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Nurse Case Management To Improve Glycemic Control in Diabetic Patients in a Health Maintenance Organization

A Randomized, Controlled Trial

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Background: Control of hyperglycemia delays or prevents complications of diabetes, but many persons with diabetes do not achieve optimal control.

Objective: To compare diabetes control in patients receiving nurse case management and patients receiving usual care.

Design: Randomized, controlled trial.

Setting: Primary care clinics in a group-model health maintenance organization (HMO).

Patients: 17 patients with type 1 diabetes mellitus and 121 patients with type 2 diabetes mellitus.

Intervention: The nurse case manager followed written management algorithms under the direction of a family physician and an endocrinologist. Changes in therapy were communicated to primary care physicians. All patients received ongoing care through their primary care physicians.

Measurements: The primary outcome, hemoglobin A_{1c} (HbA_{1c}) value, was measured at baseline and at 12 months. Fasting blood glucose levels, medication type and dose, body weight, blood pressure, lipid levels, patient-perceived health status, episodes of severe hypoglycemia, and emergency department and hospital admissions were also assessed.

Results: 72% of patients completed follow-up. Patients in the nurse case management group had mean decreases of 1.7 percentage points in HbA_{1c} values and 43 mg/dL (2.38 mmol/L) in fasting glucose levels; patients in the usual care group had decreases of 0.6 percentage points in HbA_{1c} values and 15 mg/dL (0.83 mmol/L) in fasting glucose levels ($P < 0.01$). Self-reported health status improved in the nurse case management group ($P = 0.02$). The nurse case management intervention was not associated with statistically significant changes in medication type or dose, body weight, blood pressure, or lipids or with adverse events.

Conclusions: A nurse case manager with considerable management responsibility can, in association with primary care physicians and an endocrinologist, help improve glycemic control in diabetic patients in a group-model HMO.

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The Diabetes Control and Complications Trial (DCCT) and the Kumamoto study (1, 2) showed that near-normal glycemic control reduces the development and progression of microvascular and neuropathic complications by approximately 50% in type 1 and type 2 diabetes mellitus. Additional analyses (3-5) indicate that therapy to achieve near normalization of blood glucose levels is cost-effective compared with other treatments. Thus, the American Diabetes Association has recommended that all persons with diabetes attempt to achieve near normalization of blood glucose levels (6).

This recommendation is not routinely followed in medical practice. In a 1989 national survey of physician practice behaviors in the United States, 64% of physicians agreed that achieving target HbA_{1c} values is very important but only 18% reported that they ordered HbA_{1c} tests every 2 to 3 months for patients with type 1 diabetes (7). Although 98% agreed that patient education improves glucose control, only 55% reported that they routinely used a dietitian or a diabetes educator in patient care.

Studies indicate that bringing clinical practice into line with scientific knowledge can be difficult. Methods used to achieve diabetes control in clinical trials are resource intensive. The American Diabetes Association currently recommends that patients with diabetes see their primary care physicians two to four times per year. Data from the National Health Interview Survey, a nationally representative survey (8), indicate that most patients with diabetes are seen by nonspecialists and that 69% of physician visits last less than 15 minutes. Algorithms for diabetes care exist but may be complex and difficult for physicians to follow, given patient load, diversity of patients seen, lack of information systems, and time constraints.

Simple, low-cost methods of translating guidelines into clinical care are required. One solution may be to make greater use of personnel other than physicians. Nurse case management was an integral part of intensive therapy in the DCCT and has proven to be effective in reducing smoking and cholesterol levels after acute myocardial infarction (3, 9). A nonrandomized study (10) of more than 700 patients with diabetes in a health maintenance organization suggests that nurse case management may be effective in improving metabolic control. Other studies (11, 12) show a strong association between algorithm-directed nurse interventions and improved glycemic control. To our knowledge, no randomized, controlled clinical trial of nurse case management in diabetes has yet been published.

In a 12-month randomized, controlled trial, we compared a nurse case management model of diabetes care with usual diabetes management in a primary care setting.

Methods

Patients

Our study was approved by the institutional review board of the Prudential Center for Health Care Research, and all patients gave written informed consent. Participants were recruited from two of the largest clinics within the Jacksonville Health Care Group, which is the largest provider of primary care services for the Prudential HealthCare HMO plan of Jacksonville, Florida. The Jacksonville Health Care Group is a group of 43 primary care physicians who provide care in eight clinics to more than 75 000 Prudential HealthCare plan members.

Potential study participants were identified through a database used to support quality-improvement activities. Prudential HealthCare HMO members who had diabetes were included in the database if they had visited a physician for diabetes (International Classification of Diseases, 9th Revision, codes 250.0 to 250.9), had had a hospital claim processed for diabetes, had been seen by the utilization management nurse, or had been referred to an ophthalmologist for a diabetic retinal examination. This database is updated regularly. A list with each member's name, address, telephone number, medical record number, member identification number, age, sex, physician, and clinic was generated by merging the data from the database with enrollment information. In addition, a list of members who may have had diabetes was created by using pharmacy data.

Adult members with diabetes who were potential study participants each received a recruitment call and were invited to schedule an appointment with a research assistant to discuss participation in the study. We made a total of 14 calls at different times and on different days before coding a member as unavailable. After consent was given and the eligibility assessment was completed, baseline information was obtained and an HbA_{1c} test was ordered if the result of one given within the previous 60 days was not available.

Patients were ineligible for the study if they had a recent HbA_{1c} value less than 7.0%; had uncontrolled hypertension (blood pressure > 180/110 mm Hg); had unstable angina (class 4); had had a myocardial infarction in the past 3 months; had had two or more episodes of seizures; had alcoholism or drug abuse documented in the chart; had late-stage complications of diabetes or other chronic conditions, such as severe immunodeficiency or cirrhosis; were pregnant or were planning to become pregnant in the next 12 months; or were unable to perform self-management.

Patients were randomly assigned in blocks to either the nurse case management (intervention) group or the usual care group. Randomization was based on a 1:1 allocation ratio and a block size of three. Each block contained six patients, three in each study group. This randomization scheme ensured that the desired allocation ratio—one intervention patient to one usual care patient—was maintained after sequential enrollment of every sixth patient.

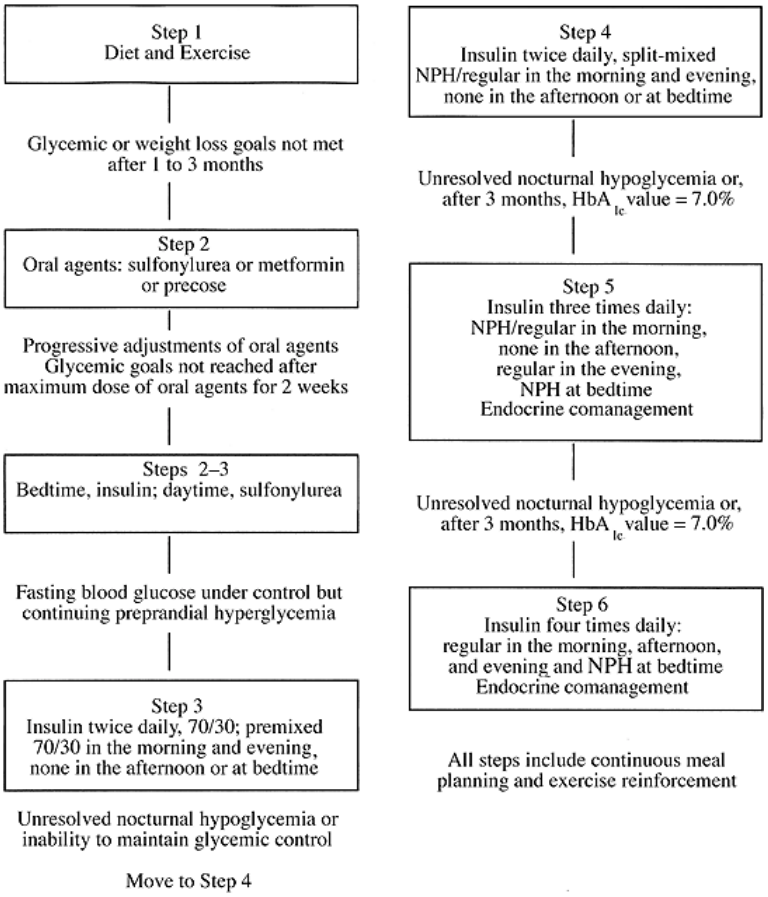
Outcome Measures

Change in HbA_{1c} value was the primary outcome measure. Decreased HbA_{1c} values correlate directly with reduced risk for diabetes-related microvascular and neuropathic complications in type 1 and type 2 diabetes (1, 3). We also assessed health-related quality of life by using four generic questions developed by the Centers for Disease Control and Prevention for the Behavioral Risk Factor Surveillance System (BRFSS) (13, 14). These questions evaluate key conceptual domains of health-related quality of life: 1) patient-perceived general health status, 2) patient-perceived physical dysfunction during the previous 30 days, 3) patient-perceived mental dysfunction during the previous 30 days, and 4) patient-perceived functional incapacity during the previous 30 days for either mental or physical reasons. The BRFSS quality-of-life measures have been validated in a national sample of adults in the United States (15). Patient-perceived health was found to be a good proxy indicator for chronic disease conditions. The other three domains further characterize general health functioning and quality of life (15). In this analysis, we report findings related to the patient-perceived general health status domain.

Intervention and Follow-up

The nurse case manager was a registered nurse and a certified diabetes educator. She was trained to follow a set of detailed management algorithms under the direction of a board-certified family medicine physician and an endocrinologist who were responsible for all diabetes management decisions for patients in the intervention group but were not primary care providers for these patients. The algorithms were specific for type of diabetes and were developed by a multidisciplinary team on which endocrinology, family medicine, nursing, pharmacy, health services research, and epidemiology were represented. The algorithms progressively moved a patient toward improvement of glycemic control through adjustments in medication, meal planning, and reinforcement of exercise (Figure 1).

Figure 1. Algorithm for management of type 2 diabetes mellitus. HbA_{1c} = hemoglobin A_{1c}; NPH = neutral protamine Hagedorn.



Patients assigned to receive nurse case management met with the nurse for an initial assessment, were instructed about a blood glucose monitoring schedule, and returned for a follow-up visit 2 weeks later.

The initial visit with the nurse averaged 45 minutes. At the 2-week follow-up visit, the nurse reviewed the patient's blood glucose log; explained the algorithm step to which the patient had been assigned; and used this information as the baseline for subsequent medication adjustments, meal planning, and exercise reinforcement. Patients receiving nurse case management were also referred to a 5-week, 12-hour diabetes education program that included individual counseling by a dietitian, individual counseling by an exercise therapist, and group diabetes education classes. Subsequent in-person follow-up visits occurred quarterly.

Patients in the nurse case management group who were taking insulin received weekly follow-up telephone calls. After the nurse reviewed the blood glucose log and discussed glucose values with the patient, medication regimens were adjusted as needed and meal planning and exercise were reinforced. Patients treated with oral agents or diet and exercise received follow-up telephone calls every 2 weeks. The nurse case manager met at least biweekly with the family medicine physician and the endocrinologist to review patient progress, medication adjustments, and other issues related to diabetes care. All medication adjustments or changes were communicated to the patients' regular primary care physicians.

Patients assigned to receive usual care were given blood glucose meters and strips, were encouraged to discuss enrollment in the diabetes education class with their physicians if they had not done so in the past year, and continued to receive diabetes care and follow-up from their primary care physicians. The 5-week diabetes education program is a standard, free-of-charge benefit for all HMO members with diabetes. All Jacksonville Health Care Group primary care physicians participate in an annual diabetes care seminar and undergo regular peer review of their adherence to published diabetes care standards.

Tests to measure HbA_{1c} values, fasting plasma glucose levels, fasting lipid levels (total cholesterol, high-density lipoprotein, triglycerides, and low-density lipoprotein), and serum creatinine concentrations were ordered at baseline and at the 6- and 12-month follow-up visits. The primary study outcome, HbA_{1c} value, was measured by using an ion-exchange, high-performance liquid chromatography technique (Bio Rad Diamat/Variant, SmithKline Beecham Laboratories, Tampa, Florida); 6.1% was the upper limit of normal.

We monitored potential adverse events in each group, including emergency department visits, hospital admissions, and patient reports of hypoglycemia. Severe hypoglycemia was defined as a patient-reported blood glucose level less than 50 mg/dL, hypoglycemia requiring the assistance of another person for treatment, or loss of consciousness. At baseline, a history of severe hypoglycemia was ascertained for the 12-month period before study enrollment.

Statistical Analysis

The distribution of baseline characteristics within each study group was described with medians and interquartile ranges (the 25th, 50th, and 75th percentiles of the distribution). We computed change scores for numeric outcome variables by subtracting the baseline value from the 12-month follow-up value. Linear regression analysis was used to regress change scores on baseline values and on an intervention-group indicator variable. Baseline-adjusted mean change scores were calculated from this model; these scores give the expected change across time after adjustment for the baseline covariate. Interaction between the study group and the baseline HbA_{1c} value in the prediction-of-change score was assessed within the regression model and by plotting, for each group, the mean change score against quintiles of baseline HbA_{1c} values. We also examined whether there was an interaction between study group and type of diabetes.

The primary regression analyses used only patients who had no values missing at the 12-month follow-up visit. However, to ensure that loss to follow-up did not bias our results, we examined two separate approaches that used conservative methods to impute missing values. These analyses were done only for the major outcome of interest: change in HbA_{1c} value. In the first imputation approach, we regressed 12-month follow-up HbA_{1c} values on the baseline HbA_{1c} values, including only the patients in the usual care group who had no missing values. The resulting equation was then used to impute follow-up HbA_{1c} values for all patients in both study groups who had missing values from the 12-month follow- up visit. In the second imputation approach, we made the conservative assumption of no change in glycemic control if a patient was lost to follow-up and set the 12-month HbA_{1c} value equal to the patient's baseline HbA_{1c} value. We considered these our intention-to-treat analyses. All statistical analyses were done with SAS software, version 6.12 (SAS Institute, Cary, North Carolina).

Results

The diabetes registry listed 545 members; we were able to gather eligibility and recruitment information for 480 of these members (Table 1). Eligibility status was established for 92% of the 480. Of the 208 members who met the eligibility criteria for randomization, 34% did not appear for their scheduled appointments (and thus were not assigned to treatment) and 66% were randomly assigned to either nurse case management or usual care. Of the 138 members who were randomly assigned to treatment, 100 (72%) provided 12-month follow-up data.

The baseline demographic and clinical characteristics of the study participants, by treatment group, are shown in Table 1.

Table 1. Baseline Characteristics by Treatment Group*

Characteristic	Nurse Case Management Group (*n* = 71)		Usual Care Group (*n* = 67)	
	Median	Interquartile Range	Median	Interquartile Range
Age, *y*	53	47-61	54	46-60
Duration of diabetes, *y*	6	3-13	6	2-13.5
Hemoglobin A_{1c} value, %	8.8	8.2-9.9	8.4	8.0-9.9
Median fasting blood glucose level, *mg/dL*	194	161-241	191	157-233
Insulin dose, *U/kg of body weight*	0.62	0.39-0.83	0.47	0.23-0.73
Diastolic blood pressure, *mm Hg*	79	75-85	79	76-83
Body mass index, kg/m^2	32	28-38	34	31-39
Serum cholesterol level, *mg/dL*	211	179-246	206	187-230
Serum triglyceride level, *mg/dL*	191	133-260	196	115-283
Serum high-density lipoprotein cholesterol level, *mg/dL*	37	33-47	37	31-47
Serum low-density lipoprotein cholesterol level, *mg/dL*	126	103-155.5	128	107-142
Self-reported health status score	3	2-4	3	3-4
Patients with type 1 diabetes mellitus, %	17		8	
Male patients, %	37		43	
White patients, %	83		70	
Patients using insulin, %	44		33	
Current smokers, %	17		11	
Obese patients, %	68		76	

* To convert glucose values to mmol/L, multiply by 0.05551. To convert cholesterol, high-density lipoprotein cholesterol, and low-density lipoprotein cholesterol values to mmol/L, multiply by 0.02586. To convert triglyceride values to mmol/L, multiply by 0.01129.

The two treatment groups were similar for most characteristics at baseline, but the intervention group had fewer members of ethnic minority groups, more smokers, and more insulin-treated patients. Seventeen percent of the patients in the intervention group and 8% of those in the usual care group had type 1 diabetes. Median baseline HbA_{1c} values were 8.8% in the intervention group and 8.4% in the usual care group. Median baseline fasting blood glucose levels were also similar in the two groups (194 mg/dL [10.76 mmol/L] compared with 191 mg/dL [10.60 mmol/L]).

The intervention group had a greater decrease in HbA_{1c} values than the usual care group did (Table 2).

Table 2. Mean Change Scores of Outcome Variables by Treatment Group*

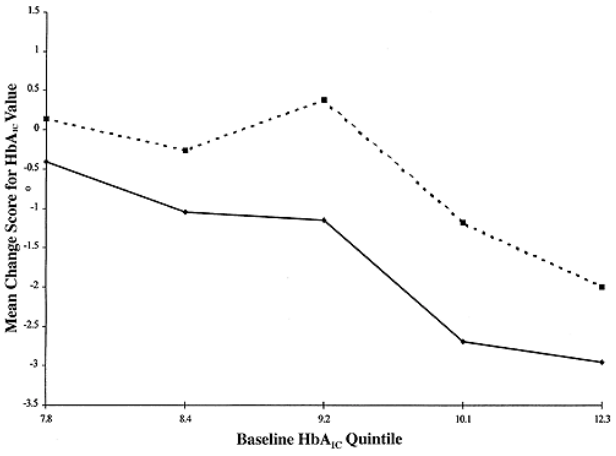
Variable	Mean Change in the Nurse Case Management Group	Mean Change in the Usual Care Group	Difference (95% CI)	*P* Value†
Hemoglobin A_{1c} value, *percentage points*	-1.7	-0.6	-1.1 (-1.62 to 0.58)	<0.001
Mean fasting blood glucose level, *mg/dL*	-48.3	-14.5	-33.8 (-56.12 to 11.48)	0.003
Insulin dose, *U/kg of body weight*	0.22	0.07	0.15 (-0.02 to 0.32)	>0.2
Systolic blood pressure, *mm Hg*	1.9	6.1	-4.2 (-9.81 to 1.41)	>0.2
Diastolic blood pressure, *mm Hg*	-0.8	1.5	-2.3 (-5.79 to 1.19)	>0.2
Weight, *kg*	-0.21	-0.4	-0.19 (-1.6 to 2.0)	>0.2
Serum cholesterol level, *mg/dL*	-11.9	-7.2	-4.7 (-21.54 to 12.14)	>0.2
Serum triglycerides level, *mg/dL*	-21.2	10	-31.2 (-130.2 to 67.89)	>0.2
Serum high-density lipoprotein cholesterol level, *mg/dL*	2	0.7	1.3 (-2.17 to 4.77)	>0.2
Serum low-density lipoprotein cholesterol level, *mg/dL*	-6	-10.2	4.2 (-8 to 16.3)	>0.2
Self-reported health status score	0.47	0.20	0.27 (-0.03 to 0.57)‡	0.02‡

* To convert glucose values to mmol/L, multiply by 0.05551. To convert cholesterol, high-density lipoprotein cholesterol, and low-density lipoprotein cholesterol values to mmol/L, multiply by 0.02586. To convert triglyceride values to mmol/L, multiply by 0.01129.
† For comparison of change scores adjusted for the baseline values of the covariates.
‡ *P* value adjusted such that it is possible for it to be inconsistent with the CI, which is not adjusted.

The average change in HbA_{1c} value was -1.7 percentage points (7.3% at 12 months minus 9.0% at baseline) in the intervention group and -0.6 percentage points (8.3% at 12 months minus 8.9% at baseline) in the usual care group ($P < 0.001$). On average, patients in the intervention group had a decrease of 48.3 mg/dL [2.68 mmol/L] in fasting blood glucose level compared with a decrease of 14.5 mg/dL [0.80 mmol/L] in the usual care group ($P = 0.003$). No statistically significant differences were seen between nurse case management and usual care with respect to changes in systolic or diastolic blood pressure, serum cholesterol and triglyceride levels, or body weight. Both groups reported an improved perception of health status after 12 months, but patients in the intervention group were more than twice as likely as patients in the usual care group to report this ($P = 0.02$).

We graphed HbA_{1c} change scores for each quintile of baseline HbA_{1c} value according to study group and found that the lines were parallel. Improvement in glycemic control was greater in the intervention group than in the usual care group in each quintile of baseline HbA1c value; this finding suggests that there was no interaction between study group and baseline HbA_{1c} value (Figure 2).

Figure 2. Mean hemoglobin A_{1c} (*HbA_{1c}*) *change score by baseline HbA_{1c} quintile and treatment group.* Dashed line represents usual care; solid line represents nurse case management.



In addition, in a regression model, we found no statistically significant interaction between baseline HbA_{1c} values and treatment group with respect to HbA_{1c} values at follow-up ($P > 0.2$).

Although only 17 of our patients had type 1 diabetes, we examined whether the difference between study groups in glycemic control was seen for both types of diabetes. We found that for patients with either type 1 or type 2 diabetes, nurse case management was associated with an improvement in glycemic control compared with usual care. Patients with type 1 diabetes in the intervention group had a mean decrease in HbA_{1c} value of 1.2 percentage points; those in the usual care group had a mean decrease of 0.2 percentage points. Patients with type 2 diabetes in the intervention group had a mean decrease in HbA_{1c} value of 1.7 percentage points; the usual care group had a mean decrease of 0.7 percentage points.

Patients lost to follow-up did not significantly differ by sex, type of diabetes, therapeutic regimen, baseline mean HbA_{1c} value, or treatment group. However, patients 18 to 44 years of age were more likely than patients 45 years of age and older to be lost to follow-up (52% compared with 23%; $P = 0.002$). Nonwhite patients were more likely than white patients to be lost to follow-up (41% compared with 26%; $P = 0.10$). In addition, a significant interaction was seen between age and treatment group in loss to follow-up ($P = 0.02$). Specifically, 11 of the 14 patients who were 18 to 44 years of age in the intervention group were lost to follow-up, and 4 of the 15 patients who were 18 to 44 years of age in the usual care group were lost to follow-up. The rate of loss to follow-up for patients 45 years of age and older was 23% in both groups.

To account for patients who were lost to follow-up, two separate intention-to-treat analyses were considered. In one, imputed follow-up values were calculated for both groups from the usual care group. In the second, follow-up values were assumed to equal baseline values. In both scenarios, the intervention group continued to show a statistically significantly greater improvement in HbA_{1c} values compared with the usual care group (Table 3).

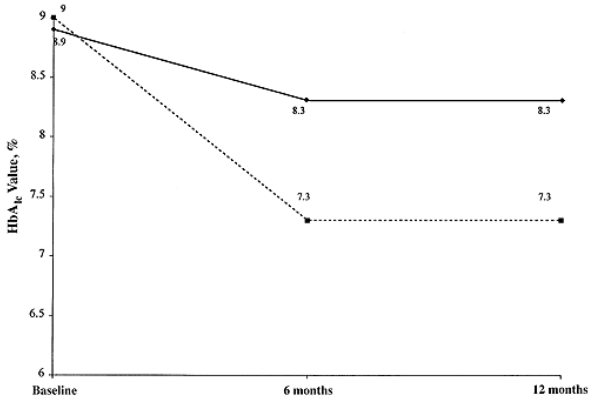
Table 3. Intention-to-Treat Analysis for Hemoglobin A_{1c} Outcome Measure

Analysis	Mean Change*	
	Nurse Case Management Group	Usual Care Group
No imputation ($n = 100$)	-1.7	-0.6
Imputation assuming that patients lost to follow-up have values equal to those of usual care group ($n = 138$)	-1.4	-0.7
Imputation assuming that follow-up values equal baseline values ($n = 138$)	-1.2	-0.4

* $P < 0.001$ for all comparisons. Values are percentage points.

We also plotted the mean HbA_{1c} values seen at baseline and at each follow-up visit. The effect of the nurse case management intervention on change in HbA_{1c} values was seen after 6 months of follow-up and was sustained over the subsequent 6 months (Figure 3).

Figure 3. Mean hemoglobin A_{1c} (*HbA_{1c}*) *value at follow-up by treatment group.* Dashed line represents nurse case management; solid line represents usual care.



Most patients who were receiving oral agents at study entry continued to receive them throughout the study. Three patients in the intervention group were switched from oral agents to insulin, and three patients who were receiving insulin at baseline were switched to oral agents. No change in the use of insulin and oral agents was seen in the usual care group during the study.

Among insulin-treated patients, no statistically significant difference was seen between study groups in the change in average total insulin dose. At baseline, the dose of insulin was similar in the two groups (0.62 U/kg of body weight for the nurse case management group compared with 0.47 U/kg for the usual care group). At the 12-month follow-up visit, the mean increase from baseline in the adjusted total insulin dose was three times greater in the intervention group than in the usual care group (0.22 U/kg compared with 0.06 U/kg), although the difference between the changes was not statistically significant ($P > 0.2$).

Hospital admissions were rare and did not significantly differ between the two study groups. The rate of hospitalization in the 12 months before randomization was 11% in the intervention group and 2% in the usual care group. At the 12-month follow-up visit, the hospitalization rate was 6% in both groups. The rate of emergency department visits was 6% for both groups at baseline and was 2% in the intervention group and 6% in the usual care group at the 12-month follow-up visit, a difference of 4 percentage points ($P > 0.2$). None of the hospitalizations or emergency department visits was related to diabetes.

The average number of outpatient visits during the study was similar for both study groups. The mean number of diabetes-related physician outpatient visits was 4.4 in the intervention group and 4.2 in the usual care group ($P > 0.2$). In the intervention group, patients met with the nurse case manager four times during the study. One patient in the intervention group had a visit to an endocrinologist.

Severe low blood glucose events at baseline occurred at a rate of 1.5% in both the intervention group and the usual care group. During the study period, the average number of severe low blood glucose events increased 3.1% from baseline in the intervention group and 2.9% from baseline in the usual care group ($P = 0.158$). Death, reported seizures, and loss of consciousness did not occur in either group.

In persons treated with insulin throughout the study, we saw baseline-adjusted mean weight gains of 3.0 kg in the intervention group and 0.5 kg in the usual care group, a difference of 2.5 kg (95% CI, -0.45 to 5.5 kg; $P = 0.11$). Patients who received oral agents throughout the study had a mean weight change of -2.0 kg in the intervention group and -0.8 kg in the usual care group, a difference of -1.2 kg (CI, -3.0 to 0.64 kg; $P > 0.2$). Neither differences in weight loss nor differences in weight gain between the groups were statistically significant.

Discussion

This randomized, controlled clinical trial demonstrated the effectiveness of a nurse case management diabetes program that included close follow-up, continuous reinforcement of meal planning and exercise, and systematic treatment adjustments. In patients randomly assigned to the nurse case management intervention, HbA_{1c} values decreased significantly. This decrease was consistent across the spectrum of baseline HbA_{1c} values greater than 7.0% and in subsamples with both type 1 and type 2 diabetes. The maximum effect size was seen after 6 months of follow-up, and the effect of the intervention was sustained until the 12-month follow-up visit. Patients in the intervention group reported better general health status than did those receiving usual care.

Nonrandomized studies have also shown that physician-directed nurse management programs are associated with improved glycemic control (10, 16). Peters and colleagues (10) examined the use of specially trained nurses to help patients with diabetes achieve better glycemic control. They found that the nurses' implementation of algorithms with computerized tracking methods and follow-up among patients at high risk for diabetes complications achieved an average decrease in HbA_{1c} values of 3.0 percentage points over 1 year. However, the focus was on referral of the highest-risk patients; the average HbA_{1c} value at baseline was 12.5%. Our study considered the spectrum of patients who had not achieved optimal control in a primary care clinic setting.

The DCCT showed that for every 1% reduction in the HbA_{1c} value, there was a 40% to 50% reduction in risk for microvascular and neuropathic complications. However, the DCCT also reported adverse consequences associated with intensive management. The risk for severe hypoglycemia was two- to threefold greater in the intensively managed group, and this group gained, on average, approximately 4.5 kg more (1). However, Ohkubo and colleagues (2) did not find statistically significant differences in weight gain between intensively and conventionally insulin-treated lean patients with type 2 diabetes. In our study, severe hypoglycemia was more common with nurse case management but was not of the

magnitude seen in other studies, and it did not significantly differ between the two study groups. Our results suggested weight gain in insulin-treated patients, and the amount of weight gain was greater in patients who were continuously treated with insulin during the study period. However, no statistically significant difference in weight gain was seen between the intervention group and the usual care group. Conversely, patients in the intervention group who were receiving oral agents had more than twice the weight loss of patients in the usual care group who were receiving these agents. In the intervention group, the greater weight loss seen may reflect the effects of persistent meal planning and exercise reinforcement, components of nurse case management, and increased self-management skills.

The increased loss to follow-up of younger patients in the intervention group may bias our results to some extent and warrants further investigation. Nurse case management, as implemented in this study, may have been less suitable for the more mobile, active lifestyle that may be characteristic of younger patients. This should be explored in future studies.

Our study shows that a nurse-implemented diabetes management program, directed by a primary care physician and an endocrinologist and implemented in a group-model health maintenance organization setting, can help patients achieve near-normal glycemic control. If this level of control is maintained, the projected lifetime risk for complications of diabetes may be reduced by 68% to 85% (1). Other studies (12) have reported a reduction in hospital admissions as a result of improved glycemic control. We did not find a statistically significant difference in hospitalizations or emergency department visits that could be attributed to the nurse management intervention, but the trend toward reducing those events favors nurse case management.

The existence of an organized system of health care delivery and a centralized database that included enrollment data, information on inpatient and outpatient encounters, and pharmacy data facilitated the implementation of the nurse case management intervention. Successful implementation was also due largely to the participation of local physician advocates.

Our nurse case manager had an RN degree and 14 years of clinical experience and was a certified diabetes educator. She managed a case load of 71 patients for this study, but we estimate that she could have managed as many as 300 patients. This figure is consistent with other studies that estimate a case load of 250 patients (10). A professional with less training and less experience may be able to fulfill the role of the nurse case manager, but this possibility requires further study. It should also be noted that the case manager worked closely with an endocrinologist and a family physician, and such supervision may be necessary for success.

As it becomes more evident that blood glucose control is associated with a reduction in risk for microvascular and neuropathic complications of diabetes, the health care community must design programs aimed at meticulous diabetes control (17).

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