preference and under-represented groups are neglected. Analyzing data at the individual level and applying it to the same individual will have far more impact than using generic information.[38] The growing availability of EHRs, PHRs, and CDSS[39–41] for use in practice will make tailored or patient-centered approaches to medication adherence more feasible.

To fully realize the potential of EHR, PHR, and CDS technologies to affect population health outcomes, informatics approaches need to be integrated. Prior studies in informatics to improve adherence have focused on single modalities to change provider or patient behavior. For example, in Vollmer *et al*,[42] an interactive voice response system called patients who appeared to have gaps in refilling their asthma medication. The system was statistically significant in changing adherence, but the mean change was not clinically meaningful. Similarly, a recent systematic review of patient portals identified just one study that demonstrated an effect on T2DM care delivery.[43] However, in the one identified study, the portal was found to be associated with a change in medication regimen but had no impact on clinical outcomes as measured by HbA_{1c} and blood pressure.[44] In this article, we outline one approach that integrates multiple informatics tools to address medication adherence in a coordinated fashion. While this one approach may not be the only method to stimulate better adherence for patients with chronic illness, we believe that future approaches in informatics need to draw upon the power of EHRs, PHRs, and CDSS to make the measurement and monitoring of medication adherence easier to perform in the context of routine clinical care.

We are currently gathering data on the approach we describe in this article. The evidence we gather will help to demonstrate whether our hunch that an integrated approach is more effective than individually targeting providers or patients is correct. Initial reactions from healthcare administrators, providers, patients, and researchers have been quite positive and reassure us that our integrated dashboard is headed in the right direction. We are eager to share the results with the biomedical informatics community.

CONCLUSION

A variety of electronic data sources are increasingly available in real-world clinical settings and are underutilized resources for addressing the complex challenge of measuring and monitoring medication adherence. We describe an approach for integrating multiple electronic data sources to inform patient–physician communication regarding medication use. Ultimately we hope the approach can improve clinicians' measurement and monitoring of medication adherence, leading to better outcomes for patients. While our approach is unlikely to be the only way, future research should explore integrated strategies that include both the patient and the wide array of care providers engaged in treating complex chronic diseases such as T2DM.

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