Information Technology for the Treatment of Diabetes: Improving Outcomes and Controlling Costs

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ABSTRACT

BACKGROUND: Diabetes in particular presents an ideal opportunity for the incorporation of information technology (IT) in the provision of care. The disease is highly prevalent in managed care populations, is frequently associated with comorbid conditions, and requires multiple medications in its management. Furthermore, effective diabetes care involves the monitoring of several measures of disease control, such as hemoglobin A1c (A1c) and lipid levels, by several different levels of providers, such as physicians, nurse practitioners, physician assistants, pharmacists, and dietitians. All of these factors combined make diabetes an opportune disease state for a case study of the implementation of health information technology (HIT) in managed care.

OBJECTIVE: To review practical applications of HIT for improving the delivery of care in diabetes management.

SUMMARY: Between 1990 and 2002, the incidence of type 2 diabetes increased by 61% in the United States. The total costs associated with diabetes have been increasing since the late 1970s as well, with a more dramatic rise over the last 10 years. In fact, the total cost of diabetes in the United States will approach $200 billion per year by the year 2020.

In order to improve diabetes management efforts nation wide, the goal of glucose-lowering therapy has been recommended to lower the hemoglobin A1c (A1c) to <7% and keep it below that level long term. Other measures beyond A1c levels have also been identified as being important components to effective diabetes management and incorporated into national treatment recommendations, providing an ideal opportunity for the incorporation of HIT interventions. These interventions have been aimed at 3 different groups of stakeholders in managed care: payers, providers, and patients.

CONCLUSIONS: While uncontrolled diabetes remains a major concern in managed care from both a health and a cost perspective, implementation of information technology enabled diabetes management (ITDM) has demonstrated significant potential for improving processes of care, preventing the development of diabetic complications, and generating cost savings. ITDM improves the synthesis of information, the delivery of knowledge, and the efficiency of communication, allowing for coordination of care across delivery teams. Of the existing technologies targeting providers, patients, and payers, provider-centered interventions, such as diabetes registries currently show the most potential for improving outcomes and reducing costs.

KEY WORDS: Diabetes, health information technology, information technology enabled diabetes management, guidelines, hemoglobin A1c, interdisciplinary, recommendations, registries

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Overview

The advent of information technology (IT) has had a profound impact on the industry worldwide through data collection, information sharing, streamlined processes, and numerous other ways. The business of health care in the United States is no exception to the inclusion of IT, where managed care organizations (MCOs) are demonstrating increased implementation of IT systems. IT stands to facilitate overall efficiency in managed care, thereby having the potential for reducing error, improving outcomes, and controlling costs. To date, IT has been incorporated at MCOs in the form of electronic medical records, claims databases, patient identification systems, prescription fill/refill records, provider notification systems, and patient education programs, just to name a few. In fact, the value of IT is so highly regarded that many MCOs grant incentives to providers for using IT systems and processes already in place at their respective plans through pay-for-performance initiatives.

The use of IT in health care would appear to provide the most benefit in disease states where patient management and coordination of care are particularly complicated. For example, the frequency of comorbid conditions associated with a particular disease state, the different levels of providers required to give adequate care, the level of pharmacotherapy involved in treatment, and the number of different disease markers that must be carefully monitored and tracked can all necessitate the inclusion of IT interventions. A high prevalence of a particular disease may also necessitate the inclusion of IT to adequately manage care for a large number of patients with a common condition.

Diabetes in particular presents an ideal opportunity for the incorporation of IT in the provision of care. The disease is highly prevalent in managed care populations, is frequently associated with comorbid conditions, and requires multiple medications in its management. Furthermore, effective diabetes care involves the monitoring of several measures of disease control, such as hemoglobin A1c (A1c) and lipid levels, by several different levels of providers, such as physicians, nurse practitioners, physician assistants, pharmacists, and dietitians. All of these factors combined make diabetes an opportune disease state for a case study of the implementation of IT in managed care.

Burden of Illness

The Centers for Disease Control and Prevention (CDC), based on projections from the 2000 Census data, estimate that at least 20.8 million people in the United States have diabetes, most of those being type 2.1 Alarmingly, a third of this total number are believed to be undiagnosed. Additionally, there are at least 64 million people who meet the criteria for the metabolic syndrome, thus representing a large pool of people potentially “at risk” for diabetes.2 This high-risk condition is characterized by abdominal obesity,
aerogenic dyslipidemia, elevated blood pressure, insulin resistance or glucose intolerance, and a prothrombotic and proinflammatory state.

Between 1990 and 2002, the prevalence of type 2 diabetes increased by 61% in the United States. Although the CDC estimates that approximately 7% of the U.S. population has diabetes, the 2006 data from the Behavioral Risk Factor Surveillance System (BRFSS) found that 23 of the 50 states reported that at least 8% of all adults aged 18 years or older had been told that they have diabetes. While there has been a great deal of speculation as to the causes of the rise in prevalence of diabetes, increasingly sedentary lifestyles at all ages and poorer diets have clearly been associated.

The total costs associated with diabetes have been increasing since the late 1970s with a more dramatic rise in the late 1990s and early 2000s. The most recent estimate of the annual cost of diabetes was calculated by the American Diabetes Association (ADA) in 2003. They estimated that the total cost of diabetes in 2002 was $132 billion with $91.8 billion in direct and $39.8 billion spent on indirect expenses. These numbers were projected to estimate that the total cost in the United States will approach $200 billion per year by the year 2020.

**Treatment Considerations**

Considering the significant burden of illness imposed by diabetes, the question arises as to what can be done to prevent the complications related to the disease, thus slowing the rise in costs. The landmark Diabetes Control and Complications Trial (DCCT) and the United Kingdom Protective Diabetes Study (UKPDS) demonstrated conclusively that intensive glycemic control, whether in type 1 or type 2 diabetes, decreases the microvascular complications associated with uncontrolled hyperglycemia (i.e., retinopathy, nephropathy, and neuropathy). Thus the goal of glucose-lowering therapy has been recommended to lower the hemoglobin A1c (A1c) to <7% and keep it below that level long term. While any decrease in A1c is beneficial, the ADA recommendation for the individual patient is now to lower the A1c to normal, if that can be done safely without unacceptable side effects.

The costs saved from even a small decrease in A1c were first shown in short-term studies but recently have been shown to continue to accrue as long as the decrease in A1c is sustained. A claims analysis by Gilmer et al. demonstrated a $2,536 cost differential ($23,873 vs. $26,408; P<0.05) accrued over 3 years between patients with an A1c of 6% to 7% and those with an A1c of 9% to 10% who had diabetes along with comorbid heart disease and hypertension (Table 1). Cost savings increased in each subsequent group of A1c reduction, up to the greatest cost savings in the group of patients who attained and maintained an A1c<7%. In this analysis, patients with heart disease and/or hypertension were compared with patients without heart disease or hypertension for statistical purposes, demonstrating the increased importance of A1c reduction in patients with comorbid conditions. Included in the claims analysis were direct medical expenditures, such as inpatient admissions, physician services, prescription drugs, outpatient hospital, outpatient clinic, as well as costs for all other outpatient services such as nursing services, laboratory services, and dialysis services.

The ADA guidelines for glucose lowering have evolved in recent years to be more aggressive with a goal of decreasing the microvascular complications related to hyperglycemia. While the Health Plan Employer Data and Information Set (HEDIS) measure on diabetes control only addresses “poorly controlled” based on an A1c >9%, the American College of Endocrinology and American Association of Clinical Endocrinologists (ACE/AACE) have recommended that the A1c target now be below ≤6.5% with a preprandial glucose target of <110 mg per dL and a 2-hour postprandial glucose target of <140 mg per dL. The ADA has responded by adding the recommendation to their guidelines that the A1c goal for patients in general is <7% but for the individual patient, the goal is an A1c in the normal range (i.e., <6% in most assays).

Based on the UKPDS data, the current standard of care is to start a patient with metformin therapy, unless the patient has a contraindication to metformin. If the patient is not at goal after 3 months, an additional agent should be added. One limitation of the UKPDS data is that participants were randomized to monotherapy. Long-term studies are now ongoing to evaluate the benefit of glucose lowering with different combination therapy regimens. Until these studies are completed, the choice of the second agent to be added is left to the discretion of the provider.

Despite the escalating intensity of current treatment guidelines, the recent announcement by the National Heart, Lung, and Blood Institute (NHLBI) that the intensive glucose-lowering arm of the Action to Control Cardiovascular Risk in Diabetes (ACCORD) Trial had been discontinued raises many questions regarding who should receive intensive therapy and how it should be done. The discontinuation of the intensive glucose-lowering arm in the ACCORD trial occurred because of an unexpected increase in

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Standardized Per-Patient Cost of Care Differentials for 1% Changes in A1c Levels for 1,694 Adults With Diabetes Over a 3-Year Perioda</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A1c Level</td>
<td>10% to 9%</td>
<td>9% to 8%</td>
</tr>
<tr>
<td>Diabetes with heart disease and hypertension</td>
<td>$2675 ± 1164</td>
<td>$2536 ± 1048</td>
</tr>
<tr>
<td>Diabetes with hypertension</td>
<td>$2078 ± 900</td>
<td>$1970 ± 811</td>
</tr>
<tr>
<td>Diabetes without heart disease or hypertension</td>
<td>$1130 ± 408</td>
<td>$1071 ± 449</td>
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The ADA and European Association for the Study of Diabetes (EASD) recently updated their joint consensus statement without changing their general algorithm describing how to approach initiation of glucose lowering therapy.14 More specific algorithms have been developed by groups such as the Texas Diabetes Council that provide a structure by which to aggressively lower the A1c with a goal of a normal A1c.16 These algorithms provide an important change to organizations’ approaches to glucose control in that they recommend, based on the published data, that the patient start with dual therapy in most cases to maximize the likelihood that the patient will attain a normal A1c. All of these newer algorithms recommend that therapy should be added upon with a goal of attaining a normal A1c rather than taking an action (e.g., increasing the dose of an oral agent) and then waiting until the A1c rises again before taking another action to intensify glucose control.16 Specifically, the patient should keep trying to lower the A1c rather than allowing it to rise above 8% before adding an additional glucose-lowering agent. These algorithms will likely now include a footnote with the qualification that stringent targets may not be appropriate for some patients, particularly those with characteristics similar to those who participated in the intensive arm of the ACCORD trial.

Considering these aggressively oriented treatment algorithms, we may need to change the paradigm of glucose management. Treatment in the United States has traditionally comprised just 1 oral agent at high dose for many years and then waiting until the A1c rises back up to 9% before another agent is added; however, it is this author’s recommendation that we consider starting with 2 agents, or at least increase the first agent to only about 50% of the maximum recommended dose and then add another agent to try to attain and maintain a normal A1c, if it can be done safely. Once the peer reviewed data from the ACCORD trial is published, it is certainly possible that these recommendations may be changed, but we must see the actual data first. The idea here is to be aggressive from the time of diagnosis rather than waiting until after the patient has had diabetes for 10 years. Allowing the A1c to rise into the “uncontrolled” HEDIS range of >9% has never been acceptable as part of long-term glucose management, and the results from ACCORD affirm this approach.12

When looking ahead to targets of therapy in glucose management, we need to also consider the National Committee for Quality Assurance Comprehensive Diabetes Care Measures, which include the following parameters of diabetes management (2005):12

- Hemoglobin A1c testing
- Poorly controlled A1c (>9.0%)
- Eye (retinal) exam performed
- LDL-C screening
- LDL-C controlled to <130 mg per dL
- LDL-C controlled to <100 mg per dL
- Nephropathy monitored
- A1c levels are controlled to <7%

The adoption of these measures in managed care is significant, as most patients in the United States are not at goal for many of these targets. The National Health and Nutrition Examination Survey (NHANES) 1999-2000 data found that 63% of the people with known diabetes had an A1c >7%, with 37% having an A1c >8%, meaning that they were not at goal for the general population.17 In subsequent years the numbers have not shown much improvement with approximately 30% having an A1c >9% in 2004 and 2005.12

Information Technology in Diabetes Management

The question remains as to why patients are not getting to goal. We have the pharmacologic agents to attain the A1c goals; thus, we now need to develop the tools to implement programs to help people get to goal. We must remember one of the important lessons from the DCCT, which is that patients are best treated in a collaborative manner by a team of health care providers with training in diabetes including the following:

- Physicians
- Nurses
- Dietitians/nutritionists
- Certified Diabetes Educators (CDEs)
- Pharmacists

The team can be assisted by the use of Information Technology Enabled Diabetes Management (ITDM) to help achieve recommended therapeutic goals and ultimately potentially increase compliance with the recommended guidelines.18 IT can assist with the identification of patients, data synthesis for population and individual patient health status reports, and with patient education for effective self-care.18 All of these actions can have a significant impact on both outcomes and costs in managed care.

To demonstrate this impact, Bu et al. created a computer...
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simulation model developed using 4 software engines to project the impact of ITDM on care processes, costs, and clinical outcomes. The model also accounted for the dilution of ITDM effects as a result of patient movement between health care organizations and programs. All insured patients aged >25 years diagnosed with type 2 diabetes in the United States were eligible for enrollment. Patients with type 1 diabetes, those with glucose intolerance or who are undiagnosed, and those without insurance were excluded from the model.

This 10-year simulation operated under the assumption that diabetes management is implemented nationally at a rate of 20% per year until full national implementation is reached in year 5. The model applied the full impact of ITDM on processes of care in the year of implementation, and this impact remained constant in the subsequent years of the simulation while a patient was being actively managed. If a patient discontinued diabetes management, all benefits of ITDM were removed in the subsequent years of the simulation. Ten-year financial values were discounted to 2004, using a 5% real discount rate. Costs in Bu et al.’s model were based on the original CDC model assumptions, updated to reflect changes in costs and standards of care.

The primary outcome of the study was projected medical cost savings over 10 years, with secondary measures being the reduction of diabetes-associated clinical outcomes, such as cardiovascular and cerebrovascular events, neuropathy, nephropathy, and retinopathy. The authors derived diabetes management data from 3 broad categories of diabetes management technologies, categorized by most commonly targeted users. First, technologies used by clinicians and other providers, such as diabetes registries, clinical decision support systems (CDSSs), and electronic medical records, were included. Second, technologies targeting patients, such as automated phone systems that provide reminders or educational content to patients, electronic diary tools that collect information to be taken at a visit, and online resources, such as peer support groups, were included. Remote monitoring technologies as described above can transmit clinical data from patients’ homes to providers’ offices so that providers can modify care plans between visits. The third group included technologies employed by payers or disease management companies on behalf of payers, such as payer systems’ interfaces with electronic claims systems to track and monitor diabetic-specific information such as comorbidities (e.g., hypertension or dyslipidemia), physiological values (i.e., Alc or cholesterol levels), and care process levels (i.e. eye exam or microalbuminuria exam rates). A fourth category was also proposed, referred to by the authors as the “integrated diabetes management system.” This proposed system would allow providers to make effective decisions both at the point of care and across the entire diabetic population, as well as empower patients to actively participate in those provider decisions. The integrated system contained all 3 of the aforementioned registry, self-management, and remote monitoring technologies employed by the 3 different managed care stakeholders targeted in the study (i.e., providers, patients, and payers). Using these technology categories, estimates of care process improvements were derived from published literature. The authors then used simulations to project outcomes for both payer and provider organizations, scaled to the national level.

The researchers’ model demonstrated the significant cost-savings potential of ITDM over 10 years as a result of IT-enabled improvements in the processes of care and prevention of subsequent diabetes-related complications. All forms of ITDM resulted in lower health care utilization and a lower incidence of clinically

<table>
<thead>
<tr>
<th>Technology</th>
<th>Projected Cost Savings ($)</th>
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<tbody>
<tr>
<td>Integrated provider-patient systems</td>
<td>16.9 billion</td>
</tr>
<tr>
<td>Diabetic registries</td>
<td>14.5 billion</td>
</tr>
<tr>
<td>Computerized decision support</td>
<td>10.7 billion</td>
</tr>
<tr>
<td>Payer-centered technology</td>
<td>7.1 billion</td>
</tr>
<tr>
<td>Remote monitoring</td>
<td>326 million</td>
</tr>
<tr>
<td>Self-monitoring</td>
<td>285 million</td>
</tr>
</tbody>
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<table>
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<tr>
<th>Eye Exam Rate (%)</th>
<th>Foot Exam Rate (%)</th>
<th>Micro-Albumin Exam Rate (%)</th>
<th>HbA1c (%)</th>
<th>SBP (mmHg)</th>
<th>Total Cholesterol (mg per dL)</th>
</tr>
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<tbody>
<tr>
<td>Baseline</td>
<td>14.2</td>
<td>44.9</td>
<td>45.0</td>
<td>7.58</td>
<td>153</td>
</tr>
<tr>
<td>Payer technologies</td>
<td>25.6</td>
<td>57.8</td>
<td>52.6</td>
<td>7.34</td>
<td>148</td>
</tr>
<tr>
<td>Provider technologies—Registries</td>
<td>61.5</td>
<td>80.0</td>
<td>66.1</td>
<td>7.08</td>
<td>152</td>
</tr>
<tr>
<td>Integrated provider-patient system</td>
<td>61.5</td>
<td>80.0</td>
<td>66.1</td>
<td>6.90</td>
<td>149</td>
</tr>
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Payer technologies: Systems in place to interface with electronic claims systems to help track and monitor diabetes-specific information.
Provider technologies—Registries: Registries to help track diabetes-specific information in an effort to generate clinical report cards, trigger communications, facilitate administrative scheduling, etc.
Integrated provider-patient system: A comprehensive, collaborative diabetes management system that would help empower patients and allow providers to make effective, point-of-care decisions.

significant events, such as myocardial infarction, stroke, end-stage renal disease, amputation, blindness, and death. Specifically, of the 3 categories of ITDM examined by Bu et al. currently in the market, the provider-centered technologies showed the greatest potential savings: diabetic registries saved $14.5 billion ($1,016 per enrolled patient), and CDSS saved $10.7 billion ($752/enrolled patient) over 10 years. Payer-centered technologies had the next largest potential for cost savings at $7.10 billion ($558 per enrolled patient), while patient-centered technologies showed the most modest cost savings, with remote monitoring saving $326 million ($130 per enrolled patient) and self-management saving $285 million ($34 per enrolled patient). As would be expected, the proposed integrated provider-patient systems saved more than any of the 3 technology categories alone: $16.9 billion ($1,180 per enrolled patient, Table 2).

These cost savings elicited by the 3 categories of ITDM interventions corresponded to analogous improvements in clinical outcomes as demonstrated by Bu et al.'s model. While the improvements in clinical outcomes were seemingly more modest in comparison to the cost savings, provider-targeted technologies again showed the greatest impact of the 3, with the proposed integrated system demonstrating the greatest potential to improve processes and outcomes (Table 3). Other studies have shown that the use of registries can improve screening and outcomes, which appears to be related to the impact on provider decision making. It is somewhat surprising that none of these interventions had more of an impact on blood pressure. Further studies are needed to develop systems to improve blood pressure. Nonetheless, the different systems improved microvascular and macrovascular outcomes. While the improvement in clinical outcomes was similar with the diabetic registries and the integrated provider-patient systems, the increased cost savings over time with the latter is significant. The question that now remains, given the cost savings described above, is how to integrate the new technologies with currently available registries to minimize cost while still improving outcomes.

**Conclusions**

While uncontrolled diabetes remains a major health concern in managed care, implementation of ITDM has demonstrated significant potential for improving processes of care, preventing the development of diabetic complications, and generating cost savings. ITDM improves the synthesis of information, the delivery of knowledge, and the efficiency of communication, allowing for coordination of care across delivery teams. Furthermore, ITDM interventions ensure that patients receive recommended care and provide tools and information for patients to improve the effectiveness of self-care.

Of the existing technologies targeting providers, patients, and payers, provider-centered interventions, such as diabetes registries currently show the most potential for benefit in improving outcomes and reducing costs. Provider- and patient-centered interventions appear to provide more modest improvements in outcomes and cost savings; however, these 2 groups of managed care stakeholders should not be overlooked in designing ITDM systems. In fact, fully integrated provider-patient systems are likely to provide an even greater potential for benefit than systems targeting single groups of stakeholders. Of course, payers must determine for themselves the benefits of ITDM interventions in relation to the systems’ implementation costs in order to assess the full value of IT for diabetes management in their organization.

**DISCLOSURES**

Kathleen Wyne discloses the following commercial/financial relationships through speakers bureaus: Boehringer Ingelheim, GlaxoSmithKline, Novo Nordisk, Merk & Co., Inc., Novartis Pharmaceuticals, Eli Lilly and Company. She was responsible for the entire study concept and design of this article. Wyne performed all the data collection, data interpretation, writing, and revisions of this article.

**REFERENCES**


