ORIGINAL ARTICLE

Effect of Electronic Messaging on Glucose Control and Hospital Admissions Among Patients with Diabetes

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Abstract

Background: Electronic messaging (EM) is increasingly utilized among patients with diabetes, but it is unclear whether it is associated with improved glycemic control, hospital admissions, or emergency visits.

Methods: Patients who were seen over a 1 year period at an academic endocrinology clinic with a diagnosis of diabetes were categorized according to portal activation and whether EMs were actually sent. The association between EM and HbA1c and inpatient or emergency department (ED) visits was further characterized using multivariable (MV) linear or logistic regression models.

Results: A total of 867 patients were using EM (active user group), 1207 patients had activated the patient portal but did not use the EM function (active nonuser group), and 1542 patients had not activated the patient portal (inactive group). There were important disparities in race, age, income, and other variables across groups. The HbA1c was $7.7\% \pm 1.5\%$, $8.4\% \pm 1.9\%$, and $8.2\% \pm 1.8\%$ among the active user, active nonuser, and inactive groups, respectively ($P < 0.0001$). After controlling for other factors, EM was associated with a 0.25% (SE 0.04%) lower HbA1c compared with the active nonuser group and a 0.19% (SE 0.04%) lower HbA1c compared with the inactive group ($P < 0.0001$ for both). However, EM frequency was not associated with HbA1c. EM use was not associated with inpatient or ED visits in MV analysis.

Conclusions: EM use was associated with improved glycemic control, even after controlling for electronic portal access and other variables, but not with hospitalizations or emergency visits. EM frequency was not associated with glycemic control, justifying the need for prospective studies.

Background

ELECTRONIC PATIENT PORTALS have been increasingly utilized in response to the American Recovery and Reinvestment Act of 2009, which provides incentives for meaningful use of electronic health records (EHR). These systems allow patients to have access to their test results, refill prescriptions, set up appointments, access educational materials, and enable secure, usually asynchronous, electronic messaging (EM) with their healthcare provider.

EM has been investigated in the management of diabetes, where it has been assumed that EM could reduce the need for frequent office visits. However, studies show mixed results, with some reporting increased outpatient visits,^{1–3} and others showing no effect.⁴ Some studies reported that EM is associated with lower HbA1c levels.^{2,5–8} Thus far, studies regarding EM have not differentiated between type 1 and type 2 diabetes, examined message content, or examined the impact of EM on hospital or emergency department (ED) visits.

This retrospective cohort study examines the relationship between EM and HbA1c levels, emergency room visits, and hospital admissions. Patients were stratified by type of diabetes and by EM use (active EM use [active users], activated account but not using [active nonusers], and not active at all [inactive users]).

Methods

Study design

This study is a retrospective cohort analysis of ambulatory patients with type 1 or type 2 diabetes who were seen in an outpatient academic endocrinology clinic over a 1 year period.

Patient selection

Patients were retrospectively identified from a single center using the institution's Information Warehouse, a computerized data analysis tool that validates and cleanses patient

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information incorporated from multiple electronic sources. Data from all patients with a diagnosis code (ICD-9 250.XX) and with an outpatient endocrinology clinic visit over a 1 year period were included. This study was approved by the OSU Institutional Review Board.

Electronic message use and classification

The medical center has written policies promoting and guiding the use of EM. Beginning in 2012, all patients who were seen at the institution's endocrinology clinics were offered access to the institution's patient portal known as OSU MyChart (Epic®), which contains a patient-provider electronic messaging system. During the roll-out, patients were approached at the time of registration and announcements were posted in clinics. Patients who were interested were provided a user name and temporary password and were required to log in to activate the account. Patient portals could only be activated in person after showing identification due to security and patient privacy concerns. Patients must agree to terms of use, which includes appropriate content of messages and expected timelines for response. In the diabetes clinics, confirmation of receipt of an EM is sent automatically by nursing staff. Providers are expected to check their inbox daily.

Patients in this sample were classified by electronic patient portal use as (1) active user if they had activated the patient portal account and sent at least one EM, (2) active nonuser if they had activated the patient portal account and had not sent any EM, or (3) inactive user if they had not activated the account. Messages were also analyzed by message count among active users. Messages were broadly categorized by diabetes related, diabetes medication related, or other.

Other data

Data were collected, including age, gender, race, most recent insurance status, most recent body mass index, diabetes type, and prior insulin use. All patients have orders for point-of-care HbA1c, which are entered by nursing staff before clinic visits. The most recent HbA1c value within the observation period, as well as change in HbA1c during the observation period (among patients with a baseline HbA1c at least 60 days before the first recorded message) was collected for analysis. Zip code was used to determine the area-level average adjusted gross income.⁹ Hospitalizations and ED visits were also collected during the analysis period.

Analysis

The primary outcome of interest was the most recent HbA1c within the observation period. Secondary outcomes included any hospitalization and any ED visit.

Continuous variables were reported as median (interquartile range) or mean (SD), as appropriate. Differences between the three groups were determined using ANOVA. Dichotomous variables were reported as number (percentage), and differences between three groups were determined using the chi-square test. *P*-values less than 0.05 were considered statistically significant. Multivariable (MV) logistic regression was performed for hospitalization or ED visits, whereas MV linear regression analyses were performed for HbA1c. Models were adjusted for relevant covariates based on un-

adjusted estimates. Analyses were performed using JMP 10.0 software.

Results

A total of 867 patients were considered active users, 1207 were active nonusers, and 1542 were inactive users. Inactive patients were older, more likely to be African American race, less likely to have private insurance, and had higher median area-level income (Table 1). Inactive users were also less likely to require insulin and more likely to have type 2 diabetes than type 1 diabetes (Table 1).

There were a total of 2748 message threads and 5264 distinct messages from all threads from the active users, with 19% of active users sending 1 message, 22% sending 2 messages, and 59% sending 3 messages or more. Of these total messages, 1600 were diabetes related and 1214 were medication related. Eighty percent of messages were two-way (sent by either the provider or the patient and accompanied by a response).

HbA1c

The most recent HbA1c was 7.66 ± 1.54 in the active user group, 8.29 ± 1.90 in the active nonuser group, and 8.23 ± 1.84 in the inactive group ($P < 0.0001$ for comparison between the active user group and both of the other groups, but $P = 0.06$ between the active nonuser and inactive groups; determined using Tukey-Kramer Honest Significant Difference (HSD) correction for multiple comparisons). Likewise, the change in HbA1c was $-0.28\% \pm 1.57\%$ in the active user group, $0.11\% \pm 1.48\%$ in the active nonuser group, and $0.15\% \pm 1.56\%$ in the inactive group ($P < 0.001$ for comparison between the active user group and both of the other groups, but $P = 0.87$ between the active nonuser and inactive groups; Tukey-Kramer HSD method).

However, among active users, HbA1c was not associated with message count (mean 7.66, 7.79, and 7.60 for patients with 1, 2, or ≥ 3 messages, respectively; $P = 0.30$, Table 2). Furthermore, HbA1c did not change when restricted to diabetes or medication-related messages (Table 2). Similarly, a change in HbA1c was not associated with message count (mean change in HbA1c -0.27% , -0.38% , and -0.24% for patients with 1, 2, or ≥ 3 messages, respectively; $P = 0.56$, Table 2). Final HbA1c (7.99 ± 1.77 , 7.93 ± 1.91 , $P = 0.71$) and change in HbA1c (-0.28 ± 1.64 , -0.27 ± 1.29 , $P = 0.98$) were similar among messages with and without reciprocity, respectively.

After controlling for other variables, active EM use was associated with a 0.156% lower HbA1c compared with inactive patients ($P = 0.0002$), and a 0.263% lower HbA1c compared with active nonusers ($P < 0.0001$, Table 3). Other variables that were significantly associated with higher HbA1c included type 2 diabetes, Caucasian race (vs. Asian race), other race (vs. Caucasian race), younger age, noninsulin use, and self-pay (vs. private insurance or Medicare). The change in HbA1c produced similar results, with a 0.119% smaller change in HbA1c compared with active nonusers ($P = 0.003$), and a 0.174% smaller change in HbA1c compared with inactive patients ($P < 0.0001$, Table 3).

Inpatient admission

There were 746 patients hospitalized overall, including 14% of active users, 19% of active nonusers, and 25% of inactive users ($P < 0.0001$, chi-square test). Among active

TABLE 1. CHARACTERISTICS OF PATIENTS WITH DIABETES MELLITUS, BY ELECTRONIC MESSAGING STATUS

	<i>EM active users n = 867</i>	<i>EM active/nonusers n = 1207</i>	<i>EM inactive n = 1542</i>	<i>P-value</i>
Age	51 ± 14	50 ± 15	56 ± 15	<0.0001
Female	436 (50%)	604 (50%)	812 (53%)	0.32
Race				<0.0001
African American	156 (18%)	314 (26%)	595 (39%)	—
Asian	18 (2.1%)	22 (1.8%)	31 (2.0%)	—
Caucasian	671 (77%)	837 (69%)	862 (56%)	—
Other	22 (2.5%)	34 (2.8%)	54 (3.5%)	—
Body mass index (kg/m ²)	31 (27–38)	32 (26–38)	32 (27–38)	0.49
Type 1 diabetes	323 (37%)	420 (35%)	378 (25%)	<0.0001
Type 2 diabetes	544 (63%)	787 (65%)	1164 (75%)	<0.0001
Insulin use	714 (82%)	979 (81%)	1206 (78%)	0.03
Area-level income	57,456 (40,200–68,775)	48,421 (38,326–66,187)	41,689 (35,936–60,294)	<0.0001
Insurance				<0.0001
Managed care	549 (63%)	649 (54%)	438 (28%)	—
Medicare	204 (24%)	310 (26%)	654 (42%)	—
Medicaid	71 (8.2%)	148 (12%)	311 (20%)	—
Other	4 (0.5%)	15 (1.2%)	12 (0.8%)	—
Self-pay	39 (4.5%)	85 (7.0%)	127 (8.2%)	—
A1c	7.66 (1.54)	8.39 (1.90)	8.23 (1.84)	<0.0001
A1c change	−0.28 (1.57) (n = 1281)	0.11 (1.48) (n = 1030)	0.15 (1.56) (n = 808)	<0.0001
ED visit	126 (15%)	222 (18%)	361 (23%)	<0.0001
Inpatient visit	125 (14%)	228 (19%)	393 (25%)	<0.0001

ED, emergency department; EM, electronic messaging.

users, the proportion of patients hospitalized was not associated with total message count, diabetes message count, or diabetes medication-related message count (Table 2). After controlling for other variables that were associated with inpatient admissions, including age, race, HbA1c, income, and insurance coverage, active use was not associated with hospital admission in several models (Table 4).

ED visits

There were 709 patients with an ED visit overall, including 15% of active users, 18% of active nonusers, and 23% of inactive users ($P < 0.0001$, chi-square test). Among active users, the proportion of patients with an ED visit was not associated with total message count, diabetes message count, or diabetes medication-related message count (Table 2). Furthermore, after controlling for other variables that were associated with

ED visits, including age, race, HbA1c, income, and insurance coverage, active use was no longer significantly associated with ED visits in several models (Table 5).

Discussion

This study demonstrates that EM is strongly associated with lower HbA1c, even after controlling for demographic, economic, and diabetes-related variables. However, the effect on HbA1c was modest and the intensity of use, determined with the number of EM messages among EM users, was not associated with HbA1c. The reasons for this differential outcome are unclear but may include (1) smaller sample size when data are restricted only to active users, particularly when only diabetes-specific EMs are included; (2) lack of specific data regarding message content; or (3) representation of residual bias or confounding. In addition,

TABLE 2. OUTCOMES BY MESSAGE COUNT

<i>Message count</i>	<i>0</i>	<i>1</i>	<i>2</i>	<i>≥3</i>	<i>P-value</i>
All messages					
A1c	—	7.66 (1.45)	7.81 (1.76)	7.60 (1.48)	0.30
A1c change	—	−0.27 (1.27)	−0.38 (1.85)	−0.24 (1.56)	0.56
Any ED	—	22 (17%)	23 (18%)	81 (64%)	0.45
Inpatient	—	27 (22%)	22 (18%)	76 (61%)	0.45
Diabetes messages					
A1c	7.63 (1.59)	7.79 (1.43)	7.81 (1.54)	7.55 (1.41)	0.45
Any ED	84 (16%)	121 (17%)	17 (13%)	18 (11%)	0.35
Inpatient	74 (14%)	18 (26%)	18 (14%)	26 (16%)	0.09
Diabetes medication messages					
A1c	7.64 (1.48)	8.33 (1.81)	7.55 (1.50)	7.67 (1.68)	0.06
Any ED	84 (16%)	3 (8.6%)	19 (11.5%)	25 (16%)	0.37
Inpatient	88 (17%)	5 (14%)	16 (9.7%)	27 (17%)	0.16

TABLE 3. MULTIVARIABLE MODEL FOR HbA1c

Term	Final HbA1c ^a			Change in HbA1c ^b		
	Estimate	SE	P-value	Estimate	SE	P-value
Intercept	8.958	0.201	<0.0001	−0.417	0.196	0.033
Type 1	−0.176	0.041	<0.0001	0.077	0.040	0.052
Age	−0.020	0.002	<0.0001	0.004	0.002	0.881
Male	−0.055	0.029	0.0606	0.005	0.028	0.848
Race (vs. Caucasian)						
African American	0.122	0.080	0.1303	−0.019	0.077	0.803
Asian	−0.375	0.162	0.0207	−0.435	0.154	0.005
Other	0.315	0.136	0.0203	0.309	0.131	0.018
Body mass index	0.006	0.004	0.1022	0.008	0.004	0.025
Median income	0.000	0.000	0.0004	0.000	0.000	0.303
Insulin use	−0.572	0.037	<0.0001	−0.086	0.037	0.019
Insurance (vs. self-pay)						
Private	−0.135	0.052	0.0089	−0.0003	0.050	0.996
Medicare	−0.292	0.059	<0.0001	0.148	0.058	0.011
Medicaid	0.034	0.068	0.6232	0.002	0.067	0.971
EM use (vs. active/user)						
Inactive	0.156	0.042	0.0002	0.174	0.040	<0.0001
Active/nonuser	0.263	0.041	<0.0001	0.119	0.040	0.003

^aR²=0.152.^bR²=0.022.

EM use was not associated with hospitalizations or ED visits after adjustment for relevant variables.

In this study, we found that EM use varied considerably by baseline characteristics, including age, race, and economic status. This likely represents differential access to electronic means of communication, which would expectedly be higher among younger (technology savvy) individuals or those with greater economic means. In fact, in a recent sample of 54 adults, a majority of participants had difficulty completing the tasks needed to utilize the EHR.¹⁰ These baseline differences highlight concerns that rather than improving access, EM technology could widen disparities. These disparities have been previously documented.^{11,12} Nevertheless, it is a strength of the study that we were able to compare patients who have activated their account with those who have activated their account but not sent a message.

With time, access to electronic patient portals has increased, as mobile technology and associated health applications have become more pervasive. This is further fueled by meaningful use requirements and systematic efforts by medical centers to promote the use of patient portals. In fact, studies show that provider attitudes greatly influence personal health record use.^{13,14} Therefore, it is possible that provider enthusiasm may have affected EM use and utility in our study. To some extent, it is also possible that patient preference for a particular

provider style may, in turn, influence adoption of EM. Other patient-reported reasons for lack of enrollment in an electronic patient portal include lack of information or motivation as well as negative attitudes toward technology, reasons that are reported more frequently than technological barriers.¹⁵ Therefore, barriers to patient portal use could be effectively addressed with better patient education and engagement. Nevertheless, expanded access, not surprisingly, creates additional clinical work that is not reimbursable through traditional fee for service models. Therefore, it is critical that outcomes are established so that other clinical care models can be considered. This might include patient-centered medical/specialty homes, other chronic care models, and advocating for direct reimbursement for EM.

By comparison, a large Kaiser Permanente study of 35,423 patients with diabetes, hypertension, or both demonstrated in both log linear models and matched case-cohort analyses that EM use was associated with improved HbA1c and other Healthcare Effectiveness Data and Information Set (HEDIS) measures.⁵ Furthermore, two or more EM threads in a 2-month period were associated with better HbA1c reduction compared with less EM use. In this study, 25% of participants had registered for EM but only 7.8% had actually sent a message. Insulin use was not reported. Harris et al. reported in a cross-sectional study of 15,427 health system patients

TABLE 4. MULTIVARIABLE MODELS OF HOSPITALIZATION (ACTIVE/USING EM VS. ACTIVE/NOT USING)

Term	Odds ratio	Lower 95%	Upper 95%	P-value	GOF
Model 1: age, HbA1c, race	0.82	0.64	1.05	0.11	0.58
Model 2: age, HbA1c, area-level income, insulin use, BMI	0.77	0.59	0.99	0.04	>0.99
Model 3: age, HbA1c, insurance	0.88	0.68	1.13	0.31	0.86

EM, electronic messaging; GOF, goodness of fit.

TABLE 5. MULTIVARIABLE MODELS OF EMERGENCY DEPARTMENT VISIT (ACTIVE/USING EM VS. ACTIVE/NOT USING)

<i>Term</i>	<i>Odds ratio</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>P-value</i>	<i>GOF</i>
Model 1: age, HbA1c, race	0.925	0.717	1.53	0.54	0.99
Model 2: age, HbA1c, area-level income, insulin use, BMI	0.876	0.679	1.13	0.31	>0.99
Model 3: age, HbA1c, insurance	0.958	0.742	1.23	0.74	0.99

EM, electronic messaging; GOF, goodness of fit.

with diabetes that 19% used EM, which was significantly associated with HbA1c <7% in MV analyses.² The same group later reported that the frequency of EM use was associated with better HbA1c levels, even after adjustment for insulin use and other variables.⁸ Lau et al. used propensity score matching in a sample of 157 patients with type 2 diabetes and determined that EM users were more likely to achieve an HbA1c of 7% or less at 6 months compared with nonusers.⁶ However, message content and type of diabetes were not reported in any of these studies.

It is important to note that the availability of EM in isolation does not necessarily imply that it is utilized for the purpose of therapeutic interventions. This is particularly relevant for many of the aforementioned studies, which did not assess message content. In the current study, message content was assessed via categorization of the message subject, and we did not identify a difference in HbA1c by message subtype. For a more robust assessment, randomized controlled trials are necessary. Tang et al. reported a 12 month trial of 415 patients with type 2 diabetes who had baseline HbA1c $\geq 7.5\%$ to a multifactorial intervention, of which EM was only one component.⁷ The intervention resulted in better HbA1c reduction compared with the standard care at 6 months but was not sustained at 12 months. Of note, this study did not provide details of therapy, such as insulin use. Thus, it is unclear whether specific subgroups may have benefited. However, it suggests that initial enthusiasm for a technology may wane over time unless there is a strong effort for continued patient engagement. Importantly, patient engagement is likely to be even lower among the general population. To understand the impact of EM more completely, future randomized trials should be targeted toward a defined population of patients undergoing a specified target-driven intervention, such as initiation of basal insulin therapy among patients with type 2 diabetes. The study intervention would ideally also stipulate indications and timelines for EM use, seek to control for disparities in access to technology, and provide ongoing engagement throughout the study.

Several studies indicate that EM use did not reduce, and in some cases actually increased the frequency of office visits.¹⁻⁴ The current analysis extends these observations by identifying no difference in hospitalizations or ED visits among EM users and nonusers.

This study has several limitations, mainly due to its retrospective nature. As a result, the observed effects, or lack thereof, after EM implementation cannot be assumed to be causal. Despite adjustment for multiple sociodemographic and illness-related factors, there could be other unmeasured factors involved in selection of patients who do or do not utilize EM. These unmeasured factors may cause residual confounding, which is not taken into account. Specifically, we were unable to account for hospitalizations or emergency visits at other

hospitals. Information about duration of diabetes was not available. Moreover, changes in covariates, such as BMI or insurance status, were not tracked, and it is possible that this could affect results. In addition, even though EM use among patients with active portals was compared, there could still be residual selection bias. Message content was categorized by subject line, though actual content may have varied, particularly within a single thread, and it is not known whether a given message was initiated by the patient or the provider. It is for this reason that messages were primarily analyzed by message rather than by thread and why message count or content was not the primary exposure variable of interest. Although some message content may not be relevant for the outcomes studied here, it may be important for other outcomes, such as patient satisfaction. In addition, area-level data for income were utilized, which may be limited for predicting individual income, but may be more informative for determining the effect of living in an economically disadvantaged area.¹⁶ Therefore, these findings warrant further investigation, ideally through randomized controlled trials.

In conclusion, EM use, but not EM frequency, is associated with lower HbA1c, but hospitalizations and ED visits are unaffected by EM use. However, significant disparities exist between patient portal users and nonusers, and this may profoundly impact the perception of outcomes attributed to EM. These findings warrant further attention in prospective studies in which the content of messaging is targeted and algorithm driven.

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Author Disclosure Statement

No competing financial interests exist.

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