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SYMPOSIUM

Implementing a Web-Based Home Monitoring System within an Academic Health Care Network: Barriers and Facilitators to Innovation Diffusion

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Abstract

The practice of outpatient type 2 diabetes management is gradually moving from the traditional visit-based, fee-for-service model to a new, health information communication technology (ICT)-supported model that can enable non-visit-based diabetes care. To date, adoption of innovative health ICT tools for diabetes management has been slowed by numerous barriers, such as capital investment costs, lack of reliable reimbursement mechanisms, design defects that have made some systems time-consuming and inefficient to use, and the need to integrate new ICT tools into a system not primarily designed for their use. Effective implementation of innovative diabetes health ICT interventions must address local practice heterogeneity and the interaction of this heterogeneity with clinical care delivery. The Center for Connected Health at Partners Healthcare has implemented a new ICT intervention, Diabetes Connect (DC), a Web-based glucose home monitoring and clinical messaging system. Using the framework of the diffusion of innovation theory, we review the implementation and examine lessons learned as we continue to deploy DC across the health care network.

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Introduction

There are nearly 20 million patients with type 2 diabetes mellitus (T2DM) in the United States, a number that is projected to double by 2050.[1] The costs of inadequate diabetes control are sobering, with over $174 billion spent on diabetes-related health care in 2007.[2,3] While rates of glycemic control have been improving, over half of patients remain above the hemoglobin A1c (HbA1c) goal.[4,5] Many T2DM patients also have poor cardiovascular risk factor control, further jeopardizing their health. Indeed, over two-thirds of T2DM patients with hypertension in the United States are not being controlled to blood pressure levels less than 140/90 mm Hg.[6,7] Given these shortcomings in T2DM management, innovative approaches to improve control of glycemia and related cardiovascular risk factors must be developed and implemented if we are to significantly improve the care of patients with T2DM. Innovations in health information communication technology (ICT) have the potential to transform outpatient T2DM care.

The Center for Connected Health (CCH) at Partners Healthcare has developed a Web-based remote glucose

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Abbreviations: (CCH) Center for Connected Health, (DC) Diabetes Connect, (DIT) diffusion of innovation theory, (HbA1c) hemoglobin A1c, (ICT) information communication technology, (RE-AIM) Reach, Efficacy, Adoption, Implementation, Maintenance, (T2DM) type 2 diabetes mellitus

Keywords: adoption, diabetes, diffusion of innovation, information communication technology, self-management

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monitoring system to support diabetes care. Diabetes Connect (DC) is an innovative ICT program using Web-based technologies to augment care between office visits by supporting patient self-management strategies and providing clinicians with access to structured patient home glucose data. In this report, we describe our experiences with implementing the system into three different outpatient practice models and use these models and other program experiences to define the barriers and facilitators to adoption of DC as related to the five factors described in the diffusion of innovation theory (DIT).[8]

The DIT describes how new innovations or technologies, such as DC, move through a population along an adoption curve based on the following five factors: (1) the perceived relative advantage of the innovation compared to the current system, (2) compatibility of the innovation with the existing values and culture of the organization, (3) complexity of understanding the innovation, (4) the ability to pilot the innovation without a required longer term commitment, and (5) the opportunity for others to observe the results of the innovation in practice. In effect, these five factors work in conjunction to minimize the perceived risk and uncertainty in the decision to adopt a new innovation.[8,9] Further, within a network of clinical practices (e.g., the target population), there are five categories describing the types of adopters: innovators, early adopters, early majority, late majority, and laggards. Each of these groups possesses certain qualities that make them more or less likely to adopt an innovation; as the category names suggest, the innovation is adopted first by the innovators and moves through each of these populations over time with the laggards accepting at the end of the diffusion process. While each of these groups differs in the speed to adopt, for all clinical practices, the decision to permanently adopt depends on the innovation continually demonstrating value over time.[10,11]

Overview of the Diabetes Connect Program

The Partners CCH launched DC in February 2009. The diabetes program provides patients with the technology to transmit their blood sugars directly from a glucometer to a centralized remote monitoring database. The glucose data are then presented in a context-rich Web site intended to help the patient with self-management strategies (**Figure 1**). Clinicians have access to a "population management" view (a stand-alone Web site outside of the clinical electronic medical record systems) that lists each participating patient and corresponding key data on a single line (see **Figure 2**). Clicking on a specific patient name allows a "drill-down" view of additional data for that patient. Clinicians can also set individualized parameters triggering alerts for specific patients and can initiate messaging interactions with participating patients. Building on our initial infrastructure for home glucose data collection, we have subsequently expanded the program to include home blood pressure monitoring.

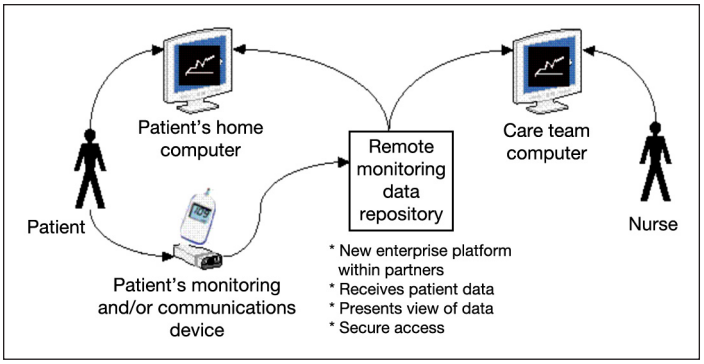

Figure 1. Remote monitoring program.

Relationship of Diabetes Connect to Diffusion Innovation Criteria

The five factors described by the DIT that contribute to the decision to adopt technologic innovations are described in the context of the DC program:

1. Relative Advantage

The primary theoretical benefit of using DC is that it provides a convenient mechanism for patients to organize and rapidly share blood glucose readings with their practice team (thereby replacing the handwritten logs, forgotten glucometers, and the many other reasons why data might not be accurately shared with clinicians regularly). Moreover, the asynchronous communication channel and the self-management tools available on the Web site are intended to help support patients outside of their scheduled office visits. These program benefits highlight the relative advantage this program offers compared to existing processes. Leaders in the early adopter practices were willing to pilot the program, in part, based on the perceived program benefit to improve current diabetes care.

2. Compatibility with Existing Workflow

From a practice leadership perspective, an important driver in the decision to adopt the new program was the potential financial benefit resulting from improvement

on the pay-for-performance measures used for managing the commercially insured diabetes population. While the program does not align with the current fee-for-service reimbursement and could create new workflow challenges, the potential for this program to improve outcomes weighed in favor of the decision to pilot DC.

3. Complexity

Diabetes Connect was offered at no cost to the practice and required no technology investment from patients and clinicians. Diabetes Connect uses existing technology in the patient home (phone line) and at the practice (Internet access). The main barrier is the integration to clinician workflow since DC is not integrated into the standard use clinical systems. There will continue to be challenges in promoting the program until the workflow between clinical systems is integrated.

4. Trialability

A key attraction for the early adopter practices was the opportunity to pilot DC prior to committing to a broader implementation. Pilot patients were identified and enrolled for a trial period, and the practice could choose to discontinue if the program did not demonstrate value.

5. Observability

A significant foundation of the program is to gather feedback for continuous improvement and conduct a rigorous program evaluation. In conjunction with the communicated benefits from the early adopters, producing evidence of value through evaluation is important to gain interest from the early majority and later adopter groups.

Approach to Initial Implementation—Early Adopter Phase

According to the DIT, early adopters have a shorter decision process time and are able to deal with abstract concepts rather than requiring evidence and observation prior to adopting an innovation. This implies early adopters are more willing to accept the uncertainty in adopting an innovation. To their peers, they are respected as opinion leaders.[8] Therefore, gaining the support of early adopters is critical to the ongoing deployment of DC. In the first 12 months of program implementation, DC was implemented with three "early adopter" clinicians at three practices within our health care network. At the time of initial implementation, no outcomes had been measured, and the evidence supporting the program was limited to small-scale pilot trials.[12] Program rollout at these three practices followed these steps: (1) discussion with practice medical director to assess the level of support from practice leadership and to gain commitment to pilot DC, (2) training of clinical staff (e.g., physicians, nurse practitioners, nurses, diabetes educators) who would be using the tool, and (3) identification of 5 to 10 initial patients from each practice to enroll into the program.

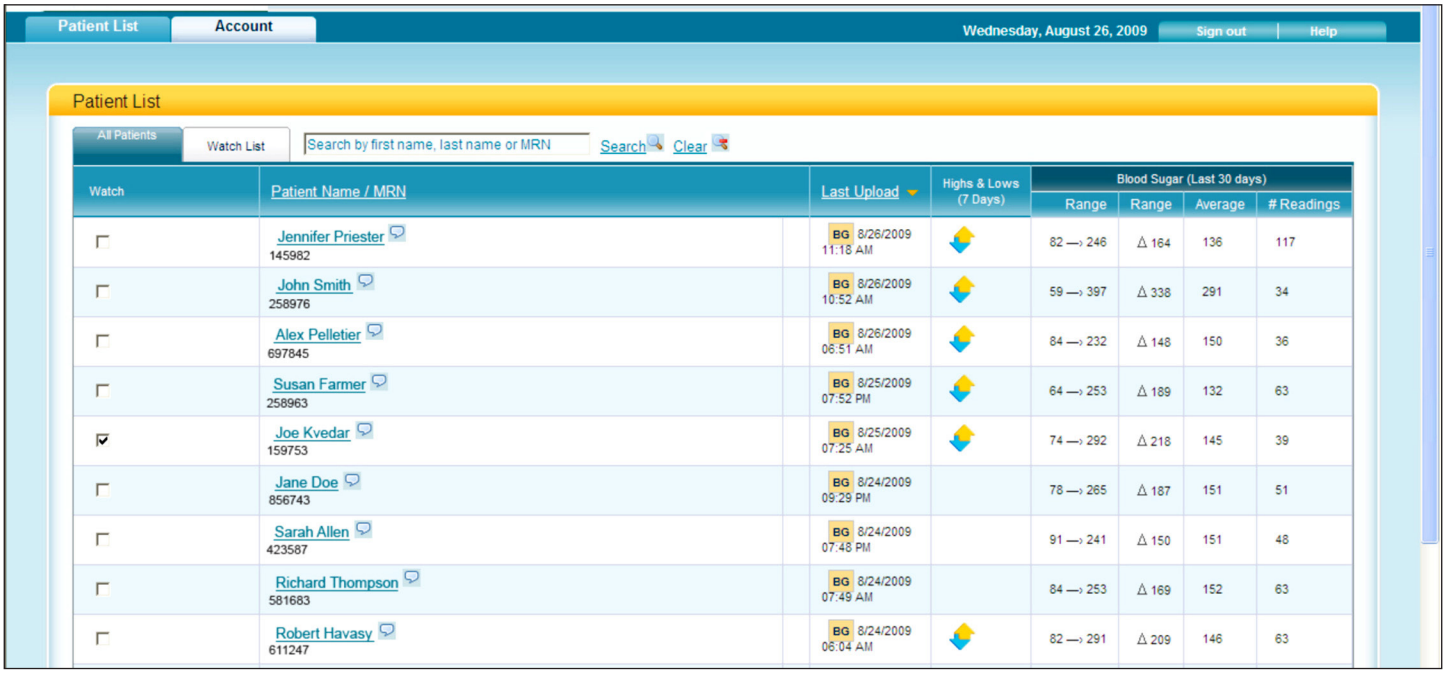

Figure 2. Diabetes Connect provider population view.

After this brief trial phase of DC, each practice could then decide whether to extend the program to a larger number of patients.

The ongoing implementation of DC relies on clinicians selecting the patients, explaining the value of the DC program, and communicating expectations about frequency of testing directly to the patients. The CCH takes an active role in evaluating Connect programs once they have been implemented into clinical practices. This evaluation and analysis of program implementation and clinical use is an important driver to adoption for the early majority practices, whose leaders are more deliberate and require more information in their decision-making process according to the DIT.

Differences in Implementation Success by Practice Setting

Type 2 diabetes patients receive care in a wide diversity of practice models within our health care network. Successful implementation of innovative ICT tools therefore requires that the tools be adapted to different local clinical practice environments. As we developed an implementation plan for DC, we identified two key features that had a critical impact on how the tool was used: (1) physician specialty (primary care provider versus endocrinologist) and (2) ability of non-medical-doctor team members to write diabetes-related prescriptions. Among our early adopter practices, we defined three practice models based on these features (practice 1, endocrinologist with nonprescribing support staff; practice 2, primary care practice with prescribing support staff; and practice 3, primary care practice with non-prescribing support staff). The major difference between the two primary care practices was that practice 2 used a "carve out" diabetes care management team (including registered nurses, certified diabetes educators, and a nutritionist) that could make algorithm-driven medication adjustments, whereas practice 3 employed a certified diabetes educator/registered nurse but reserved medication management changes as primarily the responsibility of the primary care physician. Of note, primary care practices that lacked diabetes-specific support staff were not willing to implement the DC program at all, likely because of their inability to adapt a highly visit-based care model to the requirements of non-visit-based ICT diabetes management.

Here we report our experience piloting and implementing the DC program in each of these three practice models to provide our insights into barriers and facilitators of technology adoption within a health care network (**Table 1**).

Patient Enrollment

Practice 2 had the highest rate of patient enrollment, likely due to their ability to incorporate the program into their regular workflow using the help of their administrative assistant to support the process by creating notifications and reports to the nurses weekly. Practices 1 and 3 consisted of individual clinicians without administrative resources to help support the program processes within the context of their practice.

Patient Activity

Persistent practice and patient activity reflects whether DC continues to provide value to patients and their clinicians. At practice 2, the average number of readings and uploads was higher compared to practices 1

Table 1.
Patient Enrollment, Activity, and Outcome Data Obtained from Our Three Practice Models

	Patient enrollment			Patient activity		Patient outcomes		
	Number of patients enrolled	Rate of enrollment (patients/ month)	Average logins per week/ provider	Average percentage of readings[a]	Average percentage of uploads[a]	Average pre-HbA1c	Average post-HbA1c	Average change in HbA1c
Practice 1	29	2	2.6 (n-1)	32	29	9.65	8.71	-0.94
Practice 2	48	4	3 (RN1) 6 (RN2) 6 (admin)	70	62	9.95	8.19	-1.77
Practice 3	14	1	2 (n-1)	30	27	9.44	8.74	-0.7

[a] Percentage is calculated as number of people who tested/uploaded at least once a month in the 12 months they were enrolled.

and 3. Some of the difference may be explained with the additional resources supporting the program at practice 2, but may also be reflective of how the program is communicated to the patient and reinforcing the necessity for ongoing engagement.

Patient Outcomes

The results show practice 2 as having a larger change in HbA1c for their patients, probably owing to better patient engagement and the seamless integration of DC in the practice workflow.

The continued patient enrollment by "early adopter" practices after completion of the initial pilot phase provides evidence for perceived program value in these practices. Deploying the DC program beyond the early adopter practices to the "early majority" practices requires understanding and addressing the barriers to adoption while optimizing the facilitators.

The Transition from "Early Adopters" to "Early Majority" Practices

In the first 12 months of our initial implementation, our program deployed to seven sites, including the three original pilot sites, and reached approximately 3% of the total potential T2DM population, defined as commercial patients with HbA1c >8%, across the network. Beginning in the second half of our first year and continuing through the first half of our second year, we have now enrolled 14 additional practices into the Connected Health program (including both glucose and blood pressure monitoring).

Key factors to transition from "early adopter" to "early majority" practices included our efforts to identify "champions" at each practice and our presentation and communication of preliminary evidence demonstrating outcomes from the initial results to senior medical management leaders (**Figure 3**). For example, in late 2009, the presentation of Blood Pressure Connect to senior leadership at one of our academic medical centers helped identify multiple new primary care practices tied into the academic medical center. Gaining leadership support at these senior level management meetings was an important organizational contributor to reduce the uncertainty of those practice clinicians considering the program.

While senior leadership is imperative in moving forward the decision to pilot DC, demonstrating ongoing value to all practice stakeholders, particularly the end-user clinicians, during and beyond the initial pilot phase is essential in order for the program to be fully integrated into continuing practice operations.

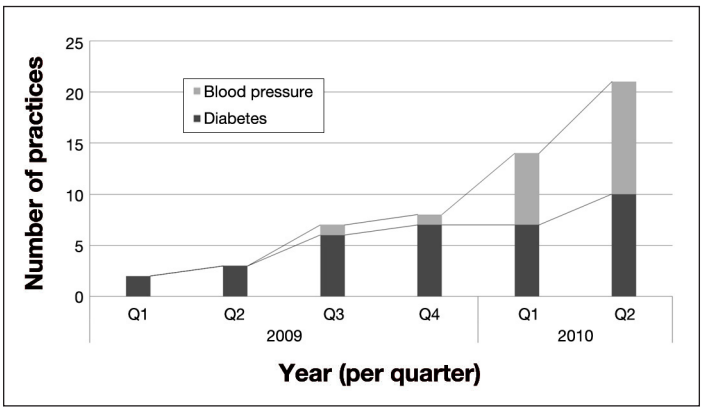

Figure 3. Growth of practices enrolling patients.

Lessons Learned

The Reach, Efficacy, Adoption, Implementation, Maintenance (RE-AIM) framework[13] is a useful tool for evaluating the broad range of activities and considerations required for new interventions to become adopted long term. In conjunction with the organizational framework of the DIT, this approach helps to elucidate the essential areas of focus as DC, or any new innovation, is introduced and eventually becomes transformed to an established part of practice.

We organize our "lessons learned" according to the RE-AIM framework created by Glasgow and colleagues[13] for the evaluation of new "real-world" interventions. This RE-AIM framework has been widely used in implementation research as a concise method for assessing the different components of successful implementation.

Reach

Champions at existing practices communicating the value of the program to their peers have promoted our reach to new practices. However, despite initial success in enrolling practices, we have been able to reach approximately 4% of the diabetes patient population at the 10 practices currently using the DC program. Thus we have encountered a second translational block, which is patient identification and enrollment within the practices. Potential reasons for the lower rate of patient enrollment in the program is the preconceived notion that their patients are unfamiliar or uncomfortable with technology and therefore would not be good candidates for the program. We are continuing to address this barrier through evidence that current program

participants represent a wide demographic and socio-economic range. Our reach has also been limited by practice resource constraints. At the practice management level, for the DC program to reach more practices, one of the important drivers to note is the eventual realignment of practice incentives to incorporate this type of asynchronous care delivery in clinical practice.

Efficacy

The efficacy, or demonstrated outcomes, of the program is clearly dependent on how effectively the practice implements DC. From our early results, among our initial three practices, the practice offering a centralized multidisciplinary team working closely with patients (practice 2) has better clinical outcomes than the other two initial practices. In addition to clinical results, practice 2 also showed better engagement with patients, as indicated by a higher number of active patients (defined as uploading their glucose readings more frequently than practices 1 and 3). This not only establishes a link between practice level factors and activity, but also activity and patient engagement, potentially translating to better clinical outcomes.

Adoption

Relating back to the DIT, adoption requires a multi-pronged approach. From our experience to date, some practices in our network that declined the program tended to express concerns about the potential time commitment required to integrate the Connect programs into their daily practice. Specifically, some practices have reported concerns regarding the lack of systems integration and the potential challenges responding to the volume of new data generated by DC. Gaining adoption from these types of practices will necessitate program workflow improvements or potentially other solutions alleviating the resource concerns. Over time, we have also learned that provider and patient confidence in the technology plays a very important role in their adoption of the program.

Implementation

Regarding the consistency of delivering the program, in the three practices evaluated, the clinicians reported an overall increasing comfort level in offering the program to their patients as well as an increasing proficiency using the program Web interface over time.

Currently, the clinician is the primary decision maker in selecting patients for the program. Even though program processes around training and support are standardized, the three practices differ in their implementation approach. For example, the absolute rate of enrollment and number of clinician logins are highest for practice 2. We contend that practice 2 was better able to incorporate the program into practice because of the structure of the team and the ability for the clinicians to utilize an administrative resource to support consistent program operations. Inconsistency of program operations may lead to patient confusion regarding program expectations and use, or result in enrollment and setup issues. While all practices received standard support from the CCH program staff for initial setup and ongoing customer service for patients, inconsistency in program operations continue to be an area of constant improvement.

Maintenance

From our observation, practice 2 has been consistently demonstrating better results in terms of activity and outcomes compared to practices 1 and 3. We believe an important contributor to long-term implementation of the program is based on the availability of resources and commitment of practice leadership. Practice 2 is a diabetes center focused on diabetes education and management and is therefore in a better position to optimize resources and incorporate the DC program into their ongoing operations. The commitment from the practice leadership is also important to strengthen and promote ongoing participation in the program. Lastly, the CCH program team outreaches to each practice site on a frequent basis to check in and gather feedback and ideas for improvement. Maintenance is a continuous effort, as practice needs continue to evolve.

Limitations

Because results were not gathered in a controlled, randomized trial, the data from various practices have limited comparability, despite there being no overt significant differences in demographic composition or disease severity. These measures do help demonstrate trends rather than proving any causal relationships.

Although most of the feedback obtained from practices has been gathered in multiple unstructured interviews with providers, we are implementing a systematic qualitative analysis with Connect providers for future evaluation.

Summary

The success of DC depends on many factors: design of efficient workflow incorporating the program into regular clinical activity, vocal leadership championing the program,

consistent organizational support to adjust processes and realign incentives, and demonstrated results of the program. The continual process of accepting and incorporating new technology programs requires an understanding of what drives adoption at each stage, from pilot to full implementation, and across different groups, from innovators to laggards. With the competing demands and existing constraints in most practice settings, learning how to apply the DIT framework to persuade, support, and move adoption of DC will be an ongoing and essential effort to realize the full potential and positive impact to health delivery.

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