Potential Short-Term Economic Benefits of Improved Glycemic Control

A managed care perspective

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OBJECTIVE — There are limited data relating glycemic control to medical costs among patients with diabetes. The goal of this study was to examine the potential impact of improved glycemic control on selected short-term complications of diabetes and associated costs in a managed care setting.

RESEARCH DESIGN AND METHODS — Using a retrospective cohort design and automated databases from 1 January 1994 to 30 June 1998, adult members of the Fallon Clinic who were diagnosed with diabetes were identified and assigned to one of three study groups based on each patient’s mean HbA1c level: good control (<8%), fair control (8–10%), and poor control (>10%) groups. Inpatient (hospital or skilled nursing facility) admissions for selected acute (short-term) complications, represented by selected infections, hyperglycemia, hypoglycemia, and electrolyte disturbances, and the associated medical charges were evaluated across the three HbA1c groups. Multivariate analyses were used to control for differences in several potential confounding factors among the study groups. All findings were expressed on a 3-year basis.

RESULTS — Of 2,394 patients with diabetes, ~10% (251) had at least one inpatient stay for a short-term complication, accounting for 447 admissions. Over 3 years, the adjusted rate of inpatient treatment ranged from 13 per 100 patients with good glycemic control to 16 per 100 patients with fair glycemic control and 31 per 100 patients with poor glycemic control (P < 0.05). The corresponding mean adjusted charges were approximately $970, $1,380, and $3,040, respectively. Among the 30% of the study population with long-term diabetic complications, the results were more marked; the adjusted admissions per 100 patients (mean charges) were estimated to be 30 ($2,610), 38 ($3,810), and 74 ($8,320) over 3 years for patients with an HbA1c of <8, 8–10, and >10%, respectively.

CONCLUSIONS — In typical practice, better glycemic control is associated with a reduced rate of admission for selected short-term complications and, therefore, reduced medical charges for these complications over a 3-year period. The potential short-term economic benefits are important to consider when making decisions regarding the adoption and use of new interventions for the management of diabetes.


Findings from the Diabetes Control and Complications Trial show that the strict control of blood glucose through intensive therapy in patients with type 1 diabetes may reduce the development and progression of long-term complications (1). Likewise, similar benefits of tight glycemic control also appear to accrue in patients with type 2 diabetes (2,3). An economic model based on these clinical findings suggests that intensive life-long treatment strategies may be cost-effective, with a cost per quality-adjusted life-year gained of approximately $16,000 (4).

However, many of the benefits of tight glycemic control accrue over fairly long periods of time, because it takes many years for complications such as retinopathy, renal disease, and neuropathy to develop. Consequently, economic models and evaluations of the costs of diabetes have almost exclusively focused on long-term complications (4–8). Less is known about the potential economic effects of improved glycemic control on short-term complications.

A retrospective database analysis by Gilmer et al. (9), based on administrative and laboratory data from a managed care plan, showed that poorer glycemic control, as measured by HbA1c levels, was associated with greater health care costs over a 3-year time period, particularly for patients with hypertension and/or heart disease. Although overall costs were increased, the specific components of the resource use associated with the worsening of glycemic control were not described. In addition, some costs, such as those for lower-extremity amputation, kidney disease, and heart disease, may not be affected by HbA1c levels evaluated over short time intervals.

A more recent database study conducted at Kaiser Permanente of Northern California showed that patients with diabetes had an excess risk of hospitalization, relative to those without diabetes, for several acute complications, including hyperglycemia, hypoglycemia, and cellulitis (10). Moreover, excess hospitalizations were noted for several other potential short-term conditions, such as pneumonia, urinary tract infection, and electrolyte imbalance. To the
Economic benefits of glycemic control

best of our knowledge, there are no data relating the incidence of such short-term complications to the extent of glycemic control among patients with diabetes.

To further explore this issue, we undertook a retrospective database study that focused on the following questions of interest: 1) How does the likelihood of inpatient admissions for selected short-term complications vary with the level of glycemic control? 2) What are the cost consequences and the potential savings associated with better control? and 3) Do these potential cost savings differ for patients with long-term complications of diabetes, such as ischemic heart disease, kidney disease, or retinopathy, versus those without these complications?

RESEARCH AND DESIGN METHODS — This study was based on a retrospective cohort design and used automated enrollment, medical and pharmacy claims, and clinical laboratory data files from the Fallon Clinic in Worcester, Massachusetts, a multispecialty group clinic with a predominantly managed care patient base. Most of the patients were members of the Fallon Community Health Plan, a health maintenance organization with over 200,000 enrollees.

The study population of interest consisted of adult plan members who had a diagnosis of diabetes between 1 January 1994 and 30 June 1998 and who also had multiple HbA1c values available. These patients were assigned to study cohorts based on their mean levels of HbA1c over this time period. Inpatient stays for specific short-term complications (events) occurring after the first HbA1c test (the index test) through 30 June 1998 were identified and related to the average HbA1c levels to explore variations in medical charges by the degree of glycemic control.

The principal measures of interest included 1) the proportion of patients with one or more inpatient admissions for short-term complications, 2) the mean number of such complications per patient, and 3) the expected costs per patient for these events. Both unadjusted and adjusted analyses were undertaken for the entire study population and stratified according to whether patients had long-term complications of diabetes. Only patients who met the following eligibility criteria were included in the study: 1) age 35 years or older, 2) a diagnosis of diabetes based on the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM 250.xx) listed on at least two medical claims between 1 January 1994 and 30 June 1998, 3) at least two HbA1c values measured no more than 18 months apart during this period, and 4) continuous enrollment in the plan from 1 January 1994 to 30 June 1998. Two claims indicating a diagnosis of diabetes were required to ensure that patients who were evaluated for diabetes, but not diagnosed, were not included in the study cohort. Multiple HbA1c values were required to help ensure that patients were not being screened for diabetes periodically but were likely to have the diagnosis and to require monitoring of glycemic control.

Patients were assigned to study cohorts based on the mean of all HbA1c values available during the study period as follows: good control (<8%), fair control (8–10%), and poor control (>10%).

Data sources

The patient enrollment file included age and sex, as well as a history of all the dates of enrollment and disenrollment from the plan. The inpatient claims file included the admission and discharge dates, a primary diagnosis (in ICD-9-CM format), up to two secondary diagnoses, and the procedures performed. Outpatient claims provided details on the date of service, the type of service, and the primary diagnosis (ICD-9-CM). The clinical laboratory file included all HbA1c tests performed and analyzed by a single contract laboratory (CliniTech). The measurement of HbA1c was stable throughout the study period.

Duration of follow-up

The duration of follow-up for each patient was defined as the number of days between the first HbA1c test that occurred on or after 1 January 1994 and the cutoff date for the data files (30 June 1998). The statistical techniques used in this study adjusted for variables follow-up, and our findings were expressed on a 3-year basis.

Study measures

Inpatient admissions for short-term complications. We determined whether each study patient had at least one inpatient admission related to a short-term complication during the study period and the number of such events. These events were defined by an inpatient stay (hospital or skilled nursing facility) with a discharge diagnosis (primary or secondary) in any of the following four groups: 1) hyperglycemia (ICD-9-CM codes 250.1x–250.3x), 2) hypoglycemia (250.8x and 251.0x), 3) selected infections (sepsis, 038.x; pneumonia, 480.x–486.x; kidney infections, cystitis, and urinary tract infections, 590.xx, 595.xx, and 599.0x; cellulitis, 680.xx–682.xx and 686.xx; and bacteremia, 790.7), and 4) electrolyte imbalance (276.xx).

Cost of inpatient care for short-term complications. The total cost of inpatient care for short-term diabetes-related complications was estimated for each study patient by totaling the charges on each inpatient medical claim, as indicated on the billing data supplied by the health plan.

Assessment of comorbidities

The burden posed by comorbidities may differ among cohorts of patients defined by HbA1c levels and may, thus, confound the relation between HbA1c levels and rates of inpatient treatment for short-term complications. To adjust for this potential problem, we examined whether each patient had a long-term diabetes complication during the study period, defined as any inpatient discharge diagnosis (primary or secondary) that included neurological disease; cardiovascular, cerebrovascular, or peripheral vascular disease; amputation or ulceration; or renal and ophthalmic symptoms. In addition, cancer was included as a separate comorbidity, because its treatment may increase the risk of infection and other complications. We also assessed comorbidity using the Deyo et al. (11) adaptation of the Charlson Index for administrative claims data, excluding diabetes, i.e., the diagnosis of interest in our study population (11,12). Because our findings were nearly identical to those based on chronic diabetic complications and cancer, they are not reported herein.

Statistical analyses

We estimated the proportion of patients with at least one inpatient stay for a short-term complication on both an unadjusted and adjusted basis using individual-level data. For the latter, we estimated the probability of inpatient treatment during follow-up using a binomial regression analysis based on a logistic function, controlling for each patient’s follow-up time (expressed in the logarithm of years and censored for the inpatient admissions). The independent variables included the HbA1c group (<8, 8–10, or >10%), age, sex, presence of a long-term diabetes complication, and presence of a cancer diagnosis. A predicted 3-year probability of inpatient treatment was calculated from the logistic function for each patient in each of the HbA1c groups.
An average 3-year risk was then derived for each HbA1c group.

We also calculated the mean number of admissions for short-term complications on both an unadjusted and adjusted basis. The latter used a Poisson regression, which was well suited for the relatively rare events (13). Each patient’s follow-up time (expressed in the logarithm of years but not censored for inpatient admissions) was controlled for in the analysis. The independent variables included the HbA1c group, age, sex, presence of a long-term diabetes complication, and presence of a cancer diagnosis. A predicted 3-year probability was calculated from the Poisson model for each patient in each of the HbA1c groups, and an average 3-year risk was then derived for each HbA1c group. Inpatient stays were evaluated for all patients and stratified by the presence of a long-term diabetic complication.

Finally, we estimated the average cost of inpatient care for short-term complications using least-squares regression, adjusting for the factors listed above. However, no statistical testing was performed on medical charges, because actual costs were unavailable and charges are not easy to generalize from one setting to another. The analyses of data were conducted using SAS Version 7.0 for Windows NT (SAS Institute, Cary, NC).

RESULTS

Patient characteristics
We identified a total of 9,156 plan members who were diagnosed with diabetes between 1 January 1994 and 30 June 1998. A total of 3,475 of these people were excluded because they were not continuously enrolled for the entire study period. In addition, 3,089 people were excluded because they did not have any HbA1c values or did not have at least two values measured no more than 18 months apart. This left a total of 2,394 diabetic plan members who met our study eligibility criteria and were included in the analysis. The average age of these patients was 63 years, and ~55% were men. Approximately 30% had a long-term diabetes complication, and 2.5% had a cancer diagnosis (Table 1). Over 80% of the population filled prescriptions for diabetes medications during the study.

There were important differences across the three study cohorts defined by average HbA1c levels. For example, patients with poor glycemic control were more likely to have long-term diabetic complications than those with good or fair control. Similarly, the duration of follow-up in the study was longer among patients in the two groups with the highest HbA1c levels. Patients experiencing poorer glycemic control may have had diabetes for a longer amount of time and may have been suffering from long-term complications. These patients, therefore, may have been more closely monitored by their physicians. Finally, the likelihood of treatment with diabetes medications was the greatest in the two groups with the highest HbA1c levels.

Relation between glycemic control and inpatient admissions
Of the 2,394 patients with diabetes, a total of 251 (~10%) were admitted for the treatment of short-term complications, accounting for a total of 447 inpatient stays. For these admissions, 59% of the qualifying diagnoses were for infections, 21% were for hyperglycemia or hypoglycemia, and 20% were for electrolyte disturbances. There were a total of 4,562 admissions during the study period for any reason.

We found a statistically significant positive relation between the HbA1c group and the likelihood of inpatient admissions for short-term complications on both an unadjusted and adjusted basis (both P < 0.01, based on a test for trend). The latter analysis, which controlled for the differences among the study cohorts in age, sex, presence of cancer, and presence of long-term diabetes-related complications, showed that the proportion of patients admitted for a short-term complication over 3 years increased from 8.5% among patients with good control to 17.8% among those with poor control (Table 2). This statistically significant increase in the likelihood of inpatient treatment was also found in both patient subgroups (those who did not have long-term diabetic complications and those who did); the absolute increase in risk was larger for those with long-term complications.

The average number of admissions for short-term complications followed a similar pattern. On an adjusted basis, the average number of admissions over 3 years was 2.5 times greater among patients with poor glycemic control versus those with good control (i.e., 13 inpatient stays per 100 patients vs. 31 per 100, respectively). Although the increase in the number of inpatient stays across the three HbA1c groups is modest for patients without long-term diabetic complications, the number of inpatient stays is substantially higher among those with such complications, ranging from 30 to 74 per 100 persons. Correspondingly, the average adjusted charges for inpatient treatment for patients with good control was approximately $970 over a period of 3 years compared with $1,380 and $3,040 for those with fair or poor glycemic control, respectively (Table 3). Among the patients with chronic diabetic complications, the results were more marked.

CONCLUSIONS — To explore the potential economic benefits of improved glycemic control, we conducted a retrospec-
Poisson regression. Both controlled for age, sex, cancer, and duration of follow-up, and adjusted to 3 years. The relation between HbA1c category and inpatient stays was significant at highest among those with poor control. Among patients with good control anding average adjusted charges were also low-
100 patients, respectively; with good glycemic control 31 vs. 13 per
levels of HbA1c. On an adjusted basis, such stays increased significantly with higher
complications and the average number of
inpatient admission for selected short-term
Clinic health plan within a recent 4-year
adults with diabetes enrolled in the Fallon
study using enrollment, medical claims,
clinical laboratory data for ~2,500
with diabetes enrolled in the Fallon
Clinic health plan within a recent 4-year
period. We found that the likelihood of
inpatient admission for selected short-term
complications and the average number of
such stays increased significantly with higher
levels of HbA1c. On an adjusted basis,
patients with poor glycemic control had
more than double the number of inpatient
admissions over a 3-year period than those
with good glycemic control 31 vs. 13 per
100 patients, respectively; P < 0.01). The
largest absolute difference in admission rates
occurred in patients who had long-term dia-etc complications (30 per 100 patients
with good control vs. 74 per 100 patients
with poor control; P < 0.01). Correspond-
ing average adjusted charges were also lowest
among patients with good control and
highest among those with poor control.
Our finding that HbA1c levels positively
correlate to medical charges in clinical prac-
tice was consistent with the study by Gilmer
et al. (9), although their data were somewhat
older and included all costs regardless of
diagnosis. To the best of our knowledge, our
study is the first to relate short-term com-
lications to levels of glycemic control. The
results from this investigation may be help-
ful in understanding the potential economic
implications of short-term interventions
designed to improve glycemic control, such
disease management programs and newer
drug therapies.
We acknowledge several limitations of
our study. First, although our analyses sug-
gest that a correlation exists between
selected short-term complications and the
extent of glycemic control, it does not
demonstrate that these events could have
been avoided. Only intervention studies
can establish whether lowering HbA1c levels
reduces the costs for acute diabetic compi-
lcations. Second, the precise diagnoses
could vary with the level of glycemic control
on a short-term basis are subject to judg-
ment. In our study, we chose to focus on
hyperglycemia, hypoglycemia, and celluli-
tis, which were all classified as short-term
(acute) complications of diabetes in a recent
database study by Selby et al. (10). We also
included several additional conditions that
diabetic patients experience more fre-
cquently than nondiabetic patients, includ-
ing other infections and electrolyte
imbalance (10). Further work is required
to identify which diagnoses are correlated
glycemic control on a short-term basis.
Furthermore, short-term complications
were identified based on selected
ICD-9-CM codes that appeared as primary
or secondary diagnoses on inpatient bills.
In the database used for this study, it was
not possible to distinguish acute hospital
stays from admissions to skilled nursing
facilities. There are also inherent inac-
curacies associated with the use of ICD-9-CM
diagnosis codes, which may have led us to
misestimate the number of events. To
address these issues, we conducted a chart
review based on samples of two groups of
inpatient stays from two randomly selected
patient samples. The first group consisted
of 69 inpatient stays (~15% of the
observed number of events) with a diagnos-
sis of a short-term diabetic complication
noted on medical claims for 50 study
patients. Of these 69 inpatient stays, 58
(85%) involved admission to an acute-care
hospital. The diagnosis data from the dis-
charge summaries, which were completed
only for hospital stays, showed that a qual-
ifying discharge diagnosis (i.e., for a short-
term event) was listed on 64 (93%) of these
admissions. For the second group of inpa-
tient admissions with discharge summaries
(n = 29, drawn from 20 patients), which

<table>
<thead>
<tr>
<th>HbA1c category (%)</th>
<th>All patients</th>
<th>Patients without long-term diabetic complications</th>
<th>Patients with long-term diabetic complications</th>
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<td>Adjusted*</td>
<td>Unadjusted</td>
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<td>17.8</td>
<td>7.9</td>
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*Proportion of patients admitted was estimated using binomial regression, while the expected number of admissions was estimated using Poisson regression. Both con-
trolled for age, sex, cancer, chronic diabetic complications, and duration of follow-up, and adjusted to 3 years. The relation between HbA1c category and inpatient stays
was significant at P < 0.01.†Proportion of patients admitted was estimated using binomial regression, while the expected number of admissions was estimated using
Poisson regression. Both controlled for age, sex, cancer, and duration of follow-up, and adjusted to 3 years. The relation between HbA1c category and inpatient stays
was significant at P < 0.01.
did not have a short-term complication noted in the billing data, 12 stays (41%) were found on examination to have a qualifying diagnosis. Therefore, the results of the chart review indicate that we may have underestimated the number of inpatient stays for acute diabetic complications, which suggests that our results may be conservative.

It is possible that some of the inpatient stays we identified as events were not the sole cause for admission or that they could, perhaps, have been incidental findings for patients who were admitted principally for other medical problems. Determining the reasons for admission based on ICD-9-CM discharge diagnoses is fraught with difficulties (14,15). Moreover, to the best of our knowledge, there are no accepted methodologies for apportioning costs among multiple diagnoses. The emphasis that we placed on acute complications may help limit but not eliminate this problem.

Because the frequency of inpatient admissions probably increases with the severity and duration of diabetes, each of which may also be correlated with HbA1c levels, it is possible that our findings are due to residual confounding by these two factors. In this study, we attempted to adjust for the severity of diabetes among the study cohorts by controlling for age, sex, several chronic diabetic complications, and follow-up time. The latter two factors are especially important because they may be a reasonable proxy for the duration of diabetes. Nonetheless, to the extent that we were unsuccessful in these efforts at statistical control, we may have overstated the reduction in costs that may be associated with better glycemic control.

We assessed the occurrence of short-term diabetes-related complications any time after the first observed HbA1c value, because the precise temporal relation between these two factors is uncertain. Moreover, patients were assigned to groups based on their average HbA1c level during follow-up because glycemic control was quite variable and a predefined starting date was not available, given that patients were not required to be newly diagnosed. Randomized studies may be required to better understand the temporal relation between glycemic control, as evaluated by HbA1c, and the occurrence of diabetic complications.

Finally, our findings regarding costs may not be generalizable to all patients with diabetes. Treatment patterns for this disease may differ according to individual physician practice styles, health plan guidelines, and geographical regions. In addition, data on resource costs were not available to us, but rather our analyses relied on charges. It is known that charges often exceed resource costs, but the magnitude of this mark-up differs from one institution to another. However, by reporting our findings in terms of admission rates, other researchers may use our findings in conjunction with their own cost data.

Despite these limitations, this exploratory analysis suggests that in typical practice, better glycemic control is associated with lower inpatient admissions and costs during a 3-year time period. These potential short-term savings in cost are important to consider when making decisions regarding the adoption and use of new interventions for the management of diabetes.

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References


