Inpatient Diabetes Education Is Associated With Less Frequent Hospital Readmission Among Patients With Poor Glycemic Control

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OBJECTIVE—To explore the relationship between inpatient diabetes education (IDE) and hospital readmissions in patients with poorly controlled diabetes.

RESEARCH DESIGN AND METHODS—Patients with a discharge diagnosis of diabetes (ICD-9 code 250.x) and HbA_{1c} >9% who were hospitalized between 2008 and 2010 were retrospectively identified. All-cause first readmissions were determined within 30 days and 180 days after discharge. IDE was conducted by a certified diabetes educator or trainee. Relationships between IDE and hospital readmission were analyzed with stepwise backward logistic regression models.

RESULTS—In all, 2,265 patients were included in the 30-day analysis and 2,069 patients were included in the 180-day analysis. Patients who received IDE had a lower frequency of readmission within 30 days than did those who did not (11 vs. 16%; P = 0.0001). This relationship persisted after adjustment for sociodemographic and illness-related factors (odds ratio 0.66 [95% CI 0.51–0.85]; P = 0.001). Medicaid insurance and longer stay were also independent predictors in this model. IDE was also associated with reduced readmissions within 180 days, although the relationship was attenuated. In the final 180-day model, no IDE, African American race, Medicaid or Medicare insurance, longer stay, and lower HbA_{1c} were independently associated with increased hospital readmission. Further analysis determined that higher HbA_{1c} was associated with lower frequency of readmission only among patients who received a diabetes education consult.

CONCLUSIONS—Formal IDE was independently associated with a lower frequency of all-cause hospital readmission within 30 days; this relationship was attenuated by 180 days. Prospective studies are needed to confirm this association.

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Hospital readmission is an important contributor to total medical expenditures and is an emerging indicator of quality of care. The Affordable Care Act is placing increasing focus on medical homes and accountable care organizations, and transition programs for hospitalized patients have garnered increasing attention (1). In addition, the Medicare Payment Advisory Commission has reduced reimbursement rates for patients who have early rehospitalizations for certain conditions such as congestive heart failure (CHF) (2). Diabetes, similar to other chronic medical conditions, is associated with increased risk of hospital readmission (3). Robbins et al. (4) showed that rehospitalizations within 30 days of discharge occurred in 20% of patients with diabetes, which is more than the 5–14% estimated for all hospital discharges. Among patients with diabetes who had been hospitalized, Jiang et al. (5) showed that 30% of these patients were hospitalized more than once within 1 year, and these patients accounted for a majority of the inpatient costs for patients with diabetes. These findings are particularly relevant because hospital stays for patients with diabetes numbered >7.7 million in 2008, accounting for 20% of hospitalizations and $83 billion (23% of total hospital costs) in the U.S. (6).

Rehospitalizations occur disproportionately among socioeconomically disadvantaged groups, including Hispanics and African Americans (AAs), those living in lower income zip codes, and those without private insurance (5,7). Other risk factors include previous hospitalization, extremes of age, and socioeconomic barriers. Failure to acknowledge diabetes at discharge is associated with increased 30-day readmissions, suggesting that suboptimal diabetes management may be an important factor for successful transitions in care (4).

The involvement of a diabetes specialist team may reduce readmissions according to limited data from some (8,9) but not all (10) studies. Results may depend on the individual components of the program and attention to discharge needs. Inpatient diabetes management teams generally incorporate some component of diabetes education (11). In the outpatient setting, nursing education has resulted in improved HbA_{1c} and adherence to medication and glucose monitoring, so the potential benefits are not limited to readmission (12–14). In the case of heart failure, self-management education has been associated with improved readmission rates (15), so such a relationship in patients with diabetes would not be unprecedented.

The objective of the study was to determine whether diabetes education, conducted by a dedicated trained diabetes educator during hospitalization, improves the frequency of readmission in patients with poorly controlled diabetes (HbA_{1c} >9%).

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RESEARCH DESIGN AND METHODS

—Patients were retrospectively identified from a single center with the Ohio State University's Information Warehouse (IW), a computerized data analysis tool that validates and cleanses patient information incorporated from multiple electronic sources. Patients with a discharge diagnosis of diabetes (ICD-9 code 250.x) for years 2008–2010 and HbA_{1c} >9% were pulled from the IW. HbA_{1c} >9% was selected because it is a major indication for a diabetes education consult at the study institution. The primary outcome was readmission within 30 or 180 days after discharge. Readmissions were calculated only on the first readmission after discharge, so subsequent readmissions for the same patient were excluded. Readmissions were assessed up to 31 December 2010; patients who did not have 30 or 180 days of observation time were excluded from those respective analyses only. The patients were also identified as having orders for a diabetes physician consult, diabetes education consult, or both by searching for the electronic consult order in the IW. Readmissions were confirmed in the electronic medical record with the patient's medical record number; if the IW and electronic medical record disagreed, the electronic medical record was taken as accurate. Patients admitted to the psychiatric hospital, patients aged <17 years, and patients who died as inpatients were excluded. This study was approved by the Ohio State University's institutional review board. Additional data included race, age, sex, marital status, average adjusted gross income by zip code (16), top three discharge diagnoses, length of stay (LOS), insurance status, initial intensive care unit (ICU) status, type of service (surgical vs. nonsurgical), year of admission, distance of residence from the hospital (>5 or <5 miles), and HbA_{1c}. Patients who had race categorized as "other" or who had no race information were included as non-AA in the models and analyses of race because they accounted for <4% of the total sample.

Diabetes education and transitions of care

Patients may receive informal diabetes education from the floor nurse about basic skills such as self-injection of insulin, or providers may order a formal diabetes physician or education consult. Most physician consults are accompanied by a comprehensive education component as appropriate regardless of whether an order for an education consult is placed. Exceptions for comprehensive education on the physician consult service include patients who are seen and discharged on the weekend (the floor nurse would handle any immediate needs) or who are otherwise inappropriate candidates for education. In contrast, if the team orders a diabetes education consult, the patient receives formal education by a trained diabetes nurse educator only.

At the time of the study, all diabetes educators were certified diabetes educators, except for one educator who was working on the certification during the study period and has since obtained certification. The Diabetes Education Program is used for teaching basic survival skills (glucose monitoring, medication administration, recognition of hypoglycemia and hyperglycemia, and basic meal planning), and in some cases advanced skills such as insulin pump management and carbohydrate counting, on an individualized basis during the hospital stay. The curriculum is based on our American Diabetes Association–accredited program. A teaching and learning flow sheet provides a checklist of the basic components and space for documentation, such as the teaching method used, an assessment of learning readiness, evaluation of patient response, and assessment of follow-up needs. Patient understanding is assessed through an interactive process and educators facilitate ongoing reinforcement with the floor nurse. Patients are also provided a diabetes survival skills book, a more comprehensive diabetes education book, a carbohydrate book (optional), and a glucose meter if needed. All materials were standardized and preapproved for content as well as understanding at an 8th grade level through the medical center's centralized education department. All nursing units are stocked with additional diabetes education tools, such as DVDs (topics include "What Is Diabetes?" "Monitoring Your Blood Glucose," "Sick Day Management," and "Putting Carbohydrate Counting Into Practice"), insulin demonstration kits, and conversation maps to assist in providing education.

At discharge, the physician team performs medication reconciliation and provides a printed copy for the patient of the discharge instructions, which include a list of medications and follow up appointments. The team also provides prescriptions for the patient's medications. The patient care resource manager takes care of other discharge needs, including scheduling follow-up appointments and obtaining medications, but does not perform any diabetes education or medication reconciliation. The diabetes educator may also provide assistance with medication reconciliation at the time of discharge, assess barriers and follow-up needs, and ensure that the patient has appropriate prescriptions for diabetes medications and supplies.

Analysis

Data are reported as *n* (%) for binomial variables and mean ± SD or median (interquartile range) for normally and nonnormally distributed variables, respectively. *P* values were obtained from the unpaired *t* test, Wilcoxon rank sum test, and Fisher exact test for variables with normal, nonnormal, and binomial distributions, respectively. Odds ratios (ORs) are reported as change in odds per unit for continuous variables and per category for dichotomous variables.

CHF, pneumonia, infection, and hyperglycemic emergency were defined with diagnosis codes. For CHF, ICD-9 codes were 428.x and 425.x. Pneumonia included diagnosis codes 481, 482.x, 484.x, 485, and 486. Hyperglycemic emergency ICD-9 codes included 250.12, 250.13, 250.2, 250.22, 250.32, and 250.33. Finally, numerous ICD-9 codes for infectious diseases were included, with diagnoses such as pneumonia, cellulitis, and osteomyelitis.

Stepwise backward multiple logistic regression analyses were performed with readmission within 30 days or 180 days as the dependent variable and sociodemographic factors (age, race, sex, marital status, and income), HbA_{1c}, LOS, type of insurance, initial ICU status, year of admission, diabetes education consult, and physician consult as independent variables. Independent variables were chosen for the initial model according to clinical relevance and availability in the IW. LOS, adjusted gross income, and HbA_{1c} were log-transformed for better fit because of their nonnormal distribution. All variables, except for the discharge diagnoses and services, were entered into the initial 30-day model. The initial 180-day model included discharge diagnoses of hyperglycemic emergency and all infections. Then one variable was eliminated at a time (determined by least statistical significance) until the final model was obtained. Variables were retained in the model for $P < 0.05$. Analyses were performed with JMP 6.0 software.

RESULTS—In all, 2,265 patients were included in the 30-day analysis and 2,069 patients were included in the 180-day analysis. The patients in both groups were aged 17–91 years. Readmission within 30 and 180 days occurred for 319 (14%) and 655 (32%) patients at 30 and 180 days, respectively. Sample characteristics are included in Table 1.

Those who were readmitted within 30 days were less likely to have had a diabetes education consult than were those who were not readmitted (33 vs. 44%; P = 0.0001; unadjusted OR 0.62 [95% CI 0.48–0.80]; P = 0.0001). The frequency of readmission within 30 days among those who received education was 11 vs. 16% among those who had not. Those who were readmitted had lower HbA_{1c} (10.7 vs. 11%; 93 vs. 97 mmol/mol; P = 0.01) and longer LOS; they were also more likely to have insurance and less likely to be male or be on a nonsurgical service (Table 1). Age, race, marital status, income, initial ICU status, and living in a zip code <5 miles from the hospital were not associated with 30-day readmission. There was no difference in readmission within 30 days for subjects who were admitted with CHF and those who were not (Table 1); similarly, there were no differences in readmission among subjects who were or were not admitted for pneumonia, hyperglycemic emergency, or all infections. The relationship between diabetes education and hospital readmission persisted after correction for sociodemographic factors, discharge diagnosis, HbA_{1c}, and year of admission in the initial model. In the final model, diabetes education was associated with lower odds of readmission (0.66 [0.51–0.85]; P = 0.001) (Table 2). Medicaid insurance (compared with self-pay) and longer LOS were also significant predictors (Table 2). To explore the possibility of readmissions to other institutions, zip code was entered into the final model; it was not significant.

Among the 2,069 patients with 6-month follow-up data, those who were readmitted by 180 days were less likely to have had a diabetes education consult (37 vs. 45%; P = 0.002; unadjusted OR 0.74 [95% CI 0.61–0.89]. Readmission was associated with lower HbA_{1c} (10.7 vs. 11.1% ; 95 vs. 98 mmol/mol; P = 0.003), AA race, female sex, residence in areas with lower income, insurance status, and longer LOS in univariable analyses. Those who were readmitted by 180 days were less likely to have a hyperglycemic emergency at the index admission (5 vs. 8%; P = 0.01) but more likely to have a diagnosis of an infectious disease. Age, marital status, initial admission to ICU, type of service, zip code <5 miles from the hospital, and other discharge diagnoses were not associated with readmission within 180 days. In the final model, patients who received diabetes education had significantly lower frequency of readmission within 180 days (0.80 [0.66–0.99]; P = 0.04) (Table 2), although the relationship was not significant in the initial model (P = 0.09). Medicaid and Medicare, AA race, longer LOS, and lower HbA_{1c} were also significant independent predictors in the final model.

Additional post hoc analysis was used to determine whether the relationship between HbA_{1c} and hospital readmission differed by education status. Among patients who received diabetes education, those who were readmitted within 30 or 180 days had lower HbA_{1c} than those who were not readmitted, whereas there was no relationship for patients without an education consult (Fig. 1).

Readmissions were also analyzed post hoc according to race. Patients were analyzed according to AA versus non-AA status (<4% were neither AA nor Caucasian). Sample characteristics by race are included in Table 3. AAs were equally likely to be readmitted within 30 days as non-AAs, but AAs had a higher readmission frequency than non-AAs within 180 days (35 vs. 29%; P = 0.009) (Table 3). There was a significant reduction in hospital readmission within 30 days in both non-AAs (16 vs. 10%; P = 0.005) and AAs (17 vs. 11%; P = 0.01) who received diabetes education. Likewise, there was a significant reduction in hospital readmission within 180 days in AAs who received diabetes education (39 vs. 30%; P = 0.003); however, the difference was not significant in non-AAs (31 vs. 26%; P = 0.055).

CONCLUSIONS—These results demonstrate that formal diabetes education for patients with poorly controlled diabetes is associated with 34% reduced odds of all-cause readmissions by 30 days and 20% reduced odds of readmissions by 180 days, after adjustment for other variables in the final models. This suggests sustained benefits from inpatient education, although the 180-day model was of borderline significance. Because few patients were actually admitted primarily for uncontrolled diabetes, the data support a role of formal diabetes education that extends beyond the management of diabetes emergencies. One explanation for this broad effect may be through modification of the comorbidity with improved glycemic control. In addition, diabetes education may have a more indirect effect, through promoting adherence to medical and dietary therapies and better self-care behaviors in general. Traditional efforts to improve transitions of care have focused education efforts on the primary reasons for hospital admission. A more comprehensive model that includes diabetes may be useful, however, because diabetes plays a direct or indirect role in other disease states.

Diabetes education in the hospital generally focuses on survival skills alone (17), and more detailed self-management education is typically deferred to the outpatient arena. This approach assumes that hospitalized patients are not suitable for more comprehensive education. The approach is individualized at the study institution, however, where patients have access to a wide variety of services, including advanced approaches such as carbohydrate counting. It is unclear whether a less comprehensive program would have similar effects.

Few published data exist for interventions targeting improved discharge care in patients with diabetes, and data are conflicting (8–10). In a randomized study of 300 hospitalized patients with diabetes, involvement by a diabetes nurse specialist did not reduce readmissions compared with routine care (10). In contrast, a randomized study of 179 patients showed that the participation of a diabetes team (nurse educator and endocrinologist) significantly reduced readmissions by more than half compared with usual care (8). It is likely that successful programs use multiple approaches (e.g., a nurse discharge advocate, prearranged follow-up appointments, medication reconciliation, patient education, and primary care provider communication) (18). Most studies do not target diabetes specifically, however, and most do not rigorously address behavioral modifications. Where certified diabetes educators are unavailable, diabetes nurse champions might be trained on each unit to facilitate education efforts, although it is unknown whether such efforts would improve outcomes to the same degree. Because of limited diabetes education resources, the study institution is currently implementing a system-wide model whereby ward nurses educate the patient on basic teaching points throughout the hospital stay. The diabetes program managers would then focus on providing staff education and assessing competency, as

Table 1—*Sample characteristics by readmission within 30 and 180 days of discharge*

	30 Days (n = 2,265)			180 Days (n = 2,069)		
	Readmitted (n = 319)	Not readmitted (n = 1,946)	P value	Readmitted (n = 655)	Not readmitted (n = 1,414)	P value
Education consult	105 (33)	860 (44)	0.0001	245 (37)	634 (45)	0.002
Physician consult	149 (47)	880 (45)	0.63	289 (44)	655 (46)	0.37
Physician and education consult	62 (19)	497 (26)		134 (20)	370 (26)	
Age (years)	51 ± 14	51 ± 14	0.51	52 ± 14	51 ± 15	0.06
Male	149 (47)	1,035 (53)	0.03	317 (48)	755 (53)	0.04
Caucasian	173 (54)	1,044 (54)	0.86	323 (49)	778 (55)	0.02
AA	138 (43)	828 (43)	0.81	311 (47)	584 (41)	0.009
Other or unknown race	8 (3)	75 (4)		21 (3)	52 (4)	
Married	102 (32)	656 (34)	0.57	215 (33)	479 (34)	0.65
Median HbA_{1c} (%)	10.7 (9.7–12.2)	11.0 (9.9–12.7)	0.01	10.7 (9.8–12.4)	11.1 (9.9–12.7)	0.003
Average adjusted gross income ($)	34,559 (29,573–41,713)	35,006 (30,716–43,216)	0.19	34,375 (30,716–41,713)	35,096 (30,716–43,863)	0.01
Zip code <5 miles from hospital	101 (32)	572 (29)	0.43	207 (32)	415 (29)	0.30
LOS (days)	5 (3–9)	4 (3–7)	<0.0001	5 (3–8)	4 (2–7)	<0.0001
Insurance			0.008*			<0.001*
HMO or PPO	70 (22)	447 (23)		131 (20)	344 (25)	
Medicaid	103 (33)	517 (27)		218 (34)	362 (26)	
Medicare	85 (27)	444 (23)		175 (27)	303 (22)	
Other	21 (7)	193 (10)		44 (7)	151 (11)	
Self-pay	34 (11)	314 (16)		75 (12)	229 (16)	
Any payor	279 (89)	1,601 (84)	0.01†	568 (88)	1,160 (84)	0.005†
Initial ICU admission	22 (7)	99 (5)	0.18	30 (5)	80 (6)	0.34
Nonsurgical service	234 (81)	1,545 (86)	0.049	508 (84)	1,114 (86)	0.45
Discharge diagnosis						
Hyperglycemic emergency	20 (6)	143 (7)	0.56	33 (5)	114 (8)	0.01
CHF	38 (12)	258 (13)	0.59	97 (15)	181 (13)	0.21
Infectious disease	43 (13)	241 (12)	0.58	98 (15)	165 (12)	0.04
Pneumonia	14 (4)	82 (4)	0.88	27 (4)	58 (4)	1.00

Data are reported as n (%), mean ± SD, or median (interquartile range). Insurance status was available for 2,228 and 2,032 subjects in the 30-day and 180-day cohorts, respectively. Hyperglycemic emergency ICD-9 codes included 250.12, 250.13, 250.2, 250.22, 250.32, and 250.33. For CHF, ICD-9 codes were 428.x and 425.x. For infectious disease, ICD-9 codes were included with diagnoses such as pneumonia, cellulitis, and osteomyelitis. Pneumonia included ICD-9 codes 481, 482.x, 484.x, 485, and 486. HMO, health maintenance organization; PPO, preferred provider organization. *P value calculated with the χ^2 test. †P value calculated with the Fisher exact test for the comparison of any insurance versus self-pay.

Table 2—*Initial and final model for readmission within 30 and 180 days*

	30 Days			180 Days		
	OR	95% CI	*P* value	OR	95% CI	*P* value
Unadjusted OR						
Education consult	0.62	0.48–0.80	0.0001	0.74	0.61–0.89	0.0002
Initial model						
Physician consult	1.04	0.80–1.35	0.76	0.86	0.70–1.06	0.15
Education consult	0.68	0.51–0.89	0.005	0.83	0.67–1.03	0.09
Male	0.87	0.68–1.12	0.28	0.91	0.75–1.11	0.37
AA	1.06	0.81–1.40	0.64	1.42	1.16–1.77	0.001
Married	0.87	0.65–1.16	0.35	0.99	0.79–1.24	0.95
Insurance (vs. self-pay)						
HMO or PPO	1.35	0.85–2.16	0.20	1.09	0.77–1.56	0.62
Medicaid	1.48	0.97–2.30	0.07	1.57	1.14–2.19	0.006
Medicare	1.48	0.94–2.37	0.09	1.42	1.00–2.03	0.051
Other	0.89	0.49–1.61	0.71	0.81	0.51–1.25	0.34
Admit to ICU	1.40	0.84–2.26	0.19	0.89	0.56–1.39	0.61
Age	1.00	0.99–1.01	0.73	1.00	0.99–1.01	0.89
Log(LOS)	1.41	1.20–1.66	<0.0001	1.40	1.23–1.60	<0.0001
Log(HbA_{1c})	0.41	0.17–0.96	0.04	0.47	0.24–0.92	0.03
Log(AGI)	0.75	0.48–1.16	0.19	0.83	0.59–1.16	0.28
Hyperglycemic emergency				0.77	0.48–1.20	0.26
Infectious disease				1.16	0.87–1.55	0.31
Year						
2009 vs. 2008	0.89	0.66–1.18	0.41	0.90	0.72–1.12	0.35
2010 vs. 2008	0.85	0.63–1.16	0.31	1.06	0.83–1.38	0.62
Final model						
Diabetes education	0.66	0.51–0.85	0.001	0.80	0.66–0.99	0.04
Insurance (vs. self-pay)						
HMO or PPO	1.24	0.80–1.95	0.33	1.08	0.77–1.51	0.67
Medicaid	1.53	1.01–2.35	0.04	1.60	1.17–2.21	0.003
Medicare	1.40	0.91–2.18	0.12	1.42	1.02–2.00	0.04
Other	0.84	0.46–1.48	0.54	0.78	0.50–1.20	0.25
Log(LOS)	1.41	1.21–1.64	<0.0001	1.38	1.22–1.57	<0.0001
Log(HbA_{1c})				0.46	0.24–0.87	0.02
AA				1.45	1.19–1.77	0.0002

HMO, health maintenance organization; PPO, preferred provider organization; AGI, average adjusted gross income (in 2009).

well as providing support for more challenging diabetes education cases. At the time of discharge, the goal is that patients receive education on the basic diabetes survival skills and are connected to follow-up in outpatient medical management and outpatient education.

Our data showed that patients with longer LOS had a significantly higher frequency of readmission, likely a consequence of greater severity of illness. Conversely, there is concern that a reduced LOS may result in increased hospital readmissions, although a recent study showed that hospital readmission did not increase even as LOS decreased (19). Further study is therefore needed. Our data also showed that Medicaid patients had higher frequency of readmission within 30 or 180 days than did those who were self-pay, as did Medicare patients for readmission within 180 days. This is somewhat unexpected, because patients without insurance might have limited ability to obtain testing supplies and medications. One possible explanation for this paradox may be related to a "pent-up demand," with increased access to medical care for socioeconomically vulnerable patients leading to an increase in health care use (20).

Rehospitalizations occur disproportionately among socioeconomically disadvantaged groups, including AAs, those living in lower income zip codes, and those without private insurance (5,7). Furthermore, disadvantaged patients are more likely to be admitted for acute complications of their diabetes, as opposed to chronic complications (5). This is of importance because acute complications are potentially more easily prevented. Our data are in agreement with these findings. As noted in Table 3, AAs in our sample were more likely be unmarried and to have lower income, longer LOS, higher HbA_{1c}, and hyperglycemic emergency. AAs had a higher readmission frequency than non-AAs within 180 days, but there was a significant reduction in hospital readmission in AAs who received diabetes education.

This study was limited to hospitalized patients with poor glycemic control (defined as an HbA_{1c} >9%) because that is a major indication for diabetes education consult at the study institution. It is thus not known whether the findings apply to patients with lower HbA_{1c}. In this study design, higher HbA_{1c} was somewhat unexpectedly associated with a lower frequency of readmission. The reasons for

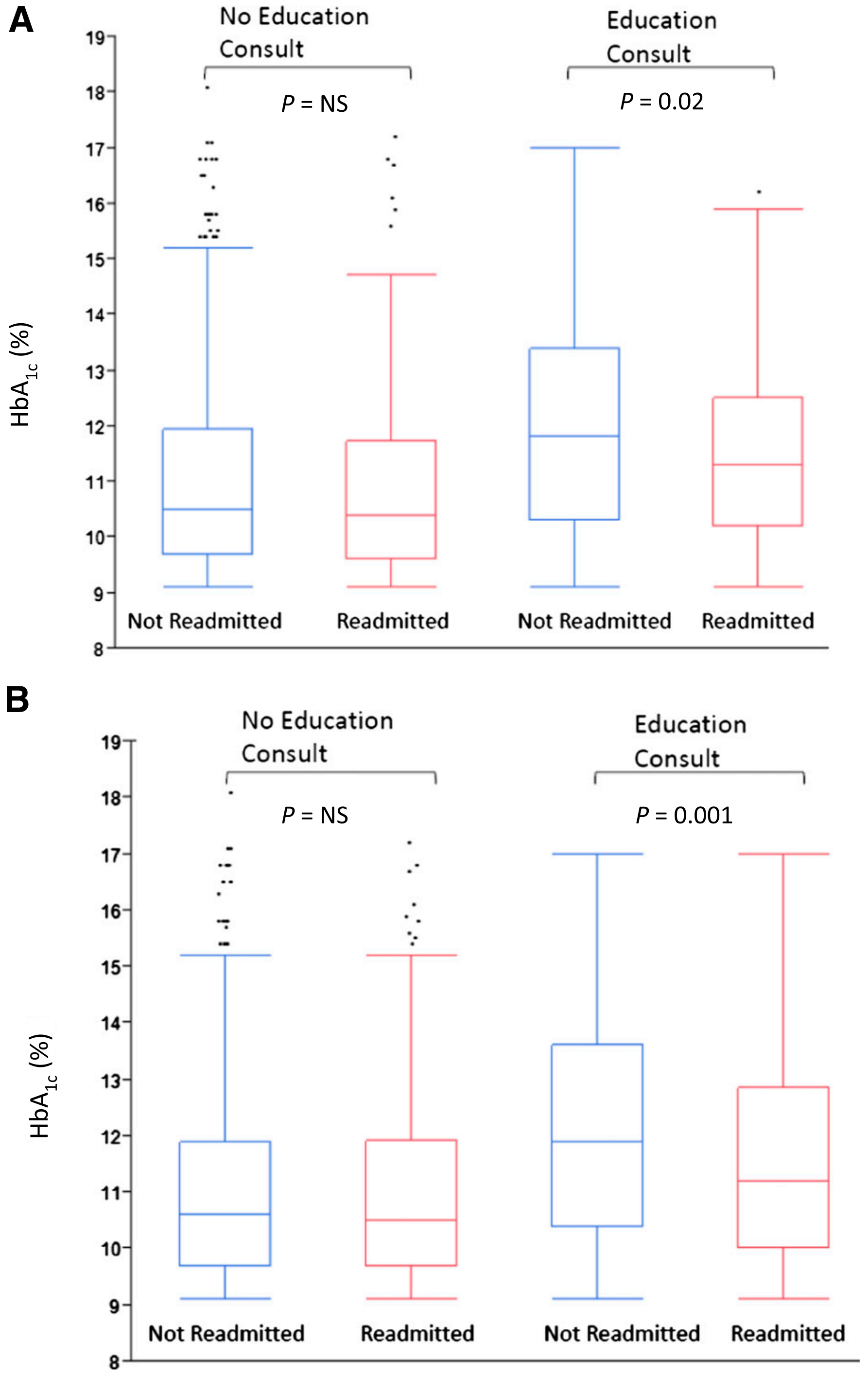

Figure 1—*Relationship between HbA_{1c} and readmissions within 30 (A) or 180 (B) days, stratified by inpatient education consult. The horizontal line within the box represents the median value, whereas the top and bottom of the box represent the 75th and 25th percentiles, respectively. The whiskers represent the highest and lowest data points still within the following values, with the top representing the 75th percentile + 1.5 (interquartile range) and the bottom representing the 25th percentile − 1.5 (interquartile range). If the data points do not reach the computed ranges, then the whiskers are represented as the highest and lowest data points.*

these findings are not clear, but stratified analyses indicate that this is only an important predictor among subjects who have received formal inpatient diabetes education (IDE). The data suggest that, even among patients with poor control, those with the highest HbA_{1c} stand to benefit more from education. We were not able to observe the change in HbA_{1c} from the initial admission to readmission because of an insufficient number of patients with subsequent HbA_{1c} measurement. Regardless, it is premature to draw any conclusions from the effect of HbA_{1c} on readmission in this study, because of the limited HbA_{1c} range (>9%). Previous data from our institution that incorporated patients with a broad HbA_{1c} range have shown that higher HbA_{1c} to be associated with higher frequency of readmission in patients with heart failure (21).

The limitations of the study are related to its retrospective design in a single center. Readmissions to other hospitals are not captured in the dataset. We were also unable to assess for outpatient deaths. Despite adjustment for multiple sociodemographic and illness-related factors, there could be other unmeasured factors involved in selection of patients who do and do not receive orders for education consults. These unmeasured factors may cause residual confounding, which was not taken into account. Specifically, we were not able to distinguish between type 1 and type 2 diabetes because diagnosis codes are not reliable for making this determination. Information about duration of diabetes was not available, and we were unable to determine whether the diagnosis of diabetes was new, which is a predictor of worse outcomes (22). Patients' medications were not available in the dataset. From past experience, however, the vast majority of patients who receive a diabetes education consult at the study institution have an HbA_{1c} >9% and are receiving insulin therapy. This is consistent with hospital guidelines and order sets, as well as national guidelines (17,23). In addition, area level data for income were used, which may be limited for predicting individual income but may be more informative for determining the effect of living in an economically disadvantaged area (24). It is possible that some patients may have been missed with the current study design because diagnosis codes for diabetes may be underrepresented in the hospital as a result of competing priorities for billing (4).

Reducing readmissions may reduce health care costs and improve quality of care. Randomized, controlled trials are needed to determine whether individualized diabetes education improves readmission rates for patients with poorly controlled diabetes and whether this intervention is cost-effective. Given the large number of hospitalized patients with diabetes, the

Table 3—Sample characteristics of patients readmitted within 30 or 180 days by race

	AA	Non-AA	*P* value
Education consult	484 (50)	504 (38)	<0.0001
Physician consult	474 (49)	566 (43)	0.004
Age	50 ± 15	51 ± 14	0.03
Male	497 (51)	711 (54)	0.25
Married	207 (21)	568 (43)	<0.0001
AGI ($)	31,787 (27,676–37,819)	38,205 (33,580–45,708)	<0.0001
LOS (days)	4 (2–6)	4 (3–8)	<0.0001
Discharge diagnosis			
Hyperglycemic emergency	84 (9)	84 (6)	0.04
Nonsurgical	812 (90)	996 (82)	<0.0001
CHF	113 (12)	185 (14)	0.10
Infectious disease	110 (11)	181 (14)	0.10
Pneumonia	50 (5)	47 (4)	0.07
Median HbA_{1c} (%)	11.3 (10–13.2)	10.7 (9.7–12.2)	<0.0001
Insurance			<0.0001*
HMO or PPO	175 (18)	352 (27)	
Medicaid	291 (30)	338 (26)	
Medicare	211 (22)	329 (25)	
Other	109 (11)	108 (8)	
Self-pay	171 (18)	182 (14)	
Any insurance	786 (82)	1,127 (86)	0.01†
Admit to ICU	54 (6)	69 (5)	0.71
Readmission, 30 days	138 (14)	181 (14)	0.81
Readmission, 180 days	311 (35)	344 (29)	0.009

Data are reported as *n* (%), mean ± SD, or median (interquartile range). AGI, average adjusted gross income; HMO, health maintenance organization; PPO, preferred provider organization. **P* value calculated with the χ^2 test. †*P* value calculated with the Fisher exact test for the comparison of any insurance versus self-pay.

appropriate criteria for obtaining an education consult and the content of such education (intensive vs. survival skills only) require further study. This is, however, the largest study to date to examine the effect of formal IDE on hospital readmissions.

In summary, this study illustrates that patients receiving IDE have significantly lower frequency of readmission. This in turn suggests that IDE remains an important component of diabetes care.

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S.J.H. and K.M.D. designed the study, performed analyses, and wrote the manuscript. D.B. and C.H. assisted with study design and review of the manuscript. A.L. assisted with data collection from the IW. K.M.D. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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