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ORIGINAL RESEARCH

Influence of Literacy, Self-Efficacy, and Social Support on Diabetes-Related Outcomes Following Hospital Discharge

Audrey White[1], Elizabeth Buschur[2], Cara Harris[2], Michael L Pennell[3], Adam Soliman[2], Kathleen Wyne[2], Kathleen M Dungan[2]

[1]Department of Internal Medicine, Vanderbilt University Medical Center, Nashville, TN, 37232, USA; [2]Division of Endocrinology, Diabetes & Metabolism, The Ohio State University, Columbus, OH, 43220, USA; [3]The Ohio State University College of Public Health, Division of Biostatistics, Columbus, OH, 43210, USA

Correspondence: Kathleen M Dungan, The Ohio State University, Division of Endocrinology, Diabetes and Metabolism, 5th Floor McCampbell Hall, 1581 Dodd Drive, Columbus, OH, 43210-1296, USA, Email kathleen.dungan@osumc.edu

Objective: To evaluate the relationship between health literacy, social support, and self-efficacy as predictors of change in A1c and readmission among hospitalized patients with type 2 diabetes (T2D).

Methods: This is a secondary analysis of patients with T2D (A1c >8.5%) enrolled in a randomized trial in which health literacy (Newest Vital Sign), social support (Multidimensional Scale of Perceived Social Support), and empowerment (Diabetes Empowerment Scale-Short Form) was assessed at baseline. Multivariable models evaluated whether these concepts were associated with A1c reduction at 12 weeks (absolute change, % with >1% reduction, % reaching individualized target) and readmission (14 and 30 days).

Results: A1c (N=108) decreased >1% in 60%, while individualized A1c target was achieved in 31%. After adjustment for baseline A1c and potential confounders, health literacy was associated with significant reduction in A1c (Estimate −0.21, 95% CI −0.40, −0.01, p=0.041) and >1% decrease in A1c (OR 1.37, 95% CI 1.08, 1.73, p=0.009). However, higher social support was associated with greater adjusted odds of reaching the individualized A1c target (OR 1.63, 95% CI 1.04, 2.55, p=0.32). Both higher empowerment (OR 0.23, 95% CI 0.08, 0.64, p=0.005) and social support (OR 0.57, 95% CI 0.36, 0.91, p=0.018) were associated with fewer readmissions by 14 days, but not 30 days.

Conclusion: The study indicates that health literacy and social support may be important predictors of A1c reduction post-discharge among hospitalized patients with T2D. Social support and diabetes self-management skills should be addressed and early follow-up may be critical for avoiding readmissions.

Clinical Trial: NCT03455985.

Keywords: type 2 diabetes, hospital discharge, basal insulin, A1c, readmission, social support, self-efficacy, literacy

Plain Language Summary

The purpose of this study was to determine whether social and behavioral factors could help predict changes in glucose control and potentially avoidable hospital readmissions among patients hospitalized with type 2 diabetes (T2D).

The study showed that high health literacy predicted greater reduction in A1c. This indicates that an assessment of health literacy could be used to help identify patients who need more intensive education in the hospital or soon after discharge. In addition, participants with greater social support were more likely to reach their individualized A1c target and were less likely to be readmitted. This suggests that interventions to increase social support may help patients with multiple outcomes. Finally, participants with greater diabetes empowerment (a way of assessing readiness to make changes in behavior) had fewer hospital readmissions. Both social support and empowerment were important for predicting readmission by 14 days but not by 30 days. The interpretation of study findings are limited due to loss of follow-up after discharge and underscores the importance of early post-discharge interventions.

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This study indicates that screening tools to assess health literacy, social support and empowerment may help to identify the need for additional education and other resources to improve outcomes for hospitalized patients with T2D. Moreover, the data support early, frequent follow-up, particularly in the most vulnerable patients.

Introduction

Over 34 million people in the United States have diabetes mellitus (DM), costing an estimated $327 billion.[1] In 2016, the hospitalization rate for adults with DM was 284 per 1000, compared to 285 per 10,000 in the general population.[2] Despite increasing costs and disproportionate healthcare utilization, only about half of patients successfully achieve glycemic control, indicating unmet needs for diabetes care and self-management support.[3,4] In addition, only 64% of patients achieve individualized Healthcare Effectiveness Data and Information Set (HEDIS) targets.[5,6]

The disproportionate rate of hospitalization points to a growing need for provider support but also an opportunity for tertiary prevention. Inpatient teams can take advantage of the hospitalization period to evaluate barriers to diabetes self-management, provide diabetes education, assess understanding, adjust treatment, and coordinate follow-up. In hospitalized patients with an A1c >9%, inpatient diabetes education is strongly associated with fewer hospital readmissions, after controlling for other variables.[4] Moreover, education earlier in the hospital stay favorably predicts A1c reduction and 30-day outpatient follow-up.[7]

A growing body of evidence demonstrates social determinants of health as important predictors of diabetes-related outcomes.[8] The COVID-19 pandemic has only magnified the existing socioeconomic disparities among patients with DM.[9,10] Inpatient providers have an opportunity to improve outcomes among vulnerable patients by addressing established social and behavioral factors during hospitalization. Socioeconomic factors such as income and education have direct effects on glycemic control and self-care.[8,11] Additionally, psychosocial factors, such as social support and self-efficacy may influence glycemic control and self-care independently of socioeconomic factors.[12] These suggest important targets for interventions to improve diabetes outcomes. The role of social determinants on post-discharge outcomes for patients with DM has been understudied, and is likely much more complex than observed in the ambulatory setting.[13]

The purpose of this study was to evaluate health literacy, social support, and self-efficacy as predictors of A1c reduction and early readmission among patients with type 2 diabetes (T2D) following hospitalization.

Methods

Design and Participants

This is a secondary analysis of a prospective trial involving hospitalized patients with insulin-requiring T2D. Procedures and results of the primary study have been reported previously (clinicaltrials.gov # NCT03455985).[14] In brief, the trial was conducted between March 2018 and September 2020 and compared the impact of an electronic discharge order set (DOS) combined with periodic study nurse phone calls to enhanced standard of care (ESC). The study was approved by the Ohio State University Institutional Review Board (Study # 2017H0354). The trial was conducted in accordance with the Declaration of Helsinki. Eligible participants were age 25–75 years, A1c >8.5%, requiring at least 10 units of basal insulin per day while in the hospital, and able to provide informed consent. All patients signed informed consent. All study participants received glargine-300 U/mL (Gla-300) at discharge. All other discharge procedures were conducted as part of standard care. Following discharge, the DOS group received phone calls from the study nurse facilitating post-discharge follow-up and basal insulin titration, while participants in the ESC group received information-gathering calls only. At in-person visits (months 3 and 6), A1c and health care utilization data were collected. In participants with missing data, outcomes were obtained from the electronic medical record, when available.

Assessment of Literacy, Social Support, and Self-Efficacy

Participants completed questionnaires to assess health literacy, self-efficacy, and social support prior to discharge. Health literacy was assessed using the Newest Vital Sign (NVS) in accordance with published methodology.[15] The NVS has good reliability (Cronbach alpha >0.76 in English) and correlates with the Test of Functional Health Literacy in Adults.

In the NVS, health literacy is defined as the understanding and application of prose literacy, numeracy, and document literacy. Patients are given an ice cream nutrition label and answer 6 verbal questions regarding the label. One point is given for each correct response: a score of 4–6 indicates likely adequate literacy; a score of 2–3 indicates the possibility of limited health literacy, and a score of 0–1 indicates high likelihood of limited literacy.[15]

Multidimensional Scale of Perceived Social Support (PSS) assessed subjective social support from family, friends, and significant others. Patients respond to 12 questions regarding their perceived social support from different sources using a Likert scale ranging from 1 (very strongly disagree) to 7 (very strongly agree). Subscale scores indicate subjective support from family, friends, and significant others and have been shown to have good reliability and construct validity.[16]

Self-efficacy was assessed using the Diabetes Empowerment Scale Short-Form (DES-SF), which is a shortened version of the 28-question Diabetes Empowerment Scale (supported by Grant Number P30DK020572 (MDRC) from the National Institute of Diabetes and Digestive and Kidney Diseases). The DES describes an individual's self-efficacy in terms of managing psychosocial aspects of diabetes, assessing dissatisfactions and readiness to change, and setting and achieving diabetes goals.[17] Patients respond to 8 prompts on a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The DES-SF has acceptable reliability (α=0.84) and validity in measuring overall diabetes-related psychosocial self-efficacy.[17]

Analysis

Primary outcomes for the secondary analyses were 12 week change in A1c, proportion of subjects achieving A1c reduction >1%, proportion of subjects achieving an individualized A1c target, and 14-day and 30-day readmission. The primary outcome for the original study was change in A1c at 24 weeks. The 12 week A1c was used for this analysis in order to minimize loss to follow-up. Individualized A1c targets were calculated from baseline data per Healthcare Effectiveness Data and Information Set (HEDIS) criteria.[5] By HEDIS criteria, the A1c target is 8% if age is ≥ 65 years or there is a known history of ischemic vascular disease, heart failure, advanced kidney disease (estimated glomerular filtration rate [eGFR] <30), dementia, proliferative retinopathy/blindness, advanced neuropathy [history of ulcer or amputation] or history of severe hypoglycemia; otherwise the A1c target is below 7%.

Differences in binary variables were determined using Fisher's exact test. Continuous variables were analyzed using 2-sample Student's *t*-tests for normally distributed variables and Wilcoxon rank-sum for non-normally distributed variables. For all comparisons, a p-value <0.05 was considered statistically significant.

Binary outcomes (A1c reduction >1%, achievement of individualized A1c target, 14-day and 30-day readmission) were analyzed as the dependent variable in separate logistic regression models with NVS, PSS, and DES-SF as independent variables. Odds ratios reported correspond to a 1-point increase in the independent variable. Models were adjusted for potential confounders (baseline variables related to the outcome which could possibly cause a change in literacy/empowerment/social support and not the other way around). Confounders were determined in part based on previously reported data.[4,7] In addition, in order to avoid overfitting models, only variables with a p-value <0.05 in univariable analysis were included. Model fit was assessed using the Hosmer-Lemeshow Goodness-of-Fit test. Change in A1c was analyzed using a linear regression model adjusted for variables related to change in A1c in univariable analyses (p-value < 0.1). All A1c-related outcomes were adjusted for baseline A1c and tests of interaction were performed to evaluate the effects of randomization to DOS. Analyses were performed using SAS V9.4 and JMP 13.1 (SAS Inc., Cary, NC).

Results

A total of 158 patients signed consent. Three patients withdrew consent and did not receive the study intervention. Patient flow is shown in Supplemental Figure 1. Over 98% completed the NVS, PSS, and DES-SF prior to discharge (Supplemental Tables 1–3) Baseline characteristics are shown in Tables 1–2. Mean age was 52 years, median duration of diabetes was 11 years, and 81% were on insulin therapy prior to hospital admission. 61% of patients received an inpatient diabetes consult and 27% followed up with an endocrinologist within 6 weeks of discharge. Median NVS score was 4 out of 6 possible points (Supplemental Table 1). Median PSS score was 6.0 out of 7 possible points and subscale scores were 6.8, 6.3, and 6.0 for significant others, family, and friends, respectively (Supplemental Table 2). Median DES-SF score was 4.4 out of 5 possible points (Supplementary Table 3).

Table 1 12 Week Change in A1c Stratified by Patient Characteristics

		N	Mean Change in A1c	SD	p-value
Randomization	DOS	54	−1.96	2.43	0.215
	ESC	54	−1.42	2.04	
Sex	Female	64	−1.43	2.39	0.145
	Male	44	−2.07	1.99	
Age group	< 45	27	−0.72	2.17	0.067
	45–50	22	−2.13	2.37	
	51–60	35	−1.91	2.39	
	>60	24	−2.06	1.78	
Race	Non-white	61	−1.58	2.53	0.550
	White	47	−1.84	1.84	
Bachelor's Degree	No	93	−1.73	2.27	0.614
	Yes	15	−1.42	2.16	
Married	No	61	−1.57	2.30	0.522
	Yes	47	−1.85	2.19	
Employed	No	67	−1.40	2.17	0.086
	Yes	41	−2.16	2.31	
Homeowner	No	39	−1.41	2.09	0.323
	Yes	69	−1.85	2.33	
Private insurance	No	78	−1.74	2.33	0.715
	Yes	30	−1.56	2.04	
Diabetes duration	0–5	15	−1.95	2.43	0.465
	6–10	36	−1.96	2.34	
	11–20	40	−1.67	2.44	
	>20	17	−0.96	1.15	
eGFR <60 mL/min/1.73 m^2	No	72	−1.82	2.17	0.379
	Yes	36	−1.42	2.41	
Insulin prior to admission	No	17	−2.96	2.77	0.009
	Yes	91	−1.45	2.07	
Metformin at discharge	No	72	−1.37	2.22	0.035
	Yes	36	−2.33	2.20	
Inpatient diabetes consult	No	63	−1.18	2.22	0.004
	Yes	45	−2.40	2.10	

Abbreviations: SD, standard deviation; DOS, discharge order set; ESC, enhanced standard care; eGFR, estimated glomerular filtration rate.

Table 2 Patient Characteristics Stratified by A1c Reduction

	≤1% Decrease A1c 12wk (N=43)	>1% Decrease A1c 12wk (N=65)	p-value	A1C>HEDIS Target 12wk (N=43)	A1C<HEDIS Target 12wk (N=65)	p-value
Discharge order set group	19 (44.2)	35 (53.9)	0.43	30 (40.5)	44 (59.5)	0.007
Male	15 (34.9)	29 (44.6)	0.33	22 (29.7)	22 (64.7)	0.0008
Age (years)	52 (44, 58)	52 (45, 61)	0.53	50.5 (44, 58)	53.5 (45.8, 62)	0.11
Caucasian	16 (37.2)	31 (47.7)	0.43	32 (43.2)	15 (44.1)	>0.99
Bachelor's degree	5 (11.6)	10 (15.4)	0.78	10 (13.5)	5 (14.7)	>0.99
Married	15 (34.9)	32 (49.2)	0.17	27 (36.5)	20 (58.8)	0.04
Not employed	28 (65.1)	39 (60.0)	0.69	45 (60.8)	22 (64.7)	0.83
Home ownership	28 (65.1)	41 (63.1)	>0.99	48 (64.9)	21 (61.8)	0.83
Private insurance	11 (25.6)	19 (29.2)	0.83	20 (27.0)	10 (29.4)	0.82
Diabetes duration	13 (7, 20)	11 (7, 19.5)	0.36	12.5 (7, 20)	10 (5.8, 18.5)	0.17
Baseline A1c	10.2 (9.2, 11.4)	11 (9.8, 12.2)	0.03	10.9 (9.5, 12.3)	10.5 (9.3, 11.3)	0.13
eGFR <60 mL/min/1.73 m^2	17 (39.5)	19 (29.2)	0.30	25 (33.8)	11 (32.4)	>0.99
Any insulin prior to admission	40 (93.0)	51 (78.5)	0.06	66 (89.2)	25 (73.5)	0.049
Bolus insulin prior to admission	28 (65.1)	32 (49.2)	0.12	48 (64.9)	12 (35.3)	0.006
Metformin at discharge	12 (27.9)	24 (36.9)	0.41	23 (31.1)	13 (38.2)	0.51
Any non-insulin diabetes medication at discharge	21 (48.8)	33 (50.8)	>0.99	36 (48.7)	18 (52.9)	0.84
Inpatient diabetes consult	10 (23.3)	35 (53.9)	0.003	31 (41.9)	14 (41.2)	>0.99
Follow-up visit						
PCP 2 week	18 (60.0)	21 (47.7)	0.35	25 (50.0)	14 (58.3)	0.62
PCP 6 week	22 (75.9)	29 (67.4)	0.60	35 (70.0)	16 (72.7)	>0.99
Endocrinology 2 week	1 (3.9)	30 (30.2)	0.01	8 (17.0)	6 (27.3)	0.35
Endocrinology 6 week	1 (3.6)	16 (38.1)	0.001	10 (20.0)	7 (35.0)	0.22
NVS	3 (2, 4)	5 (2, 6)	0.02	4 (2, 5)	5 (2, 6)	0.10
PSS	5.5 (4.5, 6.5)	6.1 (5.2, 6.7)	0.14	5.5 (4.6, 6.3)	6.4 (5.8, 6.8)	0.004
Significant other	6.3 (5.6, 7)	6.8 (6, 7)	0.11	6.3 (5.1, 7)	6.9 (6.3, 7)	0.06
Family	5.9 (4.6, 7)	6.3 (5.3, 7)	0.30	5.8 (4.8, 7)	6.5 (5.8, 7)	0.03
Friends	5.3 (4, 6.6)	6 (4.6, 7)	0.10	5.5 (4, 6.6)	6 (5.3, 7)	0.054
DES-SF	4.2 (3.9, 4.5)	4.4 (4, 4.9)	0.15	4.3 (4, 4.6)	4.4 (4.0, 4.8)	0.63

Note: Data reported as N (%) or median (25–75%).
Abbreviations: eGFR, estimated glomerular filtration rate; PCP, primary care provider; NVS, Newest Vital Sign; PSS, Multidimensional Scale of Perceived Social Support; DES-SF, Diabetes Empowerment Scale Short Form.

Glycemic Control

A1c data were available in 103 (65%) participants at 12 weeks. Insulin use prior to admission, metformin use at discharge, and inpatient diabetes consult were associated with change in A1c at 12 weeks (Table 1). Overall, 60% had an A1c reduction >1% and 31% achieved an individualized A1c target. In univariate analysis, factors associated with A1c

Table 3 Linear Regression Analysis of 12-Week Change in A1c

Score	Unadjusted Models		Adjusted Models		
	Slope (95% CI)	P value	Slope (95% CI)	P value	P interaction[c]
NVS	−0.17 (−0.39, 0.06)	0.155	−0.21 (−0.40, −0.01)[a]	0.041	0.868
PSS	−0.25 (−0.62, 0.12)	0.191	−0.22 (−0.55, 0.11)[b]	0.187	0.556
Friends	−0.23 (−0.49, 0.03)	0.083	−0.22 (−0.45, 0.01)[b]	0.067	0.489
Family	−0.11 (−0.40, 0.17)	0.439	−0.12 (−0.38, 0.14)[b]	0.378	0.169
Significant Other	−0.06 (−0.37, 0.25)	0.701	−0.03 (−0.31, 0.24)[b]	0.813	0.272
DES-SF	−0.36 (−1.12, 0.40)	0.353	−0.26 (−0.93, 0.41)[a]	0.454	0.895

Notes: [a]Adjusted for age, insulin use prior to admission, inpatient diabetes consult, employment, and baseline A1c. [b]Adjusted for age, employment, baseline A1c. [c]Test of interaction with discharge order set.
Abbreviations: NVS, Newest Vital Sign; PSS, Multidimensional Scale of Perceived Social Support; DES-SF, Diabetes Empowerment Scale Short form.

Table 4 Logistic Regression Analysis of A1c Reduction and Readmission

Score	A1c Reduction >1% at 12 wk		A1c < HEDIS Target at 12 wk		Readmission-14 Days		Readmission-30 Days	
	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value
NVS	1.37 (1.08, 1.73)[a]	0.009	1.18 (0.94, 1.48)[c]	0.160	1.00 (0.75, 1.33)	0.990	0.96 (0.74, 1.26)	0.787
PSS Total Score	1.26 (0.89, 1.79)[b]	0.190	1.63 (1.04, 2.55)[d]	0.032	0.57 (0.36, 0.91)	0.018	1.00 (0.65, 1.55)	1.000
Friends	1.22 (0.96, 1.56)[b]	0.108	1.33 (0.98, 1.80)[d]	0.065	0.77 (0.57, 1.06)	0.112	1.03 (0.74, 1.43)	0.881
Family	1.14 (0.87, 1.48)[b]	0.355	1.40 (0.98, 1.98)[d]	0.061	0.64 (0.44, 0.92)	0.016	1.04 (0.73, 1.47)	0.843
Significant Other	1.06 (0.80, 1.41)[b]	0.683	1.25 (0.85, 1.83)[d]	0.262	0.68 (0.45, 1.02)	0.060	0.93 (0.64, 1.34)	0.680
DES-SF	1.37 (0.65, 2.88)[a]	0.406	1.15 (0.52, 2.53)[e]	0.732	0.23 (0.08, 0.64)[f]	0.005	0.80 (0.31, 2.04)	0.638

Notes: P-values for interaction with the Discharge Order Set were >0.05 for all models of A1c reduction >1% and A1c <HEDIS target. Odds ratios correspond to a 1 point increase in the independent variable. [a]Adjusted for inpatient diabetes consultation and baseline A1c. [b]Adjusted for baseline A1c. [c]Adjusted for insulin use prior to admission and baseline A1c. [d]Adjusted for marital status and baseline A1c. [e]Adjusted for insulin use prior to admission, baseline A1c, and marital status. [f]Adjusted for private insurance.
Abbreviations: NVS, Newest Vital Sign; PSS, Multidimensional Scale of Perceived Social Support; DES-SF, Diabetes Empowerment Scale Short Form.

reduction >1% were baseline A1c, inpatient diabetes consult, and early endocrinology follow-up (Table 2). Factors associated with achievement of individualized A1c target were assignment to DOS treatment arm, male gender, marriage, and insulin use prior to admission (Table 2).

While NVS was not significant in univariable analysis, higher NVS was associated with greater change in A1c at 12 weeks (p=0.04, adjusted for age, employment, insulin prior to admission, inpatient diabetes consult, and baseline A1c) (Tables 1 and 3). Patients achieving an A1c reduction >1% at 12 weeks had higher median NVS scores (5 [interquartile range (IQR): 2, 6] vs 3 [IQR: 2, 4]; p=0.02) (Table 2). In the multivariate analysis, NVS predicted A1c reduction >1% with an odds ratio (OR) of 1.37 (95% confidence interval [CI]: 1.08, 1.73; p=0.009) adjusted for inpatient diabetes consult (Table 4). There was no significant difference in NVS by achievement of individualized A1c target at 12 weeks (p=0.10) in univariate (Table 2) or multivariable analysis (Tables 3 and 4).

PSS and subscale scores did not predict absolute change in A1c or A1c reduction >1% at 12 weeks in univariable or multivariable analyses (Tables 1–4). However, patients achieving an individualized A1c target at 12 weeks had higher median PSS scores (6.4 [IQR: 5.8, 6.8] vs 5.5 [IQR: 4.6, 6.3]; p=0.004) and higher family support subscale scores (6.5 [IQR: 5.8, 7] vs 5.8 [IQR: 4.8, 7]; p=0.03) (Table 2). In separate analyses of patients with a HEDIS target of 7% or 8%, there was a significant difference in PSS if the target was 7% (p=0.01) but not 8% (p=0.05). In the multivariate analysis adjusting for marriage and baseline A1c, PSS was associated with A1c reduction below individualized target (OR 1.63; 95% CI: 1.04, 2.55; p=0.03) (Table 4).

DES-SF did not predict change in A1c, A1c reduction >1%, or achievement of individualized A1c target at 12 weeks (Tables 1, 2, and 4).

There was no interaction between NVS, PSS, or DES-SF scores and assignment to the Discharge Order Set for change in A1c, A1c reduction >1%, or A1c <HEDIS target (Tables 3 and 4).

Early Readmission

Readmission data were available in 82 (52%) patients at 14 days and 130 patients (82%) at 30 days. There were 17 readmissions at 14 days and no new readmissions between 14 and 30 days. In univariable analyses, peripheral vascular disease, private insurance, and short hospital length of stay were associated with 14-day readmission, while only coronary artery disease was associated with 30-day readmission (Table 5).

NVS was not significantly associated with early readmission in univariable (Table 5) or multivariable analyses (Table 4).

Greater PSS was associated with a smaller adjusted odds of 14-day readmission (OR 0.57; 95% CI: 0.36, 0.91; p=0.018) but there was no association with 30-day readmission (Table 4).

Patients readmitted by 14 days had significantly lower median DES-SF scores (4 [IQR: 3.1, 4.5] vs 4.5 [IQR: 4.1, 4.9]; p=0.007), but there was no significant difference in DES-SF by 30-day readmission (Table 5). In the multivariate analysis, DES-SF was associated with 14-day readmission with an OR of 0.23 (95% CI: 0.08, 0.64; p=0.005) adjusted for private insurance, but was not associated with 30-day readmission (Table 4).

Discussion

This study analyzed health literacy, social support, and self-efficacy as predictors of clinically relevant A1c reduction and early readmission. Despite limited follow-up due to the COVID-19 pandemic, NVS emerged as a significant predictor of A1c reduction >1% and change in A1c, while PSS was a significant predictor of achievement of individualized A1c target. These results add to the evolving literature describing the impacts of health literacy and social support on glycemic control.[11,12,18–21] Furthermore, this is the first study to our knowledge to report self-efficacy as a predictor of early, preventable readmission among patients with uncontrolled diabetes.

Glycemic Control

Within our cohort, 32% of patients had evidence of limited health literacy, consistent with other reports.[22] We observed a positive relationship between NVS and adjusted A1c reduction >1%, and adjusted absolute change in A1c. Recent meta-analyses have found inconsistent associations between health literacy and glycemic control,[13,19,20,23] despite favorable associations with diabetes knowledge, self-care, and self-efficacy.[19,20] Outpatient education has also been shown to improve diabetes knowledge and medication adherence.[20,24,25] In the hospital setting, inpatient diabetes education was associated with reduced A1C and improved 30-day outpatient follow-up, particularly when provided earlier in the hospitalization.[7] Thus, screening tools can identify patients with poor health literacy who would benefit most from inpatient diabetes education and early, frequent diabetes follow-up and help guide the education methods used.

While PSS was not associated with change in A1c or proportion with A1c reduction >1%, patients with higher perceived social support were more likely to achieve an A1C below their HEDIS target at 12 weeks. This difference was significant when HEDIS target was 7% but not 8%. The reasons for this finding could be that social support is less focused on glucose control when there are multiple comorbidities. However, the effect of social support on glycemic control is otherwise well established.[11,17,26–28]

Surprisingly, DES did not predict change in A1c. This finding is consistent with a previous small study of hospitalized patients with DM,[7] but is in contrast to findings from ambulatory populations.[11,12] Of note, the DES-SF was designed to assess self-efficacy and A1c reduction in response to empowerment-based strategies, which were not the focus of this study.[29] Furthermore, it is possible that hospitalization and comorbid illness may have a detrimental impact on the relationship between diabetes self-efficacy and glucose control but this requires further study.

Readmission

Health literacy was not a predictor of early readmissions. Although poor health literacy is a known risk factor for readmission in general, few studies have specifically studied populations with DM.[7,30] Two qualitative studies identified

Table 5 Patient Characteristics Stratified by Readmission

	Readmission by 2 Weeks (N=17)	No readmission by 2 Weeks (N=65)	p-value	Readmission by 30 Days (N=17)	No Readmission by 30 Days (N=113)	p-value
Discharge order set	8 (47.1)	29 (44.6)	>0.99	8 (47.1)	54 (47.8)	>0.99
Male	9 (52.9)	36 (55.4)	>0.99	9 (52.9)	47 (41.6)	0.44
Age (years)	54 (42.5, 57)	52 (47.5, 61)	0.45	56 (39.5, 61)	51 (45, 58.5)	0.69
White	8 (47.1)	25 (38.5)	0.58	6 (35.3)	52 (46.0)	0.44
Diabetes duration	10 (6.5, 19)	13 (8, 20)	0.40	13 (8, 19)	11.5 (7, 20)	0.60
Heart failure	5 (29.4)	13 (20.0)	0.51	7 (41.2)	24 (21.2)	0.12
Cardiovascular disease	12 (70.6)	26 (40.0)	0.03	12 (70.6)	41 (36.3)	0.02
Cerebrovascular disease	4 (23.5)	6 (9.2)	0.20	3 (17.7)	15 (13.3)	0.71
Peripheral vascular disease	6 (35.3)	5 (7.7)	0.008	4 (23.5)	10 (8.9)	0.09
Coronary artery disease	8 (47.1)	22 (33.9)	0.40	9 (52.9)	30 (26.6)	0.04
eGFR <60 mL/min/1.73 m^2	4 (23.5)	23 (35.4)	0.40	6 (35.3)	36 (31.9)	0.79
Bachelor's degree	3 (17.7)	7 (10.8)	0.43	3 (17.7)	17 (15.0)	0.73
Married	7 (41.2)	32 (49.2)	0.60	7 (41.2)	51 (45.1)	0.80
Not employed	11 (64.7)	41 (63.1)	>0.99	12 (70.6)	66 (58.4)	0.43
Home ownership	7 (41.2)	42 (64.6)	0.10	8 (47.1)	74 (65.5)	0.18
Private insurance	9 (52.9)	15 (23.1)	0.03	6 (35.3)	35 (31.0)	0.78
Nonsurgical service	16 (94.1)	61 (93.9)	>0.99	17 (100)	107 (94.7)	>0.99
Reason for admission			0.25			0.77
Cardiovascular	3 (15.8)	16 (84.2)		5 (16.7)	25 (83.3)	
Gastrointestinal	3 (50.0)	3 (50.0)		2 (16.7)	10 (83.3)	
Infectious disease	1 (8.3)	11 (91.7)		2 (8.3)	22 (91.7)	
Other	10 (22.2)	35 (77.8)		8 (12.5)	56 (87.5)	
Hospital length of stay	3 (3, 6.5)	6 (4, 8)	0.046	5 (3, 8)	6 (4, 8)	0.37
Charlson Comorbidity Index	3 (2, 4)	3 (2, 4.5)	0.63	3 (2, 5.5)	3 (2, 4)	0.35
Inpatient diabetes consult	6 (35.3)	28 (43.1)	0.59	5 (29.4)	50 (44.3)	0.30
NVS	3 (2, 5)	3 (2, 5)	0.96	3 (2, 6)	4 (2, 6)	0.75
PSS	5.1 (4.1, 6.5)	6.1 (5.4, 6.8)	0.06	6.4 (5.1, 7.0)	6 (5, 6.8)	0.53
Significant other	6.1 (4.4, 7)	7 (6, 7)	0.12	6.9 (6, 7)	6.8 (5.9, 7)	0.90
Family	5.8 (3, 6.9)	6.3 (5.5, 7)	0.07	6.8 (4.4, 7)	6 (5, 7)	0.40
Friends	5.3 (2.4, 6.8)	6 (4.6, 7)	0.23	5.8 (4.3, 7)	5.8 (4.6, 7)	0.82
DES-SF	4 (3.1, 4.5)	4.5 (4.1, 4.9)	0.007	4.4 (3.6, 4.9)	4.4 (4, 4.8)	0.70

Note: Data reported as N (%) or median (25–75%).
Abbreviations: NVS, Newest Vital Sign; PSS, Multidimensional Scale of Perceived Social Support; DES-SF, Diabetes Empowerment Scale Short Form.

poor health literacy and health-related knowledge as contributing factors for early readmission in patients with DM.[31,32] Moreover, a previous large study of hospitalized patients with diabetes reported inpatient diabetes education was associated with improved 30-day readmission.[4] While the readmission reason was not recorded in this study, previous data indicate that the majority of readmissions are not related to hyperglycemia among persons with poorly controlled diabetes who have access to education.[7] Thus, it may possible that a larger sample size would identify health literacy as an important predictor of readmission.

PSS was also associated with early readmission by 14 days, but not by 30 days. This may be related to fewer successful contacts at 14 days compared to 30 days and requires confirmation in larger studies. This observation highlights the importance of a strong hospital discharge program for patients with T2D and early follow-up in order to address potentially preventable factors.[33] This is the first publication to our knowledge that assessed the PSS in hospitalized persons with DM. However, social support themes emerged as important contributors for readmission in two qualitative studies of patients with DM.[31,32] Thus, screening for social support during hospitalization may be useful for targeting a variety of interventions, such as community health worker and peer support programs, which have shown modest benefits for glycemic control.[18,34–37] Preferred sources of social support depend on social and cultural factors specific to the individual and resource availability.[18]

Similar to PSS, diabetes empowerment predicted early readmission at 14 days but not 30 days. To our knowledge, this is the first report to identify DES as a predictor of early hospital readmission.[38] Assessment of empowerment may be useful for targeting referrals to outpatient diabetes self-management education and support (DSMES) programs in which diabetes empowerment is a central feature. Extended support is likely necessary to sustain self-efficacy, which requires ongoing participation and adaptation to new challenges over time.[39–41] Patients with low DES-SF may particularly benefit from referrals to group-based programs.[34,42,43]

Clinical Implications

Although health literacy, social support, self-efficacy, and socioeconomic factors each carry distinct implications for glycemic control and early readmission, interventions targeting multiple factors may be most strategic. The unique characteristics and complexity of this population (including the large majority requiring insulin prior to admission) likely contribute to the observation that even usual predictors of A1c outcomes, including baseline A1c and diabetes duration were not consistent predictors. The NVS, PSS, and DES-SF are simple and accessible tools for identifying barriers to diabetes self-management, especially among vulnerable patient populations. These tools may help to guide multi-disciplinary resource allocation, such as referrals to DSMES, and diabetes specialists, and social work in order to address a multitude of barriers which might lead to hospital readmissions. In addition, these tools may be used to determine the frequency and intensity of follow-up.

Limitations

The main limitations of the study relate to limited sample size, in part related to barriers from the COVID-19 pandemic in carrying out study procedures. In particular, larger sample size would have permitted more robust multivariable logistic regression models. Additionally, certain aspects of the study design may limit external validity of results. This study excluded patients with no access to phone or electronic messaging, which may limit generalizability in low-resource settings, and non-English speaking patients were not included. Moreover, longer-term follow-up would have been clinically meaningful. There also was no evaluation for distress, depression, or treatment satisfaction, which may have had confounding effects on perceived social support and self-efficacy.[12]

Conclusions

This study demonstrates that among hospitalized patients with uncontrolled T2D, health literacy and social support predicted favorable changes in A1c. DES-SF and PSS were associated with 14-day readmission, although not readmission by 30 days. Further investigation is necessary to assess interventions addressing gaps in health literacy, social support, and self-efficacy among hospitalized patients with T2D following discharge.

Abbreviations

DM, diabetes mellitus; HEDIS, Healthcare Effectiveness Data and Information Set; T2D, type 2 diabetes; DOS, discharge order set; ESC, enhanced standard care; NVS, Newest Vital Sign; PSS, Perceived Social Support; DES-SF, Diabetes Empowerment Scale-Short Form; eGFR, estimated glomerular filtration rate; IQR, interquartile range; CI, confidence interval; DSMES, diabetes self -management education and support.

Data Sharing Statement

In accordance with institution policy on sharing data and research resources, the final research data from this study may be made available for research purposes under a limited data use agreement specifying criteria for data access, conditions for research use, privacy and confidentiality standards to ensure data security and prohibitions for manipulating data for the purposes of identifying subjects. Requests may be directed to the corresponding author (KD).

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