Impact of a Telephonic Intervention to Improve Diabetes Control on Health Care Utilization and Cost for Adults in South Bronx, New York

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EPIDEMIOLOGY/HEALTH SERVICES RESEARCH

OBJECTIVE

Self-management education and support are essential for improved diabetes control. A 1-year randomized telephonic diabetes self-management intervention (Bronx A1C) among a predominantly Latino and African American population in New York City was found effective in improving blood glucose control. To further those findings, this current study assessed the intervention's impact in reducing health care utilization and costs over 4 years.

RESEARCH DESIGN AND METHODS

We measured inpatient (n = 816) health care utilization for Bronx A1C participants using an administrative data set containing all hospital discharges for New York State from 2006 to 2014. Multilevel mixed modeling was used to assess changes in health care utilization and costs between the telephonic diabetes intervention (Tele/Pr) arm and print-only (PrO) control arm.

RESULTS

During follow-up, excess relative reductions in all-cause hospitalizations for the Tele/Pr arm compared with PrO arm were statistically significant for odds of hospital use (odds ratio [OR] 0.89; 95% CI 0.82, 0.97; $P < 0.01$), number of hospital stays (rate ratio [RR] 0.90; 95% CI 0.81, 0.99; $P = 0.04$), and hospital costs (RR 0.90; 95% CI 0.84, 0.98; $P = 0.01$). Reductions in hospital use and costs were even stronger for diabetes-related hospitalizations. These outcomes were not significantly related to changes observed in hemoglobin A_{1c} during individuals' participation in the 1-year intervention.

CONCLUSIONS

These results indicate that the impact of the Bronx A1C intervention was not just on short-term improvements in glycemic control but also on long-term health care utilization. This finding is important because it suggests the benefits of the intervention were long-lasting with the potential to not only reduce hospitalizations but also to lower hospital-associated costs.

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Diabetes is a chronic disease that requires long-term self-management education and support in order to achieve successful control (1). Diabetes self-management is a collaborative process that helps individuals gain the knowledge and skills needed to modify behavior and successfully perform routine diabetes self-care activities (1,2). Existing literature documents the benefits of engaging in self-management practices and receiving clinical services for individuals with diabetes (1,2). It is an effective strategy to improve short-term process measures, such as patient knowledge, blood glucose monitoring, hemoglobin A_{1c} (A1C) and cholesterol screenings, and dietary patterns (3,4), as well as long-term clinical outcomes, such as reductions in lipids, reductions in A1C, blood pressure control, weight management, and quality of life (5–10). Because of the long-term economic burden of diabetes and its corresponding morbidity and mortality, there is an increasing interest in the potential for diabetes self-management programs to improve disease management, avoid complications, and reduce avoidable health care utilization and cost (2). However, limited reports have been published regarding the long-term effects of diabetes self-management interventions on health care utilization and its related costs. The overall purpose of this study was to examine the effectiveness of a 1-year telephonic diabetes self-management intervention in reducing health care utilization and costs over a 4-year study period.

RESEARCH DESIGN AND METHODS

Study Setting

The Bronx A1C (6) was a randomized controlled trial comparing the impact of a diabetes self-management print-only intervention to a telephonic self-management support intervention on diabetes control (www.clinicaltrials.gov/show/NCT00797888). The target population was adult individuals with suboptimally controlled diabetes in the South Bronx, NY, where the population is predominantly Latino or African American and poverty is highly prevalent (11,12).

The Bronx A1C methods and results were described in detail elsewhere (6,11). Briefly, 941 adults >18 years with diabetes and a recent A1C >7% (53 mmol/mol) residing in the South Bronx ZIP codes were recruited into the study from September 2008 to October 2010. A total of 443 participants were randomized to the telephonic diabetes intervention (Tele/Pr) arm and 498 were randomized to the print-only (PrO) control arm. All participants were mailed the same high-quality diabetes self-management print materials at baseline randomization and modest lifestyle incentives quarterly. The Tele/Pr arm participants' telephone calls followed a curriculum developed for this study. They were delivered individually in Spanish or English by a health educator who was primarily supervised by a nurse who was a certified diabetes educator. Additionally, the Tele/Pr arm received up to four calls from health educators over 1 year if participant's baseline A1C was 7–9%, (53–75 mmol/mol) or up to eight calls if baseline A1C was >9% (>75 mmol/mol). A total of 910 participants finished the intervention (15 participants withdrew and 16 died). Postintervention A1C results (available for 694 participants) showed that from baseline to follow-up, mean A1C decreased by 0.9% among the Tele/Pr arm compared with 0.5% among the PrO arm, which is a 0.4% difference ($P = 0.01$). The intervention had a significant effect when baseline A1C was >9% (>75 mmol/mol) but not when baseline A1C was between 7% (53 mmol/mol) and 9% (75 mmol/mol). In addition, the results of a cost analysis indicated that the intervention was delivered at moderate cost relative to the gains achieved (13). Total costs for the PrO and Tele/Pr arms were $109.18 and $269.79 per person, respectively. The cost specific to the telephone intervention was $187.61 per person (13).

Data Source

For this secondary analysis of Bronx A1C, we used data from the Statewide Planning and Research Cooperative System (SPARCS), a comprehensive New York State claims database, to measure hospital inpatient health care utilization and costs and emergency department (ED) use for Bronx A1C participants (14,15). We also used information from the New York City (NYC) A1C Registry (16) to confirm the participants' NYC residency. The NYC A1C Registry is a laboratory-based surveillance system that was created in 2006 following an amendment to the NYC Health Code mandating laboratories to report A1C test results for NYC residents to the NYC Department of Health and Mental Hygiene.

Study Population

Health care utilization was assessed by matching SPARCS data to the Bronx A1C participants using unique patient identifiers. Hospital and ED use were calculated for each individual participant in the Tele/Pr and PrO arms from 2006, which is up to 2 years prior to study enrollment (i.e., preintervention utilization), to 2014, which is up to 4 years after study enrollment (i.e., follow-up utilization). Data were analyzed on an intent-to-treat basis, meaning all individuals who participated in the Bronx A1C and were NYC residents during both the preintervention and follow-up study periods were included, regardless of the effect of the intervention or the availability of A1C outcome data. A total of 816 of the 910 who completed the Bronx A1C intervention had data within the A1C Registry and/or SPARCS inpatient database during the study period. Similarly, 839 participants had data within the A1C Registry and/or SPARCS ED database during the study period and were included in the study. The median (interquartile range [IQR]) times during the 2-year preintervention period were 18.8 (11.1–22.1) and 19.6 (12.4–22.3) months for the Tele/Pr and PrO arms, respectively ($P = 0.24$). The median (IQR) follow-up times during the 4-year follow-up period were 33.9 (28.6–35.6) and 33.1 (28.9–35.7) months for the Tele/Pr and PrO arms, respectively ($P = 0.99$).

Study Measures

We evaluated hospitalizations and ED services using the ICD-9 Clinical Modification (ICD-9-CM) codes included in primary or secondary (up to 24) fields in SPARCS. Changes in inpatient health care utilization and cost were measured for overall all-cause hospitalizations and diabetes-related complications. These were defined as *1*) short-term diabetes complications, including hyperglycemia (diabetes with ketoacidosis, diabetes with hyperosmolarity, and diabetes with other coma) and hypoglycemia (diabetes with other specified manifestations) (17); *2*) long-term diabetes complications including microvascular complications (diabetic nephropathy, diabetic retinopathy, and diabetic neuropathy) and macrovascular conditions (diabetes with peripheral circulatory disorders, acute myocardial infarction, and stroke) (17,18); and *3*) lower-extremity amputations, which included amputations of the upper leg, lower leg, ankle, foot, and toe (18). Each of these outcomes was considered to be related to diabetes if any of the listed diagnoses included diabetes (ICD-9-CM: 250) (18). Any change in ED health care utilization was measured overall, including the use of any ED services, regardless of cause. The SPARCS ED data used in this study are "treat and release," meaning visits that do not result in a hospitalization. Inpatient costs were estimated by multiplying reported charges in SPARCS by a year- and hospital-specific cost-to-charge ratio (CCR) and diagnosis-specific adjustment factors, which were created by the Healthcare Cost and Utilization Project in order to account for between- and within-hospital variation in the markup of charges (19–22). The CCRs were created by comparing nationally reported charges to hospital account reports collected by the Centers for Medicare and Medicaid Services, and they were linked with SPARCS using hospital identifiers available from the American Hospital Association Linkage Files. Diagnosis-specific adjustment factors were based on the reported diagnosis-related group code, which groups hospitalizations with similar clinical and demographic characteristics. Finally, costs were adjusted for inflation to 2014 dollars using the Consumer Price Index for Medical Care from the Bureau of Labor Statistics. Since CCRs do not exist for ED services, we were unable to estimate the costs for these services.

Statistical Analysis

We compared characteristics of the two study arms using two-tailed *t* tests and Wilcoxon rank sum tests for parametric and nonparametric continuous variables, respectively, and χ^2 and Cochran-Mantel-Haenszel χ^2 tests for categorical variables. We used the negative binomial distribution to account for the highly skewed, over-dispersed nature of the data, which is a common issue in health care utilization and cost studies (23,24). In addition, as expected, health care utilization and cost outcomes were related and were highly and significantly correlated. For example, for all-cause hospitalization, correlation coefficients were as follows: number of hospital stays versus number of hospital days = 0.79 ($P <$ 0.001); number of hospital stays versus hospital cost = 0.73 ($P < 0.001$); number of hospital days versus hospital cost = 0.86 ($P < 0.001$). Hence, the joint mixed modeling approach was appropriate because it allowed for the correlation structure of different related outcomes (25,26).

Models of health care utilization and cost with joint binary outcome distribution and logit link function (hospital/ED use: yes, no), count (number of hospital stays/ED visits, number of hospital days), and semicontinuous (cost) outcomes with negative binomial distribution and log link function were estimated using repeated-measures generalized linear mixed models to account for potential correlations between related outcomes and serial correlations between repeated events (e.g., hospitalizations) within individuals. Separate models were developed for the inpatient health care utilization and ED use. We developed models that included a main effect of group (study arm), a main effect of time (utilization period), and a two-way group-by-time interaction term (study arm × utilization period) to compare differences in changes in health care utilization and costs from the preintervention to follow-up utilization periods within and between the two study arms. Since the time of events was somewhat different within and between the participants, we used the spatial power covariance structure to account for unequally spaced observations among individuals. We constructed a sample variogram to guide this decision. To further account for the duration of follow-up time intervals of different length, log mean duration of time intervals was included in the models as an offset variable. The fit of the models was examined by using mixed model diagnostic statistics, such as the likelihood ratio test and Akaike's Information Criterion and Bayesian Information Criterion measures. Results were presented as odds ratios (OR) for binary outcomes and rate ratios (RR) for count and cost data and their 95% CIs. We conducted the analysis for the whole sample and for samples with baseline A1C 7–9% (53 mmol/mol) and A1C >9% (>75 mmol/mol) at randomization. We also assessed the sensitivity of our choice of negative binomial distribution by fitting additional generalized linear mixed models using several alternative distributions, such as γ and lognormal distributions, especially for cost data. Models with negative binomial distribution had a better fit.

To measure the absolute effect of the intervention, the event-based number needed to treat was computed for the two study arms by calculating their cumulative event proportions (hospitalization) using previously published methods (27–29). The corresponding event-based number needed to treat was calculated, representing the number of individuals who need to be treated for a given time period to prevent one hospitalization event in that period (30). Since this statistic is based on absolute differences, it is helpful when examining economic implications of any health policy decision (29). All statistical analyses were performed by using SAS software version 9.4 (SAS Institute, Inc., Cary, NC). The protocol was approved by the NYC Department of Health and Mental Hygiene institutional review board.

RESULTS

Table 1 describes the characteristics of study participants at randomization included in the inpatient health care utilization and cost analysis during the preintervention period. The mean age was 57 years; 64% of participants were women; and ~67% were Latino. The mean A1C was 9.2% (77 mmol/mol), and ~40% of participants had an A1C of >9% (>75 mmol/mol). The median duration of diabetes was 10 (IQR 4–16) years. Overall, during the preintervention period, 197 (24%) of the participants had at least one inpatient encounter. This accounted for an average of 0.5 hospital stays and 2 hospital days with the average cost of $5,066. A total of 128 (16%) participants were hospitalized with a diabetes-related diagnosis during preintervention, accounting for an average of 0.3 hospital stays, ~1 hospital day, and an inpatient cost of about $3,000. Preintervention utilization and costs were similar between the two study arms. Also, the characteristics of study participants included in the ED services analysis ($n = 780$) and the magnitude of differences were similar to the characteristics of participants included in the inpatient health care utilization analysis (data not shown).

Figure 1 displays the absolute mean number of hospitalizations for the two study arms during the 6-year study period. Overall, there were substantial reductions in inpatient health care utilization for the Tele/Pr arm compared with the PrO arm during the postintervention follow-up period. In general, the absolute rates of inpatient health care utilization were similar during the 2-year preintervention period. However, the differences between the two study arms started to increase at the end of the 1st year of follow-up, and

Table 1—Characteristics of study participants at randomization and health care utilization at preintervention by study arm from Bronx A1C

Characteristic	Total (n = 816)	Tele/Pr arm (n = 384)	PrO arm (n = 432)	P value
Age (years)				0.20
Mean (SD)	56.5 (11.8)	57.1 (11.2)	56.0 (12.3)	
Median (IQR)	57 (49–64)	57 (50–64)	56 (48–64)	
Sex, n (%)				0.70
Men	297 (36.4)	137 (35.7)	160 (37.0)	
Women	519 (63.6)	247 (64.3)	272 (63.0)	
Race/ethnicity, n (%)				0.66
Non-Latino white	7 (0.9)	3 (0.8)	4 (0.9)	
Non-Latino black	230 (28.2)	117 (30.5)	113 (26.2)	
Latino	550 (67.4)	250 (65.1)	300 (69.4)	
Asian	3 (0.4)	2 (0.5)	1 (0.2)	
Other	26 (3.2)	12 (3.1)	14 (3.2)	
A1C (%)				0.17
Mean (SD)	9.2 (2.1)	9.3 (2.1)	9.1 (2.0)	
Median (IQR)	8.5 (7.7–10.1)	8.5 (7.7–10.2)	8.5 (7.6–10.0)	
A1C, n (%)				0.70
7–9%	486 (59.6)	226 (58.8)	260 (60.2)	
>9%	330 (40.4)	158 (41.2)	172 (39.8)	
Diabetes duration (years)				
Mean (SD)	11.0 (9.0)	11.4 (9.7)	10.8 (8.4)	0.92
Median (IQR)	10 (4–16)	10 (3–17)	10 (4–15)	
All-cause hospitalization				
Inpatient use, n (%)	197 (24.1)	93 (24.2)	104 (24.1)	0.99
Number of hospital stays, mean (SD)	0.46 (1.1)	0.45 (1.01)	0.47 (1.2)	0.95
Number of hospital days, mean (SD)	2.1 (6.9)	2.0 (6.7)	2.1 (7.0)	0.97
Hospital costs in dollars, mean (SD)	5,066 (20,762)	4,946 (23,249)	5,173 (18,283)	0.90
Diabetes-related hospitalization				
Inpatient use, n (%)	128 (15.7)	61 (15.8)	67 (15.6)	0.94
Number of hospital stays, mean (SD)	0.28 (0.9)	0.27 (0.8)	0.29 (1.0)	0.84
Number of hospital days, mean (SD)	1.2 (4.9)	1.2 (4.6)	1.3 (5.2)	0.96
Hospital costs in dollars, mean (SD)	3,006 (11,775)	2,855 (10,473)	3,140 (12,826)	0.97
ED services†				
ED visits, n (%)	256 (32.8)	127 (35.0)	129 (30.9)	0.09
Number of ED visits, mean (SD)	0.6 (1.2)	0.7 (1.3)	0.6 (1.1)	0.10

Percentages may not add to 100% because of rounding. †Total number of participants for ED utilization was 780.

they continued, but somewhat narrowed, during the 3rd and 4th years of follow-up.

Table 2 summarizes the results of analyses of relative differences in the change in inpatient health care utilization and cost and ED services use between the two study arms from preintervention to follow-up. Excess reductions in all-cause hospitalizations for the Tele/Pr arm relative to the PrO arm were statistically significant for the odds of hospital use (↓11%; OR 0.89; 95% CI 0.82, 0.97; $P <$ 0.01), number of inpatient stays (↓10%; RR 0.90; 95% CI 0.81, 0.99; $P = 0.04$), and hospital costs (↓10%; RR 0.90; 95% CI 0.84, 0.98; $P = 0.01$). The decline in the number of hospital days was marginally significant. For diabetes-related hospitalizations, participating in the Tele/Pr arm as opposed to the PrO arm was associated with statistically significant excess reductions in the odds of hospitalization (↓17%; OR 0.83; 95% CI 0.75, 0.93; $P <$ 0.001), number of inpatient stays (↓16%; RR 0.84; 95% CI 0.74, 0.96; $P < 0.01$), number of hospital days (↓14%; RR 0.86; 95% CI 0.77, 0.97; $P < 0.01$), and hospital costs (↓15%; RR 0.85; 95% CI 0.77, 0.93; $P < 0.001$). There were no statistically significant differences between the two study arms for any measure of ED utilization. In general, the results for individuals with A1C 7–9% (53–75 mmol/mol) at randomization were similar to the overall results and show statistically significant excess reductions in hospitalization measures for the Tele/Pr arm relative to the PrO arm (Table 2). Among individuals with A1C >9% (>75 mmol/mol) at randomization, differences in the change between the two study arms were in the expected direction, but they were not statistically significant for any measures of all-cause hospitalizations and ED services. However, the results were similar to the overall results for diabetes-related hospitalizations, and they show statistically significant or marginally significant excess reductions in these measures for the Tele/Pr arm relative to the PrO arm (Table 2).

The estimated cumulative event proportions for all-cause hospitalization during the follow-up period were 0.16 and 0.19 for the Tele/Pr and PrO arms, respectively, generating a cumulative event proportion difference of 0.03 in favor of the Tele/Pr arm. This indicates that, on average, 33 individuals need to receive the Tele/Pr intervention in order to prevent one hospitalization event over 4 years.

Sensitivity Analysis

To further access the effect of death on the results, we conducted the analysis in two ways. In the first main analysis, we

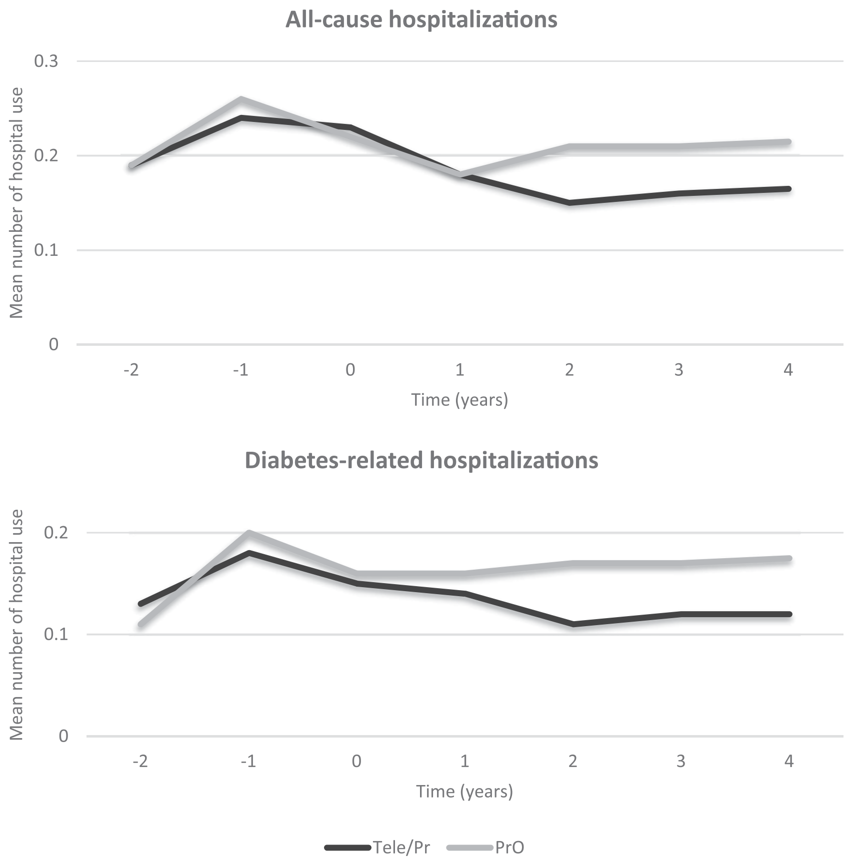

Figure 1—Absolute mean number of all-cause hospitalizations and diabetes-related hospitalizations for the two study arms during the 6-year study period from Bronx A1C. Continuous variable time in years has a range of 2 years preintervention study period (from time −2 to time 0) to 4 years of follow-up period (from time 0 to time 4), with time 0 representing the start of the intervention.

included all individuals who were alive for any part of the study period. In the second analysis, the utilization and costs of those who died in the course of the follow-up study years were excluded (32 and 29 individuals in Tele/Pr and PrO arms, respectively). The results of the second analysis indicated that although the magnitude of differences in the change between the two study arms was somewhat widened, especially for the A1C >9% (>73 mmol/mol) group, the overall direction of differences in change was similar to the first analysis. Therefore, we report the results of the main, more inclusive analysis.

We also conducted a secondary analysis to see if the differences in health care utilization and costs observed in this study related to better glycemic control. We restricted the data set to those individuals in the cohort who had a postintervention A1C measurement at the end of the original Bronx A1C study ($n = 621$). For those individuals who met this criteria, we included an effect for A1C change from baseline randomization to 12 months follow-up and an interaction effect of A1C change by study arm in the health care utilization and cost models adjusting for the baseline A1C groups (7–9% [53–75 mmol/mol] and >9% [>75 mmol/mol]). We then looked at whether this accounted for any of the observed between-groups differences in health care and utilization outcomes. The result showed, however, that the difference in A1C change as observed in the original Bronx A1C study did not significantly predict any future between-group differences in change in the health care utilization and cost outcomes.

CONCLUSIONS

This study extends previous research by examining the effectiveness of diabetes self-management behavioral interventions in reducing inpatient health care utilization and costs. Our results demonstrate that individuals with diabetes who received a health educator–delivered telephonic intervention had significant reductions in inpatient health care utilization and hospital-associated costs compared with those receiving only print-based self-management support. Specifically, participating in the telephonic intervention was associated with greater reductions in diabetes-related hospitalizations and their relative costs.

The results of this study support existing literature demonstrating the benefits of diabetes self-management programs on inpatient health care utilization and costs. Only a few studies have directly assessed associations between diabetes self-management interventions and inpatient hospital and ED services and their related health care costs. Several intervention trials have found that diabetes self-management was associated with decreased hospital admissions in managed care organization and mixed-income primary care system settings (31). Formal diabetes self-management education was also independently associated with a lower frequency of hospital readmissions among individuals with poor glycemic control (32). One randomized study showed that nurse-directed diabetes self-management in a majority Latino population resulted in less use of urgent care as well as fewer hospitalizations for preventable metabolic (diabetic ketoacidosis, hyperglycemia, and hypoglycemia) and infectious (cellulitis, foot ulcer, osteomyelitis, fungal infection, and urinary tract infection) diabetes-related conditions (33). In a large cohort of low-income primary care patients with diabetes, any type of diabetes self-management visit was associated with lower hospitalization rates and charges (34). The results of that study further indicated that even attending at least one, as opposed to zero, diabetes education visit devoted specifically to diabetes self-management was associated with a significantly lower number of hospitalizations. Another study evaluated a mobile phone–based program that provided automated self-management support and facilitated team-based care for low-income diabetes patients enrolled in an academic medical center's employee health plan (35). The results showed evidence of improved clinical outcomes, greater patient satisfaction, and lower health care utilization and related costs. Although these interventions have been shown to support individuals with diabetes

Table 2—Differences in inpatient health care utilization, cost, and ED services between the two study arms during the 4-year study follow-up from Bronx A1C for Tele/Pr versus PrO arms

	Hospital use/ED use		Number of hospital stays/ED visits		Number of hospital days		Hospital cost	
Overall	OR (95% CI)	*P* value	RR (95% CI)	*P* value	RR (95% CI)	*P* value	RR (95% CI)	*P* value
All-cause hospitalizations	0.89 (0.82, 0.97)	<0.01	0.90 (0.81, 0.99)	0.04	0.92 (0.84, 1.00)	0.06	0.90 (0.84, 0.98)	0.01
Diabetes-related hospitalizations	0.83 (0.75, 0.93)	<0.001	0.84 (0.74, 0.96)	<0.01	0.86 (0.77, 0.97)	<0.01	0.85 (0.77, 0.34)	<0.001
ED services	0.98 (0.92, 1.05)	0.61	0.99 (0.94, 1.06)	0.97				
Baseline A1C 7–9%								
All-cause hospitalizations	0.85 (0.76, 0.96)	<0.01	0.84 (0.73, 0.97)	0.02	0.86 (0.76, 0.97)	0.02	0.87 (0.78, 0.97)	<0.01
Diabetes-related hospitalizations	0.79 (0.67, 0.92)	<0.01	0.76 (0.62, 0.93)	<0.01	0.81 (0.68, 0.95)	0.01	0.80 (0.70, 0.92)	<0.01
ED services	0.97 (0.89, 1.06)	0.49	0.99 (0.92, 1.07)	0.77				
Baseline A1C >9%								
All-cause hospitalizations	0.93 (0.81, 1.06)	0.25	0.94 (0.81, 1.09)	0.43	0.97 (0.85, 1.10)	0.61	0.93 (0.83, 1.05)	0.23
Diabetes-related hospitalizations	0.85 (0.74, 0.99)	0.03	0.87 (0.73, 1.03)	0.10	0.88 (0.75, 1.02)	0.09	0.85 (0.75, 0.97)	0.02
ED services	1.00 (0.90, 1.11)	0.98	1.01 (0.92, 1.12)	0.75				

ICD-9-CM codes for diabetes-related hospitalizations: *1*) short-term complications of diabetes that include hyperglycemia (diabetes with ketoacidosis [250.1x], diabetes with hyperosmolarity [250.2x], diabetes with other coma [250.3x]), and hypoglycemia (diabetes with other specified manifestations [250.8x]); *2*) long-term complications of diabetes that include microvascular complications (diabetic nephropathy [250.4x], diabetic retinopathy [250.5x], diabetic neuropathy [250.6x, 357.2x]) and macrovascular conditions (diabetes with peripheral circulatory disorders [250.7x], acute myocardial infarction [410.xx], stroke [430–434, 436–438]); as well as procedure codes for lower-extremity amputation, which include amputation of the upper leg, lower leg, ankle, foot, and toe (84.10–84.19).

to reduce hospital admissions and costs, in general, they were expensive and labor-intensive because they required professional support staff with more advanced training and credentials, such as nutritionists, nurses, and certified diabetes educators, to conduct the intervention. In contrast, the results of the Bronx A1C study show that a more informal and flexible means of providing support through nonclinical health educators conducting a telephonic intervention under the supervision of a certified diabetes educator could potentially provide similar benefits at a relatively lower cost.

We did not find any statistically significant differences between the two study arms for any measures of ED utilization. Similarly, a recent observational study that assessed 1-year effectiveness of a diabetes self-management training among Medicare beneficiaries showed that individuals with any diabetes self-management education had a 14% significant reduction in the odds of hospitalization in the follow-up year compared with those with no training, but the odds of any ED visits were not statistically significant (3). Duncan et al. (36) also examined the value of an intervention performed by diabetes educators in an accredited diabetes self-management training program. Using a large database of payer-derived claims for services incurred, they examined the source of differences between costs of patients who used diabetes self-management training versus those who did not. The results indicated that differences in average costs were largely because of lower inpatient costs, with the individuals who did not receive diabetes education being heavier utilizers of inpatient services. In contrast, outpatient and pharmacy costs were higher for patients who used diabetes self-management training, indicating that these patients were seeking out and receiving more primary, preventive care and less inpatient care.

One implicit hypothesis behind diabetes self-management behavioral interventions is the assumption that a change in A1C is an important mechanism for effects on health outcomes. The result of our sensitivity analysis showed that the difference in A1C change in the original Bronx A1C study between the two study arms (from baseline randomization to 12 months) did not account for the future differences in any of the health care utilization and cost outcomes. This is not surprising given the similarities in health care utilization and cost observed here for baseline A1C >9% (>75 mmol/mol) vs. 7–9% (53–75 mmol/mol), despite clear differences in A1C value in the original Bronx A1C study, i.e., the intervention had a significant effect when baseline A1C was >9% (>75 mmol/mol) but not when baseline A1C was 7–9% (53–75 mmol/mol). This suggests that in a multicomponent intervention, other effects beyond potential improvement in A1C can decrease hospitalizations. It is possible, however, that our evaluation of the role of change in A1C in predicting these outcomes was limited by not including longer-term follow-up of A1C change, which may have continued beyond the assessment of the intervention's primary 1-year A1C outcome. This may also be related to a smaller sample size in the >9% (>75 mmol/mol) subgroup. Nevertheless, our results are informative in terms of how future interventions should consider the A1C-specific versus the more general effects of a diabetes self-management behavioral intervention.

We found that, on average, 33 individuals need to receive the Tele/Pr intervention in order to prevent one hospitalization event over 4 years. With a total cost of intervention at $269.79 per person, the cost of providing this intervention to 33 individuals would be about $8,903. The estimated median cost of overall hospitalization among those hospitalized over the 4-year follow-up period was ~$10,703. This indicates a cost benefit of $1,800, which can be added to the cost benefit considered in the original Bronx A1C study cost analysis (13).

Our study has several limitations. First, our data did not indicate for certain when people "came into" NYC and how much time they stayed away. Therefore, there may be gaps in health care utilization data. We tried to control for this by using our inclusion criteria to ensure that people were residents of NYC at some point during both preintervention and follow-up periods. Second, the study population was almost 70% foreign-born and may have used health care services while visiting their country of origin, artificially reducing utilization and cost estimates. However, we have no reason to believe there were differences between groups in seeking care outside of the U.S. Another limitation is that health care costs included in the current study approximate facility-level costs and do not include physician costs or other outpatient or indirect costs attributed to diabetes. In addition, we could not compare the two study arms based on ambulatory surgery and outpatient clinic visits because SPARCS data were not available at the time of the analysis. Finally, the primary Bronx A1C intervention concluded about 8 years ago and many improvements have been made to diabetes care, especially in diabetes depression or distress assessment and management, which could affect the applicability and generalizability of our results to the present diabetes population. A primary strength of our study is the longitudinal measurement of health care utilization and cost over a 6-year period in a diverse sample. In addition, this study was based on an earlier randomized controlled trial that included stringent quality control of both intervention implementation and data collection.

In conclusion, our results indicate that a telephonic self-management diabetes intervention delivered by health educators trained and supervised by a certified diabetes educator in this predominantly Latino and African American population resulted in fewer hospitalizations and hospital-associated costs. The intervention had even stronger effects for diabetes-related conditions. These longer-term outcomes may be more related to patients and health care system characteristics than to changes observed in A1C during the shorter-term 12-month intervention. Our results offer additional evidence that participation in a 1-year diabetes self-management program is relatively cost-effective in the context of programmatic costs and is associated with significant improvements in important clinical outcomes and reductions in long-term inpatient health care utilization and costs.

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