

Real-World Evaluation of the Effects of Counseling and Education in Diabetes Management

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Abstract

Background. Patient education has long been recognized as a component of effective diabetes management, but the impact of counseling and education (C/E) interventions on health care costs is not fully understood.

Objectives. To identify the incidence and type of diabetes C/E received by type 2 diabetes patients and to evaluate associated economic and clinical outcomes.

Methods. This retrospective cohort study used the Premier-Optum Continuum of Care database (2005–2009) to compare adult patients with type 2 diabetes receiving C/E to those not receiving C/E (control). The index date was the first C/E date or, in the control cohort, a randomly assigned date on which some care was delivered. Patients had at least 6 months' pre-index and 12 months' post-index continuous health plan coverage. Health care costs and glycemic levels were evaluated over 12 and 6 months,

respectively, with adjustment for differences in baseline characteristics using propensity score matching (PSM).

Results. Of 26,790 patients identified, 9.3% received at least one C/E intervention (mean age 53 years, 47% men) and 90.7% received no C/E (mean age 57 years, 54% men). Standard diabetes education was the most common form of C/E (73%). After PSM, C/E patients had some improvements in glycemic levels (among those with laboratory values available), without increased risk for hypoglycemia, and incurred \$2,335 per-patient less in diabetes-related health care costs, although their total health care costs increased.

Conclusions. Despite the low uptake of C/E services, C/E interventions may be associated with economic and clinical benefits at 12 months. Further analyses are needed to evaluate the long-term cost-effectiveness of such initiatives.

In the United States, an estimated 25.8 million people, or 8.3% of the population, are affected by diabetes, and approximately 90–95% of all diabetes patients have type 2 diabetes.¹ In economic terms, the burden of this disease on the U.S. health care system increased from \$132 billion in 2002 to \$174 billion in 2007, a trend that is expected to continue as a result of rapid growth in the number of cases of type 2 diabetes.^{1,2} Adjusting for age and sex differences, total medical costs of patients with diabetes are, on average, 2.3-fold higher than what they would be in the absence of diabetes.¹

Many patients with type 2 diabetes do not have the knowledge and skills to manage their condition appropriately. Less than half of all patients achieve optimal glycemic control, resulting in increased complication rates that are a key driver of higher health care costs.^{2,3}

Patient education has long been recognized as a component of effective diabetes management. Its objective is to reinforce healthy behaviors associated with optimal self-management, medication adherence, and quality of life.^{4–7} Health care professionals (HCPs) providing health counseling collaborate with

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patients and assist them in making decisions related to their health, whereas health education is more directive, with the HCP taking on a role as a teacher or leader rather than as a resource to patients. Diabetes counseling and education (C/E) initiatives designed to increase patients' understanding of diabetes also have the potential to prevent or delay complications and improve the outcomes of those living with diabetes.^{8,9} However, the association of C/E interventions with health resource use and health care costs is not fully understood, with evidence of effectiveness varying according to program and setting.¹⁰⁻¹³

Herein, we report the findings of a retrospective claims database study designed to identify the most common types of diabetes C/E programs received by patients with type 2 diabetes in a real-world setting and to compare the economic and clinical outcomes of those receiving some type of C/E to outcomes of patients receiving none. The study had two specific objectives: first, to identify and describe the population of type 2 diabetes patients who received C/E in the real world, and, second, to assess the impact of C/E on the three study endpoints: health care costs, glycemic control (measured through A1C levels and available only in a few patients), and incidence of hypoglycemic events.

Design and Methods

This was a retrospective analysis of medical, pharmacy, and laboratory data and enrollment information contained in the de-identified, matched Premier-Optum Continuum of Care national managed care database.¹⁴

Sample, inclusion and exclusion criteria, and data sources

Subjects were identified from the database and had been admitted to a hospital at least once for any reason. This database links a large outpatient research database and a large hospital database, resulting in detailed information about hospitalization and care before and after hospitalization.

Patients were ≥ 18 years of age and had at least one inpatient visit or at least two outpatient visits at least

30 days apart between January 2005 to June 2009. The primary or secondary diagnosis for these visits were codes 250.x0 or 250.x2 for type 2 diabetes from the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM). In addition, patients were required to have at least one prescription claim for an oral antidiabetic drug or insulin filled at any time during the study period. (Patients receiving a glucagon-like peptide-1 receptor agonist were not counted.) Patients with a diagnosis of type 1 diabetes (ICD-9-CM codes 250.x1 or 250.x3) were excluded.

Two cohorts for comparison were constructed. Patients were eligible for inclusion in the C/E group if they had at least one claim for a C/E intervention between 1 July 2005 and 30 June 2009, as identified by Current Procedural Terminology (CPT) codes. The non-C/E (control) cohort was composed of patients who did not have any claims for visits with associated C/E interventions during the same calendar period. CPT codes are used to report 15- or 30-minute educational or C/E services prescribed by a physician or other qualified HCP to an individual or group of patients through a standardized curriculum. The interventions may have been provided by a physician or by a nonphysician HCP and may have involved health, nutritional, psychological, or behavioral interventions. The codes were based on the American Association of Diabetes Educators' guidelines¹⁵ and the authors' identification of similar codes for C/E. Any codes that could be construed as "health-related counseling or education in a patient with diabetes" were identified as potentially relevant. Table 1 summarizes the ICD-9-CM and CPT codes included in this study.

The date of the first C/E encounter was defined as the index date. The index date for patients in the control group was the date of a randomly assigned office visit during the specified dates. All patients were required to have continuous medical and pharmacy health plan coverage for at least 6 months before the index date (defined as the baseline period)

Table 1. Definitions of ICD-9-CM Diagnosis Codes for Type 2 Diabetes and CPT Codes for Counseling and Education

ICD-9-CM Diagnosis Code		Definition of Complication	CPT Code	Duration (minutes)
Type 2 diabetes mellitus				
250.x0 (including 250.00, 250.10, 250.20, 250.30, 250.40, 250.580, 250.60, 250.70, 250.80, 250.90)	Diabetes mellitus, type 2, with/without mention of complication, not stated as uncontrolled			
250.x2 (including 250.02, 250.12, 250.22, 250.32, 250.42, 250.52, 250.62, 250.72, 250.82, 250.92)	Diabetes mellitus, type 2, with/without mention of complication, stated as uncontrolled			
Counseling and Education Category	Summary			
Diabetes education	Diabetes outpatient self-management training services		G0108, G0109	30

Diabetic management program, group session	S9455	45–60*
Patient self-management education and training	98960–98962	30
Education supplies provided by the physician	99071	—†
Physician educational services rendered in a group setting	99078	30–45*
Patient education not otherwise classified, nonphysician provider	S9445, S9446	—‡
Medical nutrition therapy	97802	15
	97803	15
	97804	30
Nutritional counseling for control of dental disease	D1310	15*
Medical nutrition therapy	G0270	15
	G0271	30
Nutrition classes, nonphysician provider	S9452	45–60*
Diabetic management program, dietitian visit	S9465	30–45*
Nutrition counseling, dietitian visit	S9470	—‡
Medical therapy management by a pharmacist	99605–99607	15*
Disease management program: assessment, follow-up/reassessment, or per diem	S0315	45–60*
	S0316	30*
	S0317	30–60*
Diabetic management program, follow-up visit to provider	S9140, S9141	30*
Weight management classes	S9449	45–60*
Exercise classes	S9451	45–60*
Diabetic management program, nurse visit	S9460	30*
School-based individualized education program services	T1018	—‡
Medical therapy management by a pharmacist	0115T–0117T	15

*Clinical estimation.
 †Supplies; specific time is not applicable.
 ‡Unable to estimate time.

and for at least 12 months after the index date (follow-up period).

Study endpoints

Baseline demographics and clinical characteristics of the C/E group were compared to those of the control group for each of the study's endpoints. Total health care costs were calculated using all-cause and diabetes-specific costs incurred over 1 year after C/E (C/E group) or after the date of a randomly assigned office visit (control group) from charge data in the database and were adjusted for differences in baseline demographics and clinical characteristics. Such administrative data can provide vital information for studies of economic outcomes of disease and serve as a proxy for health care costs.^{16,17}

Health care costs were considered to be diabetes-related if the claim contained a primary diagnosis code for diabetes (ICD-9-CM 250.x0 or 250.x2). For example, diabetes-related health care claims could be for antidiabetic medications, for endocrinologist visits, or for diabetes supplies (e.g., lancets or glucose test strips). Glycemic control (defined as an A1C < 7.0%) was assessed on the index date (the closest measure within 7 days before or after the index date) and at 6 months after the index date for patients for whom laboratory values were available. Hypoglycemic events identified in the baseline and follow-up periods were defined as a health care claim with an ICD-9-CM code for a hypoglycemic event (251.0–251.2, 270.3, 775.0, or 775.6) or a health care claim for diabetes with other specified manifestations (ICD-9-CM code 250.8) not in conjunction with claims for a hypoglycemic co-diagnosis (259.8, 272.7, 681.xx, 682.xx, 686.9x, 707.1–707.9, 709.3, 730.0–730.2, or 731.8).

Statistical analysis

Descriptive statistics were used to summarize the baseline characteristics of patients with type 2 diabetes in the C/E and the non-C/E group. Baseline characteristics included age, sex, race, geographical region, Charlson comorbidity index (CCI) score, and health care costs from the baseline period. Differences in glyce-

mic levels, incidence of hypoglycemic events, and health care costs between the C/E and non-C/E groups during the follow-up period were evaluated using χ^2 and *t* tests. Regression analyses were used to model differences between individuals who received C/E and those who did not.

Propensity score matching (PSM) at a matching ratio of 1:1 was used to construct a non-C/E control group that closely matched in all other measures the cohort of patients who received C/E, thereby adjusting for patient imbalances in each group in an attempt to address potential selection bias.¹⁸ Covariates included in the PSM model were demographic and baseline clinical factors, including age, sex, race, geographical region, index year, CCI score, diabetes medication, annualized number of hospitalizations, annualized number of outpatient visits before the index visit, and, for a subanalysis among patients with A1C values available, glycemic levels at baseline. Patients from one cohort could only be matched to patients in the comparator cohort if they had a highly similar probability of being a member of the overall cohort; these were fitted values known as propensity scores. For each patient in the C/E group, a non-C/E patient with the closest propensity score was selected; patients were considered matched if their propensity scores were within ± 0.001 units. Patients who were not within this supported region of the propensity score distribution were not matched and were excluded from the matched analysis. All 12-month endpoints in those receiving C/E were compared with those in matched patients who did not receive C/E.

Results

Baseline demographics and patient characteristics

A total of 341,893 patients with type 2 diabetes who were ≥ 18 years of age and had an index visit between 1 July 2005 and 30 June 2009 were identified. Of these, 26,790 patients met all study criteria, including 2,490 (9.3%) who had received at least one C/E intervention and 24,300 (90.7%) who had not received any C/E. Of

the 2,490 individuals who had C/E, 48 (2%) received the intervention in an inpatient setting. The mean age of all patients ($n = 14,325$) was 56 years, and the majority were male ($n = 14,325$; 53.5%) and white ($n = 17,974$; 67%). Baseline characteristics of patients in the C/E and non-C/E groups are summarized in Table 2.

Types of C/E

Among the 2,490 patients who received C/E, diabetes education and nutrition/diet counseling were the most common types and were received by 1,822 (73%) and 524 (21%) patients, respectively. In addition, 116 patients (4.7%) received health education that was not specific to diabetes, and 28 patients (1.1%) received other types of health education.

Propensity score–matched population

After PSM, 1,890 patients in the C/E group were matched with an equivalent number of patients from the non-C/E group for subsequent outcome analyses. Baseline characteristics of the matched population are summarized in Table 2.

Health care costs

During the baseline period, total (all-cause) health care costs among propensity score–matched patients who received C/E were similar to those without C/E. (Health care costs [mean \pm SD] at baseline were characteristics of the basis on which patients were matched: C/E group, \$20,076 \pm \$53,741; non-C/E group, \$22,432 \pm \$45,030; $P = 0.14$). At the end of the 1-year follow-up period, total health care costs (mean \pm SD) were higher for patients with C/E (\$24,747 \pm \$57,670) compared to the total costs for those without C/E (\$18,378 \pm \$37,522; $P < 0.001$). Diabetes-related charges (mean \pm SD) at baseline and 1-year follow-up were lower for matched patients who received C/E (Figure 1).

Diabetes outcomes

Only 4.2% of the identified individuals ($n = 1,125$) had an available A1C level at baseline, and approximately 16% ($n = 4,243$) had an A1C test

Table 2. Baseline Characteristics of Patients in the C/E Group Compared to Those in the Non-C/E Group

Demographics	Unmatched Cohorts		P (C/E vs. non-C/E)	Propensity Score-Matched Cohorts		P (C/E vs. non-C/E)
	C/E (n = 2,490)	Non-C/E (n = 24,300)		C/E (n = 1,890)	Non-C/E (n = 1,890)	
Age [n (%)]						
18–44 years	547 (22.0)	3,714 (15.3)	< 0.001	—	—	—
45–64 years	1,556 (62.5)	15,216 (62.6)		1,207 (63.9)	1,152 (61.0)	0.06
≥ 65 years	387 (15.5)	5,370 (22.1)		372 (19.7)	336 (17.8)	0.13
Mean age [years (SD)]	53 (12.5)	56.7 (12.3)	< 0.001	54.9 (12.2)	55.2 (12.6)	0.49
Sex [n (%)]						
Male	1,166 (46.8)	13,159 (54.2)	< 0.001	958 (50.7)	932 (49.3)	0.40
Female	1,324 (53.2)	11,141 (45.8)		932 (49.3)	958 (50.7)	
Race [n (%)]						
White	1,794 (72.0)	16,180 (66.6)	< 0.001	1,313 (69.5)	1,328 (70.3)	0.59
Black	255 (10.2)	3,434 (14.1)		212 (11.2)	208 (11.0)	0.84
American Indian	20 (0.8)	138 (0.6)				
Hispanic	87 (3.5)	1,361 (5.6)				
Asian/Pacific Islander	34 (1.4)	281 (1.2)				
Other	299 (12.0)	2,901 (11.9)				
Unknown	1 (< 0.1)	5 (< 0.1)				
U.S. geographical location [n (%)]						
Northeast	118 (4.7)	1,556 (6.4)	< 0.001	110 (5.8)	102 (5.4)	0.57
Midwest	1,226 (49.2)	6,877 (28.3)		758 (40.1)	811 (42.9)	0.08
South	969 (38.9)	13,832 (56.9)		874 (46.2)	845 (44.7)	0.34
West	176 (7.1)	2,021 (8.3)		148 (7.8)	132 (7.0)	0.32
Insurance type [n (%)]						
EPO	249 (10.0)	3,096 (12.7)	< 0.001	197 (10.4)	197 (10.4)	< 0.0001
HMO	1,037 (41.6)	4,490 (18.5)		710 (37.6)	344 (18.2)	
FFS	107 (4.3)	1,839 (7.6)		95 (5.0)	139 (7.4)	
Other	12 (0.5)	152 (0.6)		11 (0.6)	11 (0.6)	
POS	924 (37.1)	12,026 (49.5)		740 (39.2)	978 (51.7)	
PPO	161 (6.5)	2,696 (11.1)		137 (7.2)	221 (11.7)	
CCI [mean (SD)]	2.8 (2.2)	2.8 (2.3)	0.60	1.8 (1.8)	1.8 (1.6)	—

CCI, Charlson comorbidity index; EPO, exclusive provider organization; FFS, fee for service; HMO, health maintenance organization; POS, point of service; PPO, preferred provider organization.

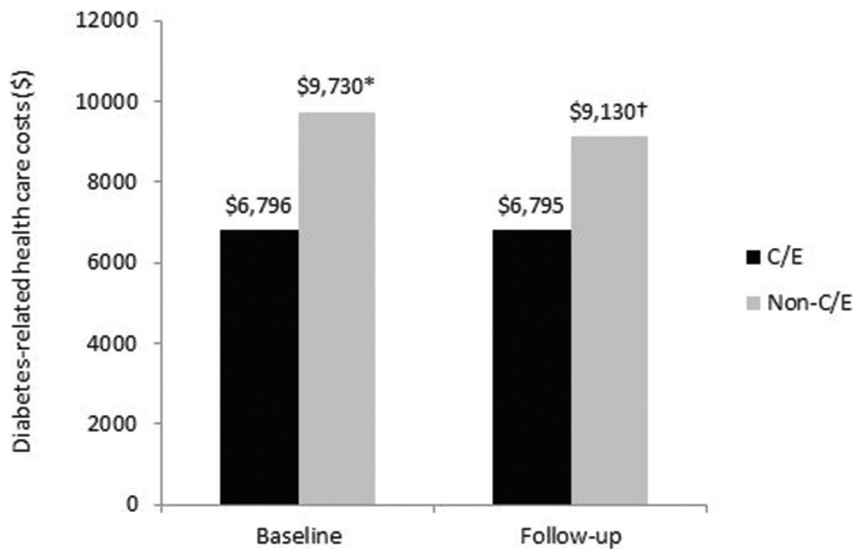


Figure 1. Diabetes-related health care costs at baseline and follow-up in type 2 diabetes patients with and without C/E in PSM analyses. * $P < 0.0001$, † $P = 0.0002$.

result during the follow-up period. A total of 32 patients in the C/E group and 1,330 patients in the non-C/E group had similar A1C levels (mean \pm SD) at baseline (7.4 ± 2.0 vs. $8.0 \pm 1.8\%$; $P = 0.60$), whereas a higher percentage of C/E patients ($n = 20$; 62.5%) than non-C/E patients ($n = 684$; 51.4%; $P = 0.02$) demonstrated glycemic control (A1C $< 7.0\%$). The results from the PSM analysis are shown in Table 3.

There were no significant between-group differences in the incidence of hypoglycemic events in either the baseline or the follow-up period, and the results of the PSM analysis mirrored the results of the analysis of the overall study population (Table 3). The adjusted odds ratio for hypoglycemia with intervention was 1.22 (95% CI 0.66–2.26).

Discussion

Compared to the general population, people with diabetes have higher health care resource use in terms of hospital inpatient care, outpatient and physician office visits, emergency visits, nursing facility stays, home health visits, visits with other HCPs, and prescription drug and medical supply use.² Despite the high uptake of health care by patients with diabetes, the Disease Management

Association of America identifies diabetes as one of the chronic conditions with the greatest potential for management.¹³ Urgent measures are needed to curtail the obvious deficit between current and optimal management of this disease and the economic burden it represents.^{1,2}

One area traditionally targeted for intervention is patient C/E. Clinical studies have shown that diabetes C/E interventions, delivered alone or as part of a comprehensive intervention program, improve physical activity, health care behavior (including self-management), glycemic control, and BMI.^{19,20} In addition to the benefits demonstrated in clinical studies, C/E interventions in real-world practice settings have been shown to improve glycemic control,^{21,22} self-efficacy,^{21,23} and lifestyle outcomes, including physical activity and weight loss.^{21,24}

Despite the potential for clinical, lifestyle, and behavioral benefits with diabetes C/E, findings from systematic reviews have led to concerns regarding the clinical effectiveness of patient education models for diabetes.^{10,12,25} Furthermore, the impact of C/E on health resource utilization and costs is not well understood, and the evidence linking intervention to treatment adherence similarly lacks

robustness.¹¹ The present study was conducted to identify the most common types of diabetes C/E received by patients with type 2 diabetes in a real-world setting and to compare economic and clinical outcomes in patients receiving some type of counseling (including both inpatient and outpatient C/E interventions) to those in patients receiving no C/E. Furthermore, the use of the integrated database in this study allowed for analysis of the effects of C/E on a wide range of outcomes.

We report here that C/E can affect outcomes. However, the study results are based on only a small proportion of patients receiving C/E. Despite recommendations from the American Diabetes Association that self-management education is an essential component of appropriate medical care and should be available to all people with diabetes,²⁶ fewer than 1 in 10 patients in this study received C/E in this managed care setting. Of those who did receive C/E, the majority (73%) received standard diabetes education.

The receipt of C/E varied by U.S. geographical location, as well as by race in the unmatched cohorts. White patients and patients residing in the Midwest were more likely to receive C/E, whereas black and Hispanic patients and patients residing in the South were more likely to be in the non-C/E cohort.

The results of this study could potentially encourage health care decision-makers to proactively consider C/E for their patients and also to make C/E more accessible. The key findings were that patients who received at least one C/E intervention experienced some improvements on study endpoints; they had lower diabetes-related health care costs at the 12-month follow-up, no difference in risk for hypoglycemia, and, among the sub-cohort of patients with A1C data available, showed a trend toward achieving glycemic control compared to patients who did not receive any C/E.

The net diabetes-related cost savings at follow-up for patients who had at least one C/E intervention were \$2,335 (\$6,135 in the unmatched analysis). Although the

Table 3. Glycemic Control and Hypoglycemia in Propensity Score–Matched Patients Who Did or Did Not Receive C/E

	Baseline			6-Month Follow-Up		
	C/E (<i>n</i> = 31)	Non-C/E (<i>n</i> = 72)	<i>P</i>	C/E (<i>n</i> = 31)	Non-C/E (<i>n</i> = 72)	<i>P</i>
A1C [mean % (SD)]	7.3 (2.1)	7.6 (1.8)	0.43	6.7 (1.4)	7.5 (1.4)	0.016
Patients with A1C < 7.0% [<i>n</i> (%)]	20 (64.5)	35 (48.6)	0.14	22 (71.0)	35 (48.6)	0.04
	C/E (<i>n</i> = 1,890)	Non-C/E (<i>n</i> = 1,890)		C/E (<i>n</i> = 1,890)	Non C/E (<i>n</i> = 1,890)	
Hypoglycemic events [<i>n</i> (%)]	30 (1.59)	25 (1.32)	0.50	26 (1.38)	20 (1.06)	0.37

PSM analysis showed similar all-cause baseline costs for the C/E and non-C/E cohorts, it is interesting to note that the difference in diabetes-related baseline costs persisted.

This study reported the results of PSM analyses, considered to be a robust methodological approach to account for heterogeneity within large patient cohorts.¹⁸ The PSM analysis was carried out to adjust for patient imbalances between groups and thus to overcome selection bias by matching patients on observed baseline characteristics. This enables evaluation of the effects of interventions in more comparable groups of patients.

However, the results of this retrospective, observational study still may be subject to unobserved confounding factors or by confounding characteristics that could not be included in the PSM model because of unavailability of information for all patients in the observational data set (e.g., A1C and diabetes duration). Consequently, the PSM analysis does not account for the effect of such characteristics on clinical and economic endpoints. There may have been a selection bias for patients receiving C/E in a managed care setting that was not possible to ascertain. Potential demographic variables that were not considered in the analysis but might explain differences include patients' education level, employment status, and satisfaction with their care and the longevity of their relationship with their physician.

A further question emerges from the finding that all-cause, but not diabetes-related, health care costs

increased relative to baseline in the C/E cohort at follow-up, but not in the non-C/E cohort. It should be kept in mind that this study used linked data from a hospital database with a managed care (primarily outpatient) database and that all patients had at least one hospitalization for any reason, implying an overall "sicker" study population. Nonetheless, it is tempting to speculate that the implementation of diabetes C/E is associated with preemptive health care-seeking behaviors and a consequent increase in costs. For example, recent findings have shown that patients with claims for diabetes education were more likely to follow treatment recommendations, receive health care, and have A1C, microalbumin, lipid, and eye tests than patients without claims for diabetes education.^{27,28} Such behavior could arguably predict an increase in diabetes-related health care costs rather than the unchanged diabetes-related costs reported here.

However, given the multifactorial nature of diabetes, it is plausible that active participation in health care, resulting from increased diabetes awareness, will drive an increase in the overall cost of diabetes management. This could be particularly conceivable in cases where increases in outpatient visits are not accompanied by a concomitant increase in diabetes-specific diagnostic and test codes for those individuals in whom diabetes is well controlled. In this regard, another U.S.-based medical claims study evaluating health care use and costs in a diabetes-management program reported that active participation in the form

of monthly telephone counseling among U.S. patients already receiving educational mailings resulted in greater reductions in inpatient days and emergency department visits and greater increases in ambulatory visits, retinal examinations, A1C tests, and urine microalbumin tests compared to patients receiving educational mailings only. Annual medical cost savings were \$783 per patient who received educational mailings with or without monthly telephone counseling compared to an historical control group lacking any similar intervention.¹³

Patients who received any type of C/E in our analysis had diabetes-related education identified from CPT codes.²⁹ This does not incorporate a counseling component per se, but could be aimed at improving blood glucose levels, reducing the risk of complications, weight loss, lifestyle modification, understanding medications, and achieving effective diabetes self-management through programs delivered by a trained diabetes educator. Only those C/E interventions that were accompanied by a code that was submitted for reimbursement would be available from the study data set. The study may have missed C/E efforts not reimbursed by the health plan or those in the form of brochures, self-education, peer-to-peer education, websites, and Internet forums or information provided during office visits for other purposes. It should also be noted that retrospective analyses such as this one do not allow for assessment of variability in C/E or level of access to C/E.

In addition to demonstrating the potential for diabetes-related cost savings, the results of our analysis also show that the sub-cohort of patients receiving C/E showed a trend toward significant improvements in A1C levels, whereas the risk of hypoglycemia was not affected by C/E interventions. Despite the low number of patients with available A1C data, the results describe a relationship between C/E interventions and clinical outcomes similar to previous studies.^{30–32}

Recent studies have demonstrated that having at least one educational intervention, as opposed to having none, was associated with a decrease in cost outcomes.^{31,32} Although this may be impractical in a real-world setting, Gillett et al.³¹ concluded that a 6-hour, structured group education program delivered by health care educators was likely to be cost-effective compared to usual care, with reductions in weight and smoking being the main benefits achieved. Gillett et al.³¹ also evaluated the effect of intervention on glycemic control but could not demonstrate any improvement in A1C.

The overall reported rate of hypoglycemia was low in both groups. It should be acknowledged that accurate identification of hypoglycemia in administrative claims data sets can be challenging. The reported rates relate only to events that involved a clinical encounter with an ICD-9-CM code, typically used for reimbursement purposes only and suggesting active management of hypoglycemia. Hypoglycemia events that are not captured in claims data were not included and, as a result, the incidence of hypoglycemia is typically underreported and undercoded.³³

In addition to the previously mentioned possibility of bias caused by unobserved confounding factors in the PSM analysis, this study has some additional limitations. First, it was carried out using medical insurance claims data and is therefore subject to coding errors or potential differences in coding behavior and to limited availability of clinical and laboratory data, as illustrated by the low number of patients with avail-

able A1C data. Second, a limitation common to all retrospective analyses is that causality of outcomes cannot be established. Third, the data are from a cohort of commercially insured, managed care patients and, as such, may not be representative of the U.S. population as a whole, given that the availability of C/E services is likely to vary across regions and according to health care providers, specific benefits and coverage plans, and patient awareness of services. Finally, to ensure the inclusion of any potential C/E provided to diabetes patients, C/E sessions that were not specific to diabetes management were included in the analyses. The exact content, level, and intensity of C/E sessions could not be ascertained, and topics covered during these sessions were not available for consideration in the analysis.

In conclusion, although the use of C/E services was low among patients with type 2 diabetes in this study, our findings suggest that such interventions may be associated with improved economic outcomes and an increasing trend toward favorable clinical outcomes. C/E interventions were associated with increased total health care costs, whereas health care costs related specifically to diabetes care were reduced compared to those for non-C/E patients. Patients who received C/E were more likely to demonstrate glycemic control, without a change in the risk of hypoglycemia. An important implication of this study would be to encourage health care decision-makers to proactively consider C/E for their diabetes patients and to increase its accessibility to patients. This may potentially result in overall future health benefits and cost savings. Further research is warranted to understand the full impact of C/E with a view to improving the delivery of high-quality C/E services.

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