Health Care Resource Utilization Associated with a Diabetes Center and a General Medicine Clinic

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OBJECTIVE: **Studies have proposed that the features of diabetes clinics may decrease hospital utilization and costs by reducing complications and providing more efficient outpatient care. We compared the health care utilization associated with a diabetes center (DC) and a general medicine clinic (GMC).**

DESIGN: **Retrospective cohort study.**

SETTING: **An urban academic medical center.**

PATIENTS/PARTICIPANTS: **Type 2 diabetes patients (*N* = 601) under care in a DC and GMC before March 1996.**

MEASUREMENTS AND MAIN RESULTS: **We compared baseline patient characteristics and outpatient care for the period of March 1996 to August 1997. Using administrative data from March 1996 to October 2000, we compared the probability of a hospitalization, length of stay, costs of hospitalizations, the probability of an emergency room visit, and costs of emergency room visits. Diabetes center patients had a longer mean duration of diabetes (12 years vs 6 years, $P < .01$), more baseline microvascular disease (65% vs 44%, $P < .01$), and higher baseline glucose levels (hemoglobin A_{1c} 8.6% vs 7.9%, $P < .01$) than GMC patients. Diabetes center patients received more intensive outpatient care directed toward glucose monitoring and control. In all crude and adjusted analyses of hospitalizations and emergency room visits, we found no statistically significant differences for inpatient utilization or cost outcomes comparing clinic populations.**

CONCLUSIONS: **Diabetes center attendance did not have a definitive positive or negative impact on inpatient resource utilization over a 4-year period. However, DC patients had more severe diabetes but no greater hospital utilization compared with GMC patients. Clear demonstration of the clinical and financial benefits of features of diabetes centers will require long-term controlled trials of interventions that promote comprehensive diabetes care, including cardiovascular prevention.**

KEY WORDS: **diabetes mellitus; endocrinology; health care costs; hospitalization; primary health care.**
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Diabetes mellitus is associated with an increased risk for multiple medical complications, higher rates of hospitalization, and increased costs of medical care.[1,2] Health care payers and policy makers are seeking ways to improve the delivery of diabetes preventive care with an eye on reducing downstream complications and inpatient costs.[3,4] Current diabetes care exists on a continuum where providers, ancillary services, and clinical systems may all vary. Diabetes centers (DC) represent one form of diabetes care which combines a specialty focus on the disease, enhanced diabetes education, and coordinated preventive services. These clinics typically build care teams with endocrinologists, dieticians, diabetes educators, and/or diabetes nurse practitioners with the aim of providing comprehensive diabetes care.[5] Some quality of care initiatives are incorporating elements of diabetes center multidisciplinary care teams and so it is valuable to evaluate the potential beneficial effects of existing diabetes centers.[5,6]

Insight into the clinical and financial impact of such disease-specific centers is available from comparisons of subspecialist physician care or clinic assignment.[7–10] Most analyses have focused on comparisons of processes of outpatient care and intermediate outcomes such as risk factor levels.[9–11] A few studies have started to empirically examine the impact of different forms of preventive diabetes care on economic outcomes such as inpatient resource utilization. Different forms of diabetes care may produce different levels of metabolic control and some studies have reported that short-term improvements in glycemic control are associated with lower inpatient costs.[12,13] Other studies have directly compared the hospital costs for diabetes patients seeing different types of physicians. Some have shown that hospital costs are lower for patients with affiliation with an endocrinologist compared to those without such affiliation,[14] while others have found little or no difference in inpatient resource utilization for subjects seeing different specialists.[7,8] Few studies have examined the impact of differences in outpatient diabetes care on long-term utilization of both hospital and emergency department services and no studies describe the extent of comanagement that exists between diabetes centers and generalist clinics. We examined inpatient utilization for diabetic patients attending a diabetes-specific clinic and a general medicine clinic at an academic medical center over a 4-year period.

METHODS

Outcomes

The main outcomes of interest were: 1) the probability of a diabetes-related hospitalization; 2) average length of stay of diabetes-related hospitalization; 3) average costs of diabetes-related hospitalizations; 4) the probability of an emergency room visit; and 5) average costs of emergency room visits not resulting in hospital admission.

The Clinics

The Massachusetts General Hospital (MGH) is an 850-bed urban academic medical center. Its DC provides comprehensive primary care with an emphasis on patients with diabetes mellitus. Physicians in the DC specialize in endocrinology and diabetes. Additional routine services include dietary counseling and diabetes teaching provided by registered dieticians and certified diabetes educators-nurse practitioners. Patients are seen in the DC because a primary care physician has referred them to the center for diabetes management or a patient has identified a DC physician as a primary care provider. The general medicine clinic (GMC) is staffed by general internists and general nurse practitioners and is not organized to provide routine, systematic diabetes education or coordinated diabetes care by specialized professionals. Both clinics utilize the same emergency room and inpatient services. Clinic physicians serve as the attendings of record for inpatients at the MGH.

Study Population

We used ambulatory claims from outpatient clinics with primary or secondary International Classification of Diseases, 9th Revision (ICD-9) diagnoses 250.00 to 250.90 submitted from March 1996 to August 1997 to identify 3,025 patients with the diagnosis of type 2 diabetes. A subset of 789 patients was randomly selected for structured chart abstraction by trained research nurses. By design, we selected 25% of the patient sample from the DC and 25% each from the 3 coverage groups within a large GMC. Diagnosis of type 2 diabetes was verified by physician notation in the chart or by documentation of insulin or oral hypoglycemic medicines in the medication list. Of the initial 789 patients, 86 were excluded because the type 2 diabetes diagnosis was first made after March 1996, 74 were excluded because the type 2 diabetes diagnosis could not be confirmed, 23 were excluded because they had type 1 diabetes, and 5 were excluded because of secondary causes of hyperglycemia. The remaining 601 patients (145 in the DC and 456 in the GMC) are the subject of this analysis. Using chart review, 2 investigators verified in which clinic a patient received the majority of diabetes care. Of the 145 DC patients, 94 (65%) had another primary care physician in addition to the DC physician. The majority (n = 127, 88%) of DC patients attended an MGH-based clinic (DC, GMC, or other) for primary care.

Patient Characteristics and Outpatient Care

Baseline patient characteristics and outpatient care details were abstracted from 601 charts for the period March 1996 to August 1997. Abstracters obtained data on the primary care physician, patient demographics, duration of diabetes, microvascular and cardiovascular complications, body mass index, detailed record of medications at the most recent clinic visit, and latest available values for blood pressure. To assess interabstractor variability, the 3 research nurses abstracted the same 42 randomly selected charts. The intraclass correlation coefficient for systolic blood pressure was 0.94. For the presence or absence of the following, κ statistics were: 0.44 for nephropathy, 0.53 for neuropathy, 0.76 for retinopathy, 0.68 for stroke, and 0.72 for coronary artery disease, all indicating moderate to excellent agreement among abstractors. Blood test results were obtained from the computerized laboratory record. The MGH Clinical Laboratories processed all standard laboratory testing ordered as part of routine care from March 1996 to August 1997. We used the most recently measured risk factor levels in analyses. Use of the most recent values for systolic blood pressure, total cholesterol, and hemoglobin A_{1c} (HbA_{1c}) have been demonstrated to provide results similar to the means of several antecedent measurements.[15–17]

We estimated outpatient costs for the period March 1996 to August 1997 using data on the frequency of medication use, outpatient visits (visits to the diabetologists and diabetes educators in the DC), dietary consultation, ophthalmology exams, and laboratory testing (total cholesterol, LDL cholesterol, HbA_{1c}, random blood sugar, microalbuminuria, and creatinine). Medication costs were limited to drugs related to diabetes or diabetic complications. For any given drug, we based the annual cost of a medication on the average daily dose of a randomly selected generic in the 2000 Red Book.[18]

Hospital and Emergency Room Utilization

We used the accounting software, Transition Systems, Inc. (TSI) from Eclypsis Inc. (Delray Beach, Fla), to examine hospitalizations and emergency room (ER) visits at MGH over a 4-year period, March 1996 to October 2000. This data overlapped and extended 2 years beyond the period of chart abstraction. We classified hospitalizations and ER visits as diabetes-related using ICD-9 codes for principal diagnosis. Diabetes-related conditions included ischemic heart disease (401, 402, 410–414, 428, 785.51, 786.5), nonischemic heart disease (394, 424.1, 425.4, 426, 427), stroke (430, 431, 433–435), metabolic abnormalities of diabetes (250.1, 250.2, 250.3, 250.4, 250.6, 250.8), diabetic foot disease (250.7, 440, 443.9, 444, 459, 607.84, 681, 682.3, 682.6, 682.7, 707, 711, 730.07, 730.1, 782, 785, 892, 945, 996, 997.6), diabetic renal disease (250.4, 403, 580.8, 584, 585, 593.8, 996.62, 996.73), and general bacterial infections (112, 323, 35, 38, 42, 381, 466, 481, 482, 486, 487, 490, 540, 567, 590, 595, 599, 604, 780.6, 790.7, 008.4, 008.8, 009, 998.5).

The costs of visits, testing, hospitalizations, and ER visits also came from TSI. The cost measure, actual total cost, includes the overhead costs for each procedure. The actual total cost of each procedure is summed to form total hospital cost for each patient. This cost measure estimates the true resource use involved in a service and is superior to using charge or reimbursement data.[19]

In order to enhance the comparability of the clinic populations, we restricted our analysis of the probability of hospitalization to those DC patients who had an MGH-based clinic as their source of primary care based on chart review (DC, $N = 127$ and GMC, $N = 456$). We further restricted our analysis of the probability of an ER visit to those individuals living within 60 miles of the hospital (DC, $N = 115$ and GMC, $N = 436$).

Statistical Analysis

All analyses were performed using SAS statistical software (Release 8.1, SAS Institute Inc., Cary, NC). We analyzed log-transformed costs to normalize their distribution. The use of the logarithm of total costs also allows regression coefficients to be interpreted as percentage change in costs. Similarly, we log transformed length of stay data.

For crude analysis of continuous outcomes, we assumed nonnormal distributions and used the Wilcoxon rank-sum test for binary predictors and the Spearman correlation coefficient for continuous predictors. For categorical outcomes we used the χ^2 test. For adjusted analyses of the impact of clinic assignment, we individually constructed linear and logistic regression models for each outcome, first considering variables significantly associated with outcomes in univariate analysis, followed by a search for collinear terms. We used this systematic approach rather than standardized models because we anticipated each outcome would have distinct predictive variables. Candidate covariates included age, gender, ethnicity, duration of diabetes mellitus, history of diabetes-related complications, most recent risk factor levels, level of preventive screening, use of specific medications, distance of residence from the hospital, median family income of zip code, proportion with college education in zip code, and insurance status. Candidate case mix adjustment variables came from prior studies evaluating health services utilization for diabetes patients.[7,8,11,20] For the analysis of inpatient length of stay and cost data, we considered types of hospitalizations as additional variables in the models. For the analysis of hospitalization costs, we forced the logarithm of length of stay as a covariate. We accounted for clustering by physician using hierarchical modeling with PROC GLIMMIX for logistic regression models and PROC MIXED for linear regression models.

To address the problem of selection bias, we attempted to use instrumental variable analysis but found that no variables met the criteria for ideal instruments.[21] To assess differences in the effect of clinic assignment by disease severity, we conducted stratified analyses based on the severity of diabetes as well as interaction term analyses in multivariable models. The results for both methods did not differ, and we only present results for interaction term analyses.

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RESULTS

Patient Characteristics

The patients in the DC were slightly younger than GMC patients (63 years vs 65 years, $P < .01$) but had more severe disease as indicated by longer mean duration of diabetes (12 years vs 6 years, $P < .01$), more baseline microvascular complications (65% vs 44%, $P < .01$), and poorer glycemic control (mean HbA_{1c} 8.6% vs 7.9%, $P < .01$) (Tables 1 and 2). Cardiovascular disease risk factor levels were not different between the 2 clinic populations.

For both clinics, the predominant insurer was Medicare or Medicaid. A greater percentage of DC patients had commercial insurance than in the GMC. DC patients lived in zip codes with higher median household incomes and educational attainment. The majority of patients from both clinics lived within 15 miles of the hospital but the percentage living outside 15 miles was larger for the DC than the GMC.

Outpatient Care

For the period March 1996 to August 1997, DC and GMC physicians saw their patients for diabetes care with similar frequency but DC caregivers provided more intensive microvascular preventive care than their GMC counterparts (Table 2). In particular, they ordered and performed more frequent HbA_{1c} testing, ophthalmology exams, and foot exams. DC providers were also more likely than GMC providers to prescribe insulin or a thiazolidinedione.

The clinics differed little in provision of cardiovascular preventive care, with relatively high levels of care provided in both settings. Nearly all patients had their blood pressure and cholesterol levels measured. Among patients with hypertension, a similar proportion of patients in each clinic were on antihypertensive medications, and among hypercholesterolemic patients, a similar proportion were taking cholesterol-lowering medications. Among patients diagnosed with coronary artery disease, a similar proportion of patients took prophylactic aspirin.

For the period of chart review, the average costs of outpatient care was significantly greater for DC patients compared to that of GMC patients ($5,156 vs $4,555, $P = .02$). These estimates do not include the cost of specialist referrals, but the frequency of referrals was not statistically different comparing clinics.

Hospitalizations

Over the 4-year period, a similar proportion of patients from the 2 clinics were admitted to MGH for any reason

Table 1. Baseline Clinic Population Characteristics

Patient Characteristics	Diabetes Clinic (*N* = 145)	Internal Medicine Clinic (*N* = 456)	*P* Value*
Mean age, y	63	65	< .01
Nonwhite race, %	19	18	.77
Male sex, %	65	56	.07
Mean duration of diabetes, y	12	6	< .01
Coronary artery disease, %	44	45	.79
Stroke, %	10	12	.62
Diabetic foot disease, %	9	11	.59
Neuropathy, %	41	28	< .01
Retinopathy, %	39	17	< .01
Nephropathy, %	19	10	< .01
Insurance			
Commercial, %	35	26	.03
Managed care, %	15	17	.55
Medicare/Medicaid, %	36	45	.04
Other insurance, %	14	12	.49
Median family income of zip code, $	20,760	18,176	< .01
College degree in zip code, %	41	35	< .01
Distance from hospital			
Within 15 miles, %	66	81	< .01 for trend
Between 15 and 60 miles, %	23	14	
Beyond 60 miles, %	12	4	

* P *values were computed using Wilcoxon rank-sum for continuous variables and* χ^2 *tests for categorical variables.*

(DC 52% vs GMC 50%) (Table 3). When restricting the analysis to diabetes-related admissions, we continued to find no significant difference in the proportion of patients with admissions (DC 35% vs GMC 37%) (Table 3). There was also no difference in the frequency of diabetes-related admissions per patient or in the mean length of stay. When examining reasons for admissions, we found that the diagnostic category with the largest proportion of patients was ischemic heart disease for both clinics (19%). Renal disease admissions were more frequent among DC patients (DC 5.5% vs GMC 2.0%, $P = .03$). Covariates such as increasing age, increasing duration of diabetes, increasing baseline glucose levels, history of complications, greater frequency of HbA_{1c} testing, and greater frequency of foot examination were also associated with a higher likelihood of admission for diabetes-related hospitalization.

After accounting for disease severity, other confounders, and clustering by physician, we continued to find that diabetes clinic membership was not associated with a significant difference in the likelihood of hospital admission (odds ratio [OR], 0.88; 95% confidence interval [CI], 0.52 to 1.49) (Table 4). Increasing baseline glucose levels, prior history of coronary artery disease, prior history of stroke, and increasing number of medications remained significant predictors in the full model.

Length of Stay

We found no difference in mean length of stay in crude contrasts of DC and GMC subjects admitted over the 4-year period. On the other hand, variables such as duration of diabetes, baseline diabetic foot disease, retinopathy, nephropathy, admission for diabetic foot disease, and admission for kidney disease were each associated with greater lengths of stay for diabetes-related hospitalizations. In multivariable analysis, we continued to find no significant difference in mean length of stay comparing clinic populations (Table 4). Admissions for diabetic foot disease and kidney disease management remained significant predictors in the full model.

Hospitalization Costs

Diabetes center patients had slightly but not significantly higher average diabetes-related hospitalization costs compared with GMC patients (DC $12,491 vs GMC $10,444). Our analysis of hospitalization costs examined the impact of clinic association beyond the effects of length of stay. The major predictor of higher diabetes-related hospitalization costs was the logarithm of length of stay (correlation coefficient 0.90, $P < .01$). Other variables associated with increasing costs included duration of diabetes, prior coronary artery disease, and prior diabetic foot disease. Patients who had an admission for nonischemic heart disease, diabetic foot disease, or for kidney disease also had higher average costs compared to those with other kinds of admissions. The effect of the diabetes clinic variable continued to be nonsignificant in multivariable analysis (Table 4). Prior history of coronary artery disease and increasing length of stay remained highly significant predictors of increasing hospital admission costs. On the other hand, increasing age was associated with lower hospital costs.

Table 2. Outpatient Visit Analysis for March 1996 to August 1997

Care Characteristics	Diabetes Clinic (*N* = 145)	Internal Medicine Clinic (*N* = 456)	*P* Value*
Diabetes-related office visits and referrals			
Mean number of visits	4.9	5.2	.27
Mean number of referrals	2.7	1.6	.27
Testing characteristics			
HbA_{1c} tested, %	97	91	.02
Mean number of HbA_{1c} tests	3.4	2.4	< .01
Eyes examined by eye care specialist, %	70	42	< .01
Foot examined, %	85	42	< .01
Mean number of foot exams	2.5	1.1	< .01
Blood pressure tested, %	97	100	< .01
Cholesterol tested, %	76	76	.96
LDL cholesterol tested, %	64	67	.61
Risk factor levels			
HbA_{1c}, Mean %	8.6 (140)	7.9 (412)	< .01
HbA_{1c} < 8%, %	35	57	< .01
Mean LDL cholesterol, mg/dL (*N*)	127 (86)	127 (279)	.90
LDL cholesterol < 130 mg/dL, %	59	58	.88
Mean systolic blood pressure, mmHg (*N*)	139 (141)	138 (456)	.43
Systolic blood pressure < 130 mmHg, %	26	25	.98
Mean diastolic blood pressure, mmHg (*N*)	77 (141)	77 (456)	.90
Diastolic blood pressure < 85 mmHg, %	78	81	.49
Medications			
Mean number of medications	6.4	5.7	.08
Insulin, %	66	33	< .01
Thiazolidinediones, %	8	1	< .01
If hypertensive, taking blood pressure medications, % (*N*)	86 (96)	85 (343)	.69
If hypertensive, taking an ACE inhibitor, % (*N*)	58 (96)	48 (343)	.09
If hypercholesterolemic, taking cholesterol medications, % (*N*)	61 (82)	56 (213)	.43
If existent coronary heart disease, taking aspirin, % (*N*)	50 (64)	55 (207)	.48
Mean outpatient costs (for 1.4 years), $	5,156	4,555	.02

* P *values were computed using Wilcoxon rank-sum for continuous variables and* χ^2 *tests for categorical variables.*

Emergency Room Visits

We found that a similar proportion of DC patients utilized the MGH ER compared to that of GMC patients (54% vs 61%, *P* = .17) (Table 3). When examining visits by diagnoses, the only difference between clinics was in the proportion of subjects with visits unrelated to diabetes, which was lower for the DC than the GMC (30% vs 42%, *P* = .02). Other factors individually associated with greater ER use included increasing age, increasing duration of diabetes, a history of cardiovascular disease, a history of microvascular disease, increasing number of chronic medications, lower proportion of zip code with college education, lower median family income of zip code, and greater proximity of residence to the hospital. In multivariate analysis, we found no statistically significant association between DC clinic membership and the likelihood of visiting the MGH ER (OR, 0.90, 95% CI, 0.55 to 1.46) (Table 4).

The mean costs of ER visits not resulting in an admission were also not significantly different between the DC and GMC patients (Table 3). Predictors of greater ER visit costs were increasing age, prior history of coronary artery disease, and increasing number of medications, although the significance of these effects were attenuated in the multivariate model. In the model, DC affiliation was not associated with significantly different mean ER costs compared to GMC affiliation (Table 4).

Interaction Term Analysis

We created interaction terms between the clinic variable and variables that were significantly associated with enrollment in the DC (e.g., duration of diabetes) and found that none of these interactions were statistically significant.

DISCUSSION

Our study provides one of the most detailed descriptions of inpatient resource utilization comparing subjects attending a DC and a GMC. Diabetes center subjects appeared to be sicker with greater duration of diabetes, worse baseline glycemic control, and more documented microvascular complications. Outpatient care was more intensive for DC subjects with regard to testing for microvascular complications and use of insulin and thiazolidinediones. While differences in baseline glycemic control have been associated with differential hospitalization rates,[22] the

Table 3. Hospital and Emergency Room Utilization for March 1996 to October 2000*

Utilization Outcomes	Diabetes Clinic (*N* = 127)	Internal Medicine Clinic (*N* = 456)	*P* Value†
Hospital admission, %	52	50	.79
Diabetes-related hospital admission, %	35	37	.70
Mean number of diabetes-related admissions	2.4	2.3	.30
Coronary heart disease admission, %	21	18	.43
Stroke admission, %	7.1	6.1	.70
Diabetic foot disease admission, %	5.5	7.5	.50
Renal disease admission, %	5.5	2.0	.03
General infection admission, %	7.9	11.8	.21
Mean length of stay for diabetes-related admissions, days	7.2	6.5	.47
Mean cost for diabetes-related hospitalization, $	12,491	10,444	.48
ER visit, %‡	54	61	.17
ER visit resulting in admission, %‡	50	52	.76
ER visit related to diabetes, %‡	40	42	.77
ER visit unrelated to diabetes, %‡	30	42	.02
Mean number of ER visits‡	3.3	3.3	.67
Mean cost for ER visit without admission, $‡	530	697	.25

* *All proportions represent proportion of clinic patients with an outcome.*
† P *values were computed using Wilcoxon rank-sum for continuous variables and* χ^2 *tests for categorical variables.*
‡ *Emergency room analyses restricted to patients living within 60 miles of hospital (for DC,* N *= 115; for GMC,* N *= 436).*
ER, emergency room.

probability of inpatient utilization and the costs associated with this utilization were similar comparing DC and GMC patients. Although suggestive that more intensive outpatient care in the DC led to lower than expected hospital utilization, the lack of difference in inpatient resource utilization observed in this analysis does not definitively establish a beneficial impact of DC compared to GMC outpatient management.

Our results are at odds with studies that have found that inpatient resource utilization is significantly lower when patients are seen in diabetes clinics or cared for by an endocrinologist. Investigators have found that care of diabetic ketoacidosis was more efficient with the presence of an endocrinologist, but we were unable to confirm this finding.[14] We evaluated hospitalizations globally and found that cardiovascular diagnoses represented the largest proportion of hospitalizations. Our results are more consistent with a Medicare study that found little or no difference in resource utilization for patients cared for by internists versus endocrinologists[8] and the Medical Outcomes Study, which showed no major differences in complication rates over a 4-year period for the same comparison.[7]

Table 4. Diabetes Clinic Association with Hospital and Emergency Room Utilization for March 1996 to October 2000

Outcome	Unadjusted Association	Adjusted Association*
Likelihood of a diabetes-related hospitalization	OR, 0.92 95% CI, 0.61 to 1.39	OR, 0.88 95% CI, 0.52 to 1.49†
Average length of stay for a diabetes-related hospitalization	Average length of stay 0.10% higher for DC, *P* = .44	Average length of stay 0.07% higher for DC, *P* = .62‡
Average cost of a diabetes-related hospitalization	Costs 0.10% higher for DC, *P* = .48	Costs 0.03% higher for DC, *P* = .85§
Likelihood of an ER visit	OR, 0.75 95% CI, 0.49 to 1.13	OR, 0.90 95% CI, 0.55 to 1.46‖
Average cost of an ER visit not resulting in admission	Costs 0.13% lower for DC, *P* = .25	Costs 0.10% lower for DC, *P* = .40¶

* *All models adjusted for clustering by physician.*
† *Adjusted for age, gender, nonwhite racial status, duration of diabetes, baseline glucose level, history of coronary artery disease, history of stroke, number of medications, and insurance status.*
‡ *Adjusted for age, duration of diabetes, baseline diabetic foot disease, retinopathy, admission for diabetic foot, admission for renal failure, and insurance status.*
§ *Adjusted for age, duration of diabetes, history of coronary artery disease, natural log transformation of the length of stay, and insurance status.*
‖ *Adjusted for age, history of coronary artery disease, history of neuropathy, proportion of zip code with college education, living greater than 15 miles from the hospital, number of medications, and insurance status.*
¶ *Adjusted for age, history of coronary artery disease, number of medications, and insurance status.*
ER, emergency room; OR, odds ratio; CI, confidence interval.

There are divergent explanations for our findings. One hypothesis is that the preventive care provided in both centers was not different enough to influence hospitalization rates or costs. Cardiovascular risk factor management was very similar comparing clinic populations. Documentation of eye and foot examinations was greater for DC subjects but baseline glucose levels were actually higher among DC patients compared to GMC patients. We believe that this is, in part, due to the fact that the DC subjects had a much longer duration of diabetes than GMC subjects, and greater duration of diabetes is associated with progressive worsening of glycemic control.[23] Diabetes center providers did utilize a greater number of medications including insulin, but glucose control efforts may still not have been intense enough to produce equivalent or lower glucose levels.

The fact that glycemic control was actually worse among DC subjects suggests an alternative hypothesis. Higher baseline glucose levels have been previously found to be a major predictor of higher rates of hospitalization.[22] We also found that higher baseline glucose levels were independently associated with higher hospitalization rates in crude and adjusted analysis. Given this association between glucose levels and hospitalizations, we would have expected to find a higher rate of hospitalization among DC subjects who had longer disease duration and higher baseline glucose levels. We instead found no difference in hospitalizations or emergency room utilization. Our inability to observe higher hospitalization rates among DC subjects may suggest that factors associated with DC care led to reduced hospital and ER use compared with GMC. However, we did not find a statistically significant difference between the clinics in analyses accounting for disease severity.

The quality of preventive care was overall similar to prior observations, with more mixed results in comparisons with national studies. Compared to the quality of care from the National Health and Nutrition Examination Survey, the DC had higher rates of HbA_{1c} testing, foot exams, and eye exams, but at the same time cholesterol testing occurred less frequently (76% annual testing for the DC vs 85% biannual testing nationally).[24] When compared with data from clinic-based studies, rates of processes of care measures were highly similar, as were risk factor levels for both clinic populations.[11] Differences in processes of care between endocrinologists and generalists were also similar to those seen in our study.

The nature of the relationships between the patients, primary care physicians, and DC physicians may have also influenced our results. The original reason for referral to the DC is important to consider. Some patients may have been attending the DC because they were particularly motivated to improve their diabetes care, while other patients may have been attending the DC because their diabetes was difficult to control for medical or behavioral reasons. While we did consider many clinical and socioeconomic factors that might be associated with such referral patterns, we did not have data that directly identified the reason for referral. We also found that many patients were comanaged with a DC physician and a primary care physician (65% of DC patients). Such comanagement may have helped to exaggerate the differences in diabetes care received by patients in the DC versus the GMC in essence because they had an expanded chronic care management team. Conversely, if decisions regarding hospitalizations and ER visits were made by the primary care physician, then this phenomenon would minimize differences in resource utilization between groups. Our results cannot distinguish between these scenarios. Of note, we found no differences in hospital utilization between DC patients who had an additional primary care physician and those who went to the DC for primary care.

Apart from this, we did not account for utilization of hospitals outside of MGH or to what extent this occurred differentially for the 2 clinic populations. However, MGH patient survey data suggest that we have captured the majority of inpatient utilization (80%) (written personal communication, P. Nordberg, MS, June 8, 2001). We also restricted our analysis to those patients with a primary care physician at MGH and further restricted our ER analysis to patients living within 60 miles of the hospital. Finally, while our study had power (80%) to detect differences in hospitalization rates (e.g., 36% vs 21% for 1 year) previously described in comparable studies, larger numbers and longer follow-up might have provided us with greater power to detect differences between the clinics.[8]

Our study is a comparison of 2 clinics, organized with differences in physician specialty, routine provision of diabetes self-care education, and explicitly coordinated care, system-level elements often cited as important in improving diabetes care. The study helps to illustrate how care of diabetes patients is often shared between specialists and how inpatient health care utilization is tied to a complex web of factors, including patients' severity of illness, intensity of preventive care, and management of inpatient care. Subjects attending the DC were systematically sicker individuals based on duration of diabetes and existing diabetes complications. Preventive care in the DC was remarkable for greater microvascular testing and the use of insulin but did not lead to superior management of glucose, blood pressure, or cholesterol in the DC compared to the GMC. Despite differences in baseline severity of illness, inpatient utilizations did not differ between populations. Diabetes centers will likely continue to play a role in caring for highly complicated diabetes patients, but generalist clinics will continue to care for the vast majority of diabetes patients. Whether or not diabetes quality improvement efforts that borrow features of diabetes centers will lead to inpatient cost savings remains an important and unanswered question. In light of our study's observations regarding the predominance of cardiovascular hospitalizations, such quality improvement efforts may need to focus specifically on enhancing cardiovascular prevention practices as part of comprehensive diabetes care.[25]

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