Electronic Patient-Provider Communication in Diabetes Care

Lynne T. Harris

A dissertation
submitted in partial fulfillment of the
requirements for the degree of

Doctor of Philosophy

University of Washington
2012

Reading Committee:
James D. Ralston, Co-Chair
Diane P. Martin, Co-Chair
Thomas D. Koepsell

Program Authorized to Offer Degree:
Public Health-Health Services

University of Washington

Abstract

Electronic Patient-Provider Communication in Diabetes Care

Lynne T. Harris

Co-Chairs of the Supervisory Committee:
Associate Assistant Professor James D. Ralston
Professor Emeritus Diane P. Martin
Department of Health Services

Diabetes is a chronic illness of increasing public health importance affecting one in five Americans over the age of 65. Nearly half of all individuals with diabetes do not meet recommended guidelines for blood sugar control, sharply elevating their risk for long-term complications. Effective diabetes management requires a competent, engaged care team, but the difficult work of maintaining day-to-day glycemic control is primarily done by the patient between clinic visits.

Web-based health services may help to improve the quality of diabetes care by strengthening the patient-provider relationship and bridging the gap between home and clinic. These new tools can enable patients to access their lab results or medical records, schedule appointments, and securely communicate with care providers between visits. Little is known about the use of electronic patient-provider communication in diabetes care, and how use of this technology may impact care processes and health outcomes.

In this dissertation, I address three issues related to use of secure patient-provider messaging within a shared electronic medical record. All studies included adults with diabetes receiving care at a large integrated delivery system. The goal of the first study was to evaluate differences in diabetes care quality and outpatient utilization associated with secure messaging. Second, I studied age-related differences in use of the electronic record and secure messaging. Finally, I used longitudinal data to reexamine the relationship between secure messaging and process and outcome measures of care.

I found that a quarter of all adults with diabetes used secure messaging when available over a three-year period. Older adults were less likely to use electronic messaging and placed a higher value on in-person interactions. The majority of patients who used secure messaging had relatively modest levels of use (1-3 threads per year) and slightly more frequent clinic visits. The most active users tended to have more complex medical histories and higher outpatient utilization. Results of the longitudinal study suggest that secure messaging may have a small, positive, effect on glycemic control and adherence to glycated hemoglobin (HbA1c) testing recommendations. These findings provide a justification and framework for further research, and may be informative to providers and payers who are considering broader implementation of electronic patient-provider communication in the future.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

I would like to acknowledge the outstanding mentorship of my committee members: James Ralston, Diane Martin, and Thomas Koepsell. I am greatly indebted to Sebastien Haneuse for extensive mentorship on the statistical methods relevant to this work. Finally, I thank my husband and parents for their support of my studies, and for providing loving care to my two daughters while I was completing this work.

DEDICATION

This work is dedicated to Harold Goldberg, who was my first mentor and inspired me to work in this field.

1 Introduction

1.1 OVERVIEW

Diabetes is a prevalent and serious chronic condition, affecting 8.3% of the U.S. population (1) and estimated to cost over $174 billion dollars each year (2). Approximately twenty percent of medical expenditures are for people with diagnosed diabetes (2). Recent data from the National Health and Nutrition Examination Survey suggest that nearly half of all patients with diabetes do not meet recommended targets for blood sugar control (3), placing them at an increased risk of medical complications (4, 5).

An increasing number of health care providers are providing services to patients directly through the World Wide Web. These sites, often termed "patient portals", allow patients to access their laboratory results or medical records, schedule appointments, and send secure electronic messages to their care providers. These new services have the potential to assist with care coordination, facilitate patient-provider communication, and improve the timeliness of care. Yet little is known about how these services are used by patients with diabetes, and what impact their use may have on care processes and health outcomes.

1.2 RESEARCH QUESTIONS AND DATA SOURCES

In this dissertation, I addressed three issues related to use of a shared electronic medical record (SMR) with secure patient-provider messaging ("secure messaging") by adults with diabetes. All three studies were conducted at Group Health Cooperative, a nonprofit health care system that provides medical coverage and care to over 660,000 members in the Pacific Northwest. Approximately 70% of members are served by Group Health's Integrated Group Practice and receive care from salaried Group Health physicians. All patients who are served by the Integrated Group Practice have had access to an electronic record with secure messaging since August of 2003.

The goal of the first analysis was to evaluate differences in diabetes care quality and outpatient utilization associated with use of secure messaging. In this study, I tested the hypotheses that frequent use of secure messaging was associated with better diabetes care quality and lower utilization of traditional outpatient services. This analysis used observational data from January 1, 2004 – March 1 2005, a five-quarter period that began six months after secure messaging was first available to all patients in Group Health's Integrated Group Practice. This analysis included 15,427 adults with diabetes, 19% of whom used secure messaging during the period of observation.

Second, I evaluated age-related differences in use of the SMR and secure messaging by individuals with diabetes. The primary data source for this study was a mixed-mode survey of Group Health members with diabetes that was conducted in September of 2009. 910 individuals from five clinics were surveyed, and 718 responded by mail or phone. In addition to the survey data, metrics of SMR and secure messaging use and variables related to health status and utilization were abstracted from Group Health's clinical data warehouses.

Finally, I used longitudinal data to reexamine the relationship between secure messaging use and diabetes care quality. In this study I tested the hypothesis that patients who engage in frequent secure messaging during a given quarter were more likely to have good glycemic control in the subsequent quarter. As a second aim, I tested the hypothesis that recent, frequent use of secure messaging was associated with higher levels of adherence to HbA1c testing recommendations. This study used observational data from October 2003 – January 2006, a three-year period that began two months after secure messaging was first available to all patients in Group Health's Integrated Group Practice. This analysis included 6,301 adults with diabetes who registered for access to the SMR, 74% of whom used secure messaging at least once during the three-year period of observation.

1.3 WORKS CITED

1 American Diabetes Association. Diabetes Statistics: Data from the 2011 National Diabetes Fact Sheet (released Jan. 26, 2011) Available from http://www.diabetes.org/diabetes-basics/diabetes-statistics/

2 American Diabetes Association. Economic costs of diabetes in the U.S. In 2007. Diabetes Care 2008;31(3):596-615. Erratum in: Diabetes Care. 2008;31(6):1271

3 Cheung BM, Ong KL, Cherny SS, Sham PC, Tso AW, Lam KS Diabetes prevalence and therapeutic target achievement in the United States, 1999 to 2006. Am J Med 2009;122(5):443-453

4 Stratton, Irene, et al, Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): prospective observational study, BMJ 2000;321:405–12

5 The Diabetes Control and Complications Trial Research Group. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. N Engl J Med 1993;329(14):977-86

2 Diabetes Quality of Care and Outpatient Utilization Associated with Electronic Patient-Provider Messaging: A Cross-Sectional Analysis

2.1 ABSTRACT

Objective: To test the hypothesis that electronic patient-provider messaging is associated with high care quality for diabetes and lower outpatient utilization.

Research Design and Methods: We conducted a cross-sectional analysis of electronic patient-provider messaging over a 15-month period between January 1, 2004 and March 31, 2005. The study was set at Group Health Cooperative, a consumer-governed, nonprofit health care system that operates in Washington and Idaho. Participants included all patients aged 18 or over with a diagnosis of diabetes mellitus. In addition to usual care, all patients had the option to use electronic messaging to communicate with their care providers. The primary outcome measures were diabetes-related quality of care indicators (HbA1c, blood pressure, and LDL cholesterol) and outpatient visits (primary care, specialty care, and emergency).

Results: Nineteen percent of patients with diabetes used electronic messaging to communicate with their care providers during the study period (n = 2,924; overall study cohort = 15,427). In multivariate models, frequent use of electronic messaging was associated with HbA1c < 7% (RR 1.36, 95% CI 1.16 to 1.58). Contrary to our hypothesis, frequent use of electronic messaging was also associated with a higher rate of outpatient visits (RR 1.39, 95% CI 1.26 to 1.53).

Conclusions: Frequent use of electronic secure messaging was associated with better glycemic control and increased outpatient utilization. Electronic patient-provider

communication may represent one strategy to meet the healthcare needs of this unique population. More research is necessary determine if there is a causal link between use of secure messaging and improved glycemic control or increased utilization, and if so to elucidate the mechanisms for these effects.

2.2 INTRODUCTION

Online patient-provider communication has the potential to fill unmet needs of patients with chronic conditions. The Institute of Medicine (IOM) has suggested a shift in care towards "continuous healing relationships" supported by access to care outside in-person office visits such as over the Internet and by telephone (1). Although email has been slow to diffuse into clinical settings, use is increasing in response to the IOM report and strong consumer demand (2). Despite the promise of electronic patient-provider communication to improve care, there is a paucity of prior research in the area and consequently little is understood about the relationship between electronic communication and care quality. Specifically, it is unclear whether electronic communication is used as a complement to or a substitute for traditional outpatient utilization.

To explore these questions, we have conducted a cross-sectional analysis of electronic patient-provider messaging at a large health care delivery system. Our analysis focused on diabetes care due to the need for frequent communication and care coordination in this condition (3). We hypothesized that electronic messaging would be associated with improved care quality and lower utilization of in-person services (4, 5). Although causation cannot directly be inferred from cross-sectional data, demonstration of an association between electronic messaging and care quality or altered patterns of utilization would suggest that electronic messaging may interact with care processes in important ways and provide justification for further study.

2.3 RESEARCH DESIGN AND METHODS

Study Design

We conducted a cross-sectional analysis of electronic messaging activity at Group Health Cooperative (Group Health) between January 1, 2004 and March 31, 2005. All study variables were abstracted from clinical and administrative data repositories.

Setting

The study was conducted at Group Health, a mixed-model health care financing and delivery organization in Washington State and North Idaho. Approximately 460,000 members receive care through Group Health's Integrated Delivery System, which includes 20 Group Health–owned facilities and over 500 Group Health physicians. Beginning in August of 2003, all patients in the Integrated Delivery System were able to access patient Web services through the MyGroupHealth Web site. These services included prescription refills, appointment scheduling, medical record access, and secure messaging (SM) to contact health care team members as previously described (6). The MyGroupHealth patient Web site had two levels of security (Table 2.1). At the initial level (registration only) a patient created a password-protected account on the Web site. At this level, the user could not exchange personally identifiable health information with Group Health providers, but could access discussion groups on several topics. Group Health discouraged disclosure of personally identifiable information in the discussion groups. A facilitator was employed to review all content and remove any personally identifiable content. A second, higher level of security provided access to the medical record, SM, and other advanced Web services. Access to this security level required each patient to complete an additional step verifying their identity (ID verification). At the time of this study, they could submit an online request with follow-up paperwork by mail or present a legal form of identification in person at a Group Health clinic. At this level of security, patients and providers shared clinical and other personal health information.

Inclusion Criteria and Cohort Definitions

The study was restricted to patients with diabetes over age 18 that were continuously enrolled in Group Health's Integrated Group Practice during the study period. Patients were identified as having diabetes by three or more outpatient ICD-9 diagnoses for diabetes during the two years prior to the study period. We divided the study population into several groups by their use of MyGroupHealth (Figure 1). Of the baseline population of adults with diabetes at Group Health, 34% completed the process of identity verification to gain access to SM and other advanced services. This group was further divided into two subgroups: members who used SM at least once during the study period ("Secure Messaging Users"), and members who had obtained identity verification but did not use SM during the study period ("ID-verified"). The ID-verified group was selected as the primary comparison cohort because they were expected to be most similar to the SM users in terms of unmeasured characteristics (Figure 1). The group of patients who had no prior MyGroupHealth registration or who elected to obtain only basic username and password access was designated as a secondary comparison cohort ("Non-Verified").

Measurement of Primary Outcome Variables

Three diabetes-related quality of care indicators were selected to assess care quality: HbA1c < 7%, blood pressure (BP) ≤ 130/80 mm Hg, and LDL < 100 mg/dL (7). Outpatient visits were identified and categorized using Current Procedural Terminology (CPT) and department codes.

Measurement of Secure Messaging

Message threads, rather than individual messages, were used to quantify SM activity. A thread was defined as the set of messages related to an original message by successive replies. Threads could be initiated by patients or providers. Prior analysis of patient-provider messaging patterns at Group Health has suggested that a message thread is most conceptually similar to a single episode of clinical care. For example, during 2004, 96% of all threads contained 5 or fewer messages, 86% spanned 3 or fewer calendar days, and 99.7% contained fewer than 10 messages (8).

Patient Population Characteristics

Patient age and gender were abstracted from administrative databases. Twelve Aggregated Diagnostic Groups (ADGs) were selected a priori to control for medical comorbidity (9). ICD-9 data were used to generate a count of complications to control for diabetes severity (10). Depression severity was modeled as an ordinal variable with four levels (Gregory Simon, personal communication). A history of depression was defined by three or more outpatient visits with an ICD-9 diagnosis of depression in the year prior to the study. Moderate depression was defined by any diagnosis of depression by a psychiatrist or other mental health (MH) specialist, and severe depression was defined by any inpatient MH admission. Insurance was grouped into three categories: Commercial, Medicare, or Medicaid. Members with Medicaid insurance were grouped with members in Washington State's Basic Health Plan, an insurance program for low-income individuals not qualifying for Medicaid. Primary care provider (PCP) participation in SM was measured as a percent of total outpatient encounters. Because GHC databases contained little information on race, income, or education, these variables were abstracted from US Census data. Low neighborhood socioeconomic status (SES) was defined as a neighborhood where at least 20% of the population earned less than $20,000/yr or at least 25% of adults over age

Primary Care Provider Characteristics

Provider gender, specialty, quintile rank of age, the proportion of SM threads that were provider-initiated, and the average provider response time were abstracted from administrative databases.

Statistical Analysis

Multivariable regression models were used to examine the association between SM use and care quality. A second set of models was generated to examine the association between SM use and the number of outpatient visits. The patient was the unit of analysis for all regression models, with clustering by PCP. Robust Poisson models were used to estimate relative risks or rate ratios. Models were adjusted for age, gender, overall medical comorbidity, diabetes severity, depression severity, insurance, PCP age, PCP gender, and

PCP participation in SM. To ensure a flexible specification and minimize residual confounding, age was modeled using linear splines. For each spline, the function being smoothed was visually assessed and knots were placed in regions of rapid variation. Neighborhood-level racial/ethnic and SES measures were not significant in preliminary models and were dropped from final models. Generalized estimating equations were used to estimate regression coefficients (12), and the Huber-White robust sandwich estimator was used for variance estimates (13). Wald tests were used to assess the significance of explanatory variables, using two-sided p-values evaluated at the 0.05 significance level. Variables were abstracted from clinical data warehouses using SAS Version 8. STATA Version 10 was used for statistical analyses.

2.4 RESULTS

Thirty-four percent of the study cohort completed the process of identity verification for use of advanced web services including SM (n = 5,274; overall study cohort = 15,427). Of the patients who obtained identity verification, 55% went on to use SM (n = 2,924). SM users participated in an average of 5.3 threads, consisting of 11.8 individual messages. 86.9% of threads were patient-initiated. The mean age of the SM cohort was 58, whereas the mean age of the non-messaging subgroups was 63 (Table 2.2). Among the subgroup with at least 12 SM threads per year, 77% had high or very high expected resource use compared to 44% of the ID-verified cohort. 64% of PCP's with high SM use were female, compared to 37% of PCP's with low SM use (Table 2.3). 10% of PCP's with high SM use and 32% of PCP's with low SM use had panels of over 2,000 patients. Unadjusted relative risks are presented in Table 2.4 (Model A). In multivariate models, the rate of HbA1c < 7% was 36% higher among patients with the highest rate of SM use (>= 12 threads per year) compared to the non-messaging, ID-verified, comparison cohort (RR 1.36, 95% CI 1.16 to 1.58, Table 2.4). In contrast, SM use was not significantly associated with control of BP < 130/80 mm Hg. There was a small but statistically significant association between SM and LDL < 100 mg/dL. For all three quality measures, the non-messaging "ID-Verified" cohort had slightly better outcomes than the non-messaging "Non-Verified" cohort. The primary care visit rate was 32% higher among patients with high use of SM compared to the non-

messaging comparison cohort (RR 1.32, 95% CI 1.19 to 1.45, Table 2.4). This translates to approximately 3 to 4 additional outpatient office per year visits given a baseline visit rate of 9 visits per year. High SM users also had more outpatient specialty visits (RR 1.43, 95% CI 1.25 to 1.64, Table 2.4) and emergence care visits (RR 1.66, 95% CI 1.23 to 2.26, Table 2.4) compared to the non-messaging comparison cohort.

2.5 CONCLUSIONS

Secure Messaging and Glycemic Control

In this cross-sectional study, patients who used more SM had better glycemic control. SM may have enabled better glycemic control by filling unmet needs for care. Care providers may have used SM to recommend medication changes between in-person visits, thereby optimizing treatment regimens more quickly. Medication intensification has previously been found to be the most significant predictor of variation in HbA1c (14). By increasing the frequency of contact, SM might also strengthen continuity of care, which has also been associated with improved glycemic control (15). As with nearly all observational studies, unmeasured differences between users and non-users of SM may also explain our results. Users of SM may have had higher health literacy, education, or other characteristics that are also found among individuals with better glycemic control. Patients who engage in SM may be also more engaged in self-care behaviors that promote better glycemic control. Finally, it is possible that use of advanced Web services other than SM, which included prescription refills, appointment scheduling, and medical record access, may explain some of these results. Among patients who did not use SM, the cohort who had access to advanced Web services exhibited slightly better control of HbA1c, blood pressure, and LDL when compared to the cohort without access.

Secure Messaging and Outpatient Visit Rates

Contrary to our hypothesis, we found a positive association between SM use and the number of outpatient visits. Two prior longitudinal studies of physicians have found electronic messaging systems to be associated with a reduction in outpatient visit rates (4, 5). These studies suggest that electronic consultations may substitute for traditional in-

person office visits. Our results may differ from these studies because of our focus on diabetes. Patients with diabetes who use SM may be more proactive with care providers both online and in person, and may use SM as a complement to care rather than a substitute. For example, SM may be used as aftercare following outpatient visits. SM use may also expose unmet needs in this population that require further engagement either in person or through SM.

Strengths and Weakness of the Study

A key strength of our study is its setting: a large nonprofit health care system that serves approximately 460,000 members. Limitations include the cross-sectional design of the study, the short duration of exposure to SM and potential self-selection bias. SM users may have differed from non-users by unmeasured factors such as self-efficacy, attitudes toward medical care, race, SES, and health literacy. Given the cross-sectional design of this study, it we cannot infer from these results that electronic messaging was causally related the outcomes that we observed. Randomized controlled trials or longitudinal analyses will be required to assess the causal relationship between SM and utilization, care quality, and health outcomes.

Unanswered Questions and Future Research

As physicians and healthcare organizations consider how and when to support electronic communication with patients, we must understand how this new care environment differs from traditional in-person care. SM may serve as an important part of care for patients with diabetes and an opportunity to support them in self-management outside of routine visits. Our findings suggest that patients with diabetes who are frequent users of electronic patient-provider messaging systems may represent a unique patient population, characterized by better glycemic control and greater use of outpatient visits. Future studies could explore the observed associations in further detail, particularly addressing the question of possible causal links between SM and glycemic control or outpatient visit rates. In addition, it will be important to determine whether the cost of providing SM is offset by improvements in patient outcomes or shifts in existing utilization patterns.

2.6 WORKS CITED

1 Institute of Medicine: Crossing the Quality Chasm: A New Health System for the 21st century. National Academies Press, 2001

2 Harris Interactive: Patient/physician online communication: many patients want it, would pay for it, and it would influence their choice of doctors and health plans. Health Care News 2002;2(8):1-4

3 Wielawski IM: Improving Chronic Illness Care. To Improve Health and Health Care, The Robert Wood Johnson Foundation Anthology, Volume X. Jossey-Bass, 2006

4 Zhou YY, Garrido T, Chin HL, Wiesenthal AM, Liang LL: Patient access to an electronic health record with secure messaging: impact on primary care utilization. Am J Manag Care 2007;13(7):418-24

5 Bergmo TS, Kummervold PE, Gammon D, Dahl LB: Electronic patient-provider communication: will it offset office visits and telephone consultations in primary care? Int J Med Inform 2005;74(9):705-10

6 Ralston JD, Carrell D, Reid R, Anderson M, Moran M, Hereford J: Patient web services integrated with a shared medical record: patient use and satisfaction. J Am Med Inform Assoc 2007;14(6):798-806

7 American Diabetes Association: Standards of Medical Care for Patients with Diabetes Mellitus. Diabetes Care 2003;26:S33-50

8 Carrell D, Ralston J: Messages, strands and threads: measuring use of electronic patient-provider messaging. AMIA Annu Symp Proc 2005;913

9 Clinical Groups (ACG) Assignment Software (Version 7.0 for Windows) [computer program]. Baltimore: Johns Hopkins University, 1990-2006

10 Simon G, Katon W, Lin E, Ludman E, Von Korff M, Ciechanowski P, Young B: Diabetes complications and depression as predictors of health care costs. Gen Hosp Psychiatry 2005;27:344-351

11 Kreiger N: Overcoming the Absence of Socioeconomic Data in Medical Records: Validation and Application of a Census-Based Methodology. Am J Public Health 1992;82(5):703-710

12 Liang KY, Zeger SL: Longitudinal data analysis using generalized linear models. Biometrika 1989;73:13-22

13 White HA: Heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. Econometrica 1980;48:817-830

14 O'Connor PJ, Rush WA, Davidson G, Louis TA, Solberg LI, Crain L, Johnson PE, Whitebird RR: Variation in quality of diabetes care at the levels of patient, physician, and clinic. Prev Chronic Dis 2008;5(1):A15

15 Sperl-Hillen JM, Solberg LI, Hroscikoski MC, Crain AL, Engebretson KI, O'Connor PJ: The effect of advanced access implementation on quality of diabetes care. Prev ChronicDis 2008;5(1):A16

Table 2.1 Patient Services on the MyGroupHealth Website.

Service	Level of Access	
	Registration Only	ID-Verification
Healthwise® knowledge base	X	X
Discussion groups	X	X
Health assessment tools	X	X
Choose a primary care provider	X	X
Appointment requests		X
Shared medical record		
Pharmacy refills and list of medications		X
Secure messaging to and from health care team		X
Medical test results		X
After-visit-summaries		X
Medical conditions		X
List of allergies		X
Immunization history		X

Table 2.2 Population characteristics.
Percentage or mean (standard deviation).

			Secure Messaging Users		
	Non-Verified[1]	MyGH ID-Verified[2]	1-3 Threads	4-11 Threads	12+ Threads
	(n = 10,153)	(n = 2,350)	(n = 1,892)	(n = 814)	(n = 218)
Male	52%	45%	46%	49%	49%
Age, years	64 (13)	60 (12)	58 (12)	57 (12)	57 (11)
< 35	1.9%	2.2%	3.2%	3.1%	4.1%
35 – 49	12%	15%	17%	24%	21%
50 – 64	36%	46%	52%	50%	53%
>= 65	50%	37%	28%	23%	22%
Low Neighborhood SES[3]	25%	20%	20%	19%	24%
Distance to Clinic, miles	9.6 (69)	10 (85)	13 (108)	7.8 (9.7)	7.9 (11)
Rural	3.0%	3.2%	3.4%	4.0%	3.7%
Insurance					
Commercial	46%	58%	68%	73%	65%
Medicare	52%	40%	31%	26%	33%
Medicaid, Basic Health Plan	1.9%	2.0%	0.9%	0.4%	1.8%
Expected Resource Use					
None or Low	5.8%	5.8%	3.8%	2.7%	0.5%
Moderate	48%	50%	51%	46%	22%
High	26%	26%	28%	30%	38%
Very High	21%	18%	18%	21%	39%
Depression Visits[4]	0.69 (2.7)	0.86 (3.6)	0.83 (4.1)	1.1 (4.3)	2.5 (8.9)
Diabetic Complications	1.5 (1.1)	1.4 (1.1)	1.3 (1.1)	1.3 (1.1)	1.8 (1.0)
# Quarters with Any SM[5]	N/A	0	1.5 (0.67)	3.2 (1.0)	4.4 (0.85)
Patient's Ratio of SM[5] Threads:	N/A	0	0.20 (0.14)	0.41 (0.17)	0.54 (0.16)
All Encounters					
PCP[6] Ratio of SM[5] Threads: All	0.14 (0.07)	0.14 (0.07)	0.16 (0.08)	0.18 (0.09)	0.19 (0.10)
Encounters					
PCP Gender, % male	72%	73%	71%	68%	67%
Panel Size	1408 (363)	1434 (366)	1403 (356)	1375 (356)	1382 (351)
Tenure with PCP[6], years	6.2 (5.2)	6.1 (5.2)	6.2 (5.2)	6.1 (5.3)	6.2 (5.1)
HbA1c, %	7.8 (1.6)	7.7 (1.6)	7.6 (1.5)	7.6 (1.5)	7.5 (1.6)
< 7%	34%	36%	37%	38%	45%
BP[7], mm Hg	134/74 (20/11)	133/75 (19/11)	132/75 (18/11)	132/76 (18/11)	132/75 (19/11)
< 130/80	33%	35%	36%	34%	36%
LDL, mg/dL	96 (35)	95 (34)	95 (35)	94 (36)	93 (34)
< 100	80%	82%	81%	81%	83%
Outpatient Visits[4]	9.5 (14)	9.4 (14)	9.7 (14)	12 (15)	18 (20)
Primary Care	49%	48%	47%	45%	42%
Specialty Care	47%	49%	51%	53%	55%
Emergency	4.6%	3.6%	3.1%	3.2%	4.1%

[1]Non-Verified = Patients with no MyGroupHealth Web site registration or only basic username/password registration; [2]MyGH ID-Verified = Patients who registered to use the MyGroupHealth Web site and completed secondary identity verification but never used secure messaging; [3]SES = socioeconomic status; [4]Annualized visits; [5]SM = Secure messaging; [6]PCP = Primary care provider; [7]BP = Blood pressure.

Table 2.3 Characteristics of primary care providers.
Percentage or mean (standard deviation).

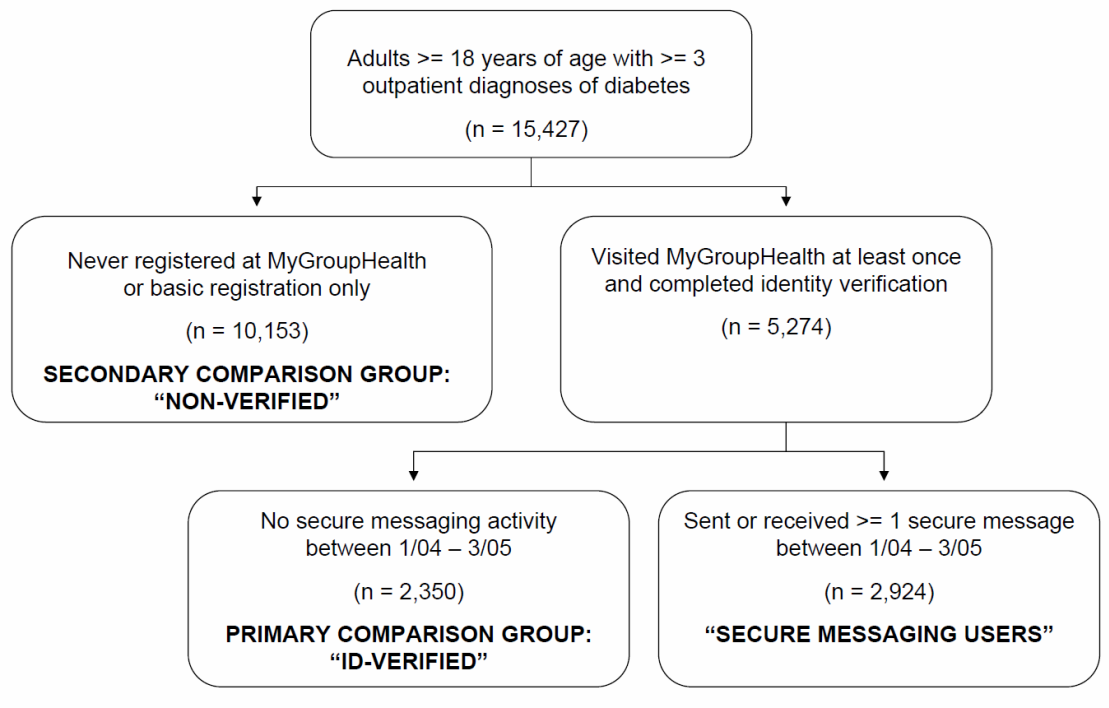
	All Providers	Secure Messaging < 20% Of All Encounters	Secure Messaging >= 20% Of All Encounters
Total Number of Providers	186	136	50
Male	56%	63%	36%
Age, years			
29 to 41	20%	16%	30%
42 to 49	20%	21%	17%
50 to 52	21%	20%	23%
53 to 56	19%	19%	19%
57 to 63	20%	24%	11%
Panel Size			
< 500	11%	12%	8.0%
500-2000	63%	56%	82%
> 2000	26%	32%	10%
Provider-Initiated Threads			
None	15%	18%	4%
< 15%	62%	68%	46%
> 15%	23%	13%	50%
Time to Respond, hours	8.2 (4.6)	8.8 (4.9)	6.5 (3.2)

Table 2.4 Multivariable regression results.
Model A is unadjusted. Model B is adjusted for age, gender, overall medical comorbidity, diabetes severity, depression severity, and insurance type, primary care provider (PCP) participation in secure messaging, PCP age, PCP gender, and PCP panel size.

Outcome	Secure Messaging Intensity	Model A RR[1]	Model A 95% CI	Model A p-value[2]	Model B RR[1]	Model B 95% CI	Model B p-value[2]
		(n = 14,075)			(n = 13,908)		
HbA1c	Non-Verified	0.95	(0.90 - 1.01)	< 0.001	0.92	(0.87 - 0.98)	< 0.001
< 7%	0 Threads, ID-Ver.	1	-		1	-	
	1 - 3 Threads	1.06	(0.97 - 1.15)		1.08	(1.00 - 1.18)	
	4 - 12 Threads	1.08	(0.98 - 1.20)		1.13	(1.02 - 1.25)	
	12 + Threads	1.29	(1.10 - 1.50)		1.36	(1.16 - 1.58)	
		(n = 10,181)			(n = 10,079)		
BP[3]	Non-Verified	0.92	(0.86 - 0.99)	0.150	0.92	(0.87 - 0.99)	0.155
< 130/80	0 Threads, ID-Ver.	1	-		1	-	
mm Hg	1 - 3 Threads	1.00	(0.92 - 1.10)		1.01	(0.92 - 1.11)	
	4 - 12 Threads	.97	(0.87 - 1.09)		0.98	(0.87 - 1.09)	
	12 + Threads	1.00	(0.80 - 1.26)		0.98	(0.78 - 1.24)	
		(n = 11,637)			(n = 11,487)		
LDL	Non-Verified	0.97	(0.93 - 1.01)	0.255	0.94	(0.90 - 0.98)	< 0.001
< 100	0 Threads, ID-Ver.	1	-		1	-	
mg/dL	1 - 3 Threads	0.97	(0.91 - 1.02)		0.99	(0.93 - 1.05)	
	4 - 12 Threads	1.02	(0.96 - 1.10)		1.07	(1.00 - 1.15)	
	12 + Threads	0.99	(0.87 - 1.13)		1.01	(0.89 - 1.14)	
		(n = 15,427)			(n = 15,237)		
Total	Non-Verified	1.01	(0.97 - 1.06)	< 0.001	0.98	(0.95 - 1.02)	< 0.001
Outpatient	0 Threads, ID-Ver.	1	-		1	-	
Visits	1 - 3 Threads	1.03	(0.98 - 1.09)		1.05	(1.01 - 1.10)	
	4 - 12 Threads	1.27	(1.18 - 1.36)		1.19	(1.13 - 1.25)	
	12 + Threads	1.97	(1.76 - 2.20)		1.39	(1.26 - 1.53)	
		(n = 15,427)			(n = 15,237)		
Primary	Non-Verified	1.04	(0.99 - 1.08)	< 0.001	0.99	(0.96 - 1.03)	< 0.001
Care	0 Threads, ID-Ver.	1	-		1	-	
Visits	1 - 3 Threads	1.01	(0.96 - 1.07)		1.02	(0.98 - 1.07)	
	4 - 12 Threads	1.18	(1.10 - 1.26)		1.11	(1.05 - 1.18)	
	12 + Threads	1.74	(1.57 - 1.94)		1.32	(1.19 - 1.45)	
		(n = 15,427)			(n = 15,237)		
Specialty	Non-Verified	0.97	(0.92 - 1.03)	< 0.001	0.96	(0.91 - 1.01)	< 0.001
Care	0 Threads, ID-Ver.	1	-		1	-	
Visits	1 - 3 Threads	1.06	(0.98 - 1.14)		1.08	(1.01 - 1.15)	
	4 - 12 Threads	1.36	(1.24 - 1.48)		1.26	(1.16 - 1.36)	
	12 + Threads	2.17	(1.87 - 2.51)		1.43	(1.25 - 1.64)	
		(n = 15,427)			(n = 15,237)		
Emergency	Non-Verified	1.33	(1.16 - 1.54)	< 0.001	1.17	(1.05 - 1.32)	< 0.001
Visits	0 Threads, ID-Ver.	1	-		1	-	
	1 - 3 Threads	0.90	(0.76 - 1.07)		1.04	(0.90 - 1.21)	
	4 - 12 Threads	1.19	(0.94 - 1.51)		1.19	(0.98 - 1.44)	
	12 + Threads	2.34	(1.61 - 3.41)		1.66	(1.23 - 2.26)	

[1]RR = Relative risk; [2]Wald tests for composite linear hypotheses; [3]BP = Blood pressure.

Figure 2.1 Overview of study population.



3 Shared Electronic Medical Record and Secure Messaging in Diabetes Care: An Analysis of Age-Related Differences in Use

3.1 ABSTRACT

Objective. Our objective was to study age-related differences among patients with diabetes in the use of a shared electronic medical record (SMR) integrated with secure patient-provider messaging. We hypothesized that use would be lower in older age groups, and that most of the difference would be explained by the gap in Internet access and computer use between age groups.

Research Design and Methods. Cross-sectional survey of patients aged 18 or over with a diagnosis of diabetes mellitus. The study was set at Group Health Cooperative, an integrated delivery system in Washington and Idaho.

Results. Use of the SMR and secure messaging declined monotonically with increasing age (SMR: 74% for 18-50, 64% for 51-65, 53% for 66-75, and 35% for over 75; messaging: 61% for 18-50, 50% for 51-65, 39% for 66-75, 23% for over 75). After adjusting for Internet use in everyday life, demographic characteristics, and measures of health, the odds of SMR and secure messaging use remained lower in older age groups (SMR: OR 0.6 for 51-65, 0.5 for 66-75, 0.5 for over 75, p for trend = 0.03; secure messaging: OR 0.6 for 51-65, 0.4 for 66-75, 0.3 for over 75, p for trend < 0.01).

Conclusions. Older patients were less likely to use the SMR and secure messaging even after adjusting for Internet use and several demographic and health characteristics. Our results may be partially explained by age-related differences in care preferences, computer-related knowledge, and willingness to share personal information online.

3.2 INTRODUCTION

Diabetes is estimated to affect nearly 25% of adults over 65, one third of whom are undiagnosed (1, 2). Lower rates of glycemic control among older adults suggest that current care delivery processes are inadequate (3, 4). Diabetes care for older adults is often complicated by concomitant functional decline, multiple comorbidities, and psychosocial challenges (5, 6). In addition to the classic macrovascular and microvascular complications, poorly controlled diabetes presents unique risks to older patients, such as dementia, depression, and falls (2, 7).

Care experienced by older adults with multiple chronic conditions has been characterized as fragmented, incomplete, inefficient, and ineffective (8). When asked to describe an ideal process of care, older adults emphasize convenient access to care providers, access to the same provider over time, and a relationship with a provider who communicates clearly and takes the time to fully understand their concerns (9). Older adults are reluctant to "bother" physicians with in person appointments unless they are perceived to be necessary; those who used email to communicate with their providers appreciated the increased access that email affords (9). These studies suggest that among the older, chronically ill population, there is a mismatch between current care processes and patient preferences.

Patient Web portals offering access to medical records and secure patient-provider messaging may help to fill some of the unmet needs of older adults with diabetes (10). Diabetes management requires frequent coordination with a multidisciplinary care team, and Web-based medical records and secure messaging services have the potential to facilitate these on-going interactions. Although secure patient-provider messaging has been slow to diffuse into clinical settings, its use is rising in response to reports of strong consumer demand (11, 12) and new management paradigms such as the Chronic Care Model (13, 14) and the Patient-Centered Medical Home (15). A survey of health care organizations conducted in 2010 found that patient-provider secure messaging or e-mail was used on at least a limited basis in 43% of organizations (16). In contrast, a survey five years prior to this found only 2.9% of physicians reported using email frequently to communicate with patients, and 16.6% had reported ever using it (17). In addition to

increasing the timeliness and convenience of care, these new tools have the potential to strengthen the patient-provider relationship and optimize management by enabling more frequent monitoring and treatment adjustments between visits. Yet little is currently known about the extent to which older adults use online electronic medical records and patient-provider messaging in the context of a chronic condition, how they use these tools, and what factors influence use or non-use. Although older adults use the Internet at lower rates than their younger counterparts, they also represent the fastest growing Internet user group (18). Given that many organizations are currently deciding when and how to leverage these new tools, it is important to understand age-related differences in use.

In this analysis we present results from a cross-sectional analysis of adults with diabetes receiving care at a large, non-profit health care system (Group Health Cooperative). We hypothesized that older adults would use the SMR and secure messaging at lower rates than younger adults and that most of the difference would be explained by the gap in Internet access and computer use between age groups.

3.3 RESEARCH DESIGN AND METHODS

Setting

The study was conducted at Group Health Cooperative (Group Health), an integrated delivery system that operates in Washington and Idaho. Approximately 460,000 members receive care from Group Health's Integrated Group Practice, which includes 20 Group Health–owned facilities and over 500 Group Health physicians. Beginning in 2003, all patients could access an SMR (www.ghc.org) with the following eight features: secure messaging with health care providers, medication refill requests, appointment requests, after-visit summaries, medical condition lists, allergies, immunizations, and test results. Patients were required to verify their identity to Group Health before using these features (19). Detailed descriptions of the patient website have been previously reported (19-21).

Study Design and Sampling Frame

The data used in this analysis are from a cross-sectional survey conducted in September 2009 to evaluate health and demographic characteristics associated with use of the SMR among enrollees with diabetes. In addition to survey data, we asked respondents for permission to access automated diagnostic, laboratory, pharmacy, and utilization data. Driven by the objectives of the parent study, participants were sampled from five medical clinics in the Seattle metropolitan area selected for high levels of racial and ethnic diversity. The sample population included 910 patients aged 18 or over with a diagnosis of diabetes mellitus, stratified by use of the SMR. Pharmacy and claim data were used to identify patients with type 1 or type 2 diabetes (22). Patients were required to be continuously enrolled in Group Health's Integrated Group Practice for 24 months prior to the survey and have two or more visits to a primary care physician (PCP) for inclusion. Patients with a diagnosis of dementia or major psychosis were excluded. A stratified sampling approach was chosen to achieve a balanced sample and increase precision. The first stratum consisted of individuals who had used one or more of the eight core SMR services on two occasions separated by 30 days or more in the prior two years. Patients who logged on only once were not considered to be engaged SMR users and were excluded from this stratum. The second stratum consisted of everyone else who met the overall eligibility criteria. Both groups were of equal size. Surveys were mailed to 910 patients, using a modified Dillman approach with a $2 bill incentive and up to 5 follow-up attempts for survey completion – first in a full mailed version and then (in the last attempt) a shorter phone version (23). All study procedures were approved by the Group Health Human Subjects Review Committee.

Measurement of Outcome Variables

Our primary outcomes were SMR use and secure messaging use. SMR use was defined as use of one or more of eight online services on two occasions separated by 30 days or more in the prior two years. These patients may have used secure messaging or any of the other services available on the MyGH website (www.ghc.org). Secure messaging use was defined as participation in two or more message threads in the prior two years. A message thread, conceptually analogous to a single episode of care, was defined as the set of messages

related to an original message by successive replies (24). Threads could be initiated by patients or providers.

Patient Population Characteristics

Survey data were used to describe income, education, Internet and e-mail use, Internet access, and primary care provider (PCP) encouragement to use the SMR. All other population characteristics reported were abstracted from administrative databases including age, gender, distance to clinic, several measures of health status and utilization, and PCP participation in secure messaging. Home address records were used to calculate the distance from home to clinic. Outpatient visits were identified and categorized using Current Procedural Terminology and department codes. Overall comorbidity was modeled with a standardized risk score that was based on the patient's Adjusted Clinical Group (ACG) (25). The Diabetes Complication Severity Index, a 13-point scale, was used to measure diabetes severity (26). A history of treated depression was defined by an antidepressant prescription associated with a diagnosis of a depressive disorder. The question on provider encouragement was modeled on wording from a CAHPS Health Plan Survey, and the response option was a four-point Likert scale indicating how often the patient felt that their provider encouraged them to access the SMR (27). PCP participation in secure messaging was measured as a percent of the provider's total outpatient encounters (i.e. in-person, phone, and electronic).

Statistical Analysis

Unadjusted odds ratios were used to examine the crude association between age and the SMR or secure messaging in all respondents and within the subset of patients who reported any Internet or email use. Multivariable logistic regression models were used to examine the association between age and the SMR or secure messaging within Internet users. The patient was the unit of analysis for all regression models. Models were adjusted for medical need (as described below), gender, education, broadband Internet access, provider encouragement, and PCP participation in secure messaging and clustered by primary care provider. Three variables were used to control for medical need: overall medical comorbidity as reflected by a weighted ACG score, diabetes severity, and history of treated

depression. Sequential models were constructed in which sets of related covariates were added at each stage. Income was excluded due to potential nonresponse bias. Trend tests were used to assess the significance of age, using two-sided p-values evaluated at the 0.05 significance level. To examine barriers to the use of secure messaging and SMR, relevant percentages were presented descriptively by age group. STATA Version 11 for Windows was used for statistical analyses.

3.4 RESULTS

Population Characteristics

Of the 910 participants identified for inclusion, 718 completed the mailed or shorter phone version of the survey (response rate=79%). Among the respondents, 625 patients (87%) also consented to medical record review. Demographic and health characteristics are presented in Table 3.1. The mean age was 66 years, with 88% of respondents over the age of 50. Older patients were less likely to report any Internet use (age 75+: 31%; age 18-50: 87%). Among Internet users, older patients were more likely to lack Internet access at home (age 75+: 32%; age 18-50: 7%). Older patients tended to have higher levels of comorbidity and diabetes severity, but lower rates of treated depression. Among the primary care providers of the survey respondents, secure messaging represented approximately one-third of total patient contacts (i.e. in-person, phone, or secure messaging). Providers of older patients used similar levels of secure messaging when compared to the providers of younger patients.

Older patients had higher rates of outpatient visits and phone consults, but lower rates of SMR and secure messaging and use. For patients 50 and under, there were nearly as many secure messaging threads as there were primary care clinic visits (3.5 secure messaging threads/year vs. 3.7 visits). In contrast, for patients over 75, primary care visits outnumbered secure messaging threads by 6:1 (0.8 secure messaging threads/year vs. 4.9 visits). For patients 65 and under, the majority of primary care contacts (56%) took place out of the clinic, either by secure messaging or by phone. These utilization trends are summarized graphically in Figure 3.1.

Relationship between Age and Use of Secure messaging and the SMR

Adjusted use of both the SMR and secure messaging were monotonically lower in relation to older age (SMR: $p = 0.03$, secure messaging: $p < 0.01$). Unadjusted odds ratios along with results from partially and fully adjusted multivariate models are presented in Tables 3.2 and 3.3.

Reasons for Nonuse of the Internet, Secure messaging and the SMR

Internet non-users were asked to indicate their reasons for not using the Internet or email (Table 3.4, top panel). *Limited Access to a Computer or the Internet* was the most common reason given in all age groups. In addition, 40% of patients over age 50 cited *Preferences or Attitudes* as a reason, and 25% of patients over age 50 cited *Lack of Knowledge*. In a separate survey item, Internet users were asked to indicate their reasons for not using the SMR (Table 3.4, bottom panel). *Preferences or Attitudes* was the most common reason given in all age groups. *Lack of Knowledge* and *Concerns about Information Security* were also common reasons for nonuse among respondents over age 50.

3.5 CONCLUSIONS

Secure messaging and the SMR may serve as an important part of care for patients with diabetes and an opportunity to support them in self-management outside of routine visits. As physicians and health care organizations consider how and when to support electronic communication with patients, it is important to understand how this new care environment differs from traditional in-person care and how it can be shaped to meet the needs of patients of all ages.

In this cross-sectional study, older patients with diabetes were less likely to use secure messaging and the SMR than younger patients. Consistent with prior literature (18), older patients were also much less likely to use the Internet and were less likely to have broadband Internet access at home. But contrary to our hypothesis, odds of SMR and secure messaging use were still significantly lower in older patient subgroups when restricting our sample to Internet users and adjusting for demographic, socioeconomic,

health-related, and provider factors. Approximately 80% of Internet users over 50 cited *Preferences or Attitudes*, *Lack of Knowledge*, or *Concerns about Information Security* as a reason for SMR nonuse. Cohort effects, rather than age itself, may explain part of the observed associations. As a more computer literate generation ages into older adulthood, these differences may narrow. However, as new modes of patient-provider communication emerge, younger cohorts, who are more often exposed to new technology through education or employment, will likely continue to drive adoption.

This study has several limitations. As with all survey research, our results may be biased by survey non-response. Social desirability bias may also be present, particularly in responses obtained by phone. Our findings may not be generalizable to healthier populations without chronic medical conditions. In an effort to minimize respondent burden, we did not explore the reasons for nonuse in depth. Future research using qualitative methods should explore the reasons behind lower use of SMR and secure messaging services among older patient populations in more detail.

Most physicians do not currently use secure messaging or e-mail to communicate with their patients (28, 29). Diffusion of the Chronic Care Model (13, 14) and the Patient-Centered Medical Home model (15) throughout primary care organizations has led to the use and evaluation of secure messaging in numerous demonstration projects (30). In addition, proposed "Meaningful use" criteria for electronic health records from the Centers for Medicare and Medicaid Services may facilitate the uptake of secure messaging (31). As a result of these factors, secure messaging is likely to be available to a larger portion of patients with diabetes in the coming years.

It is still unclear what impact SMRs will have on care quality, patient experience and health outcomes, nor how to optimally implement them. In cross-sectional studies, patients with diabetes who use secure messaging or an SMR without messaging capabilities have been found to have better glycemic control (32, 33). Use of secure messaging has also been associated with improvements in diabetes-related effectiveness of care (34). Our findings suggest that a substantial proportion of older, chronically ill, patients are interested in these new services, but potentially modifiable factors such as a lack of knowledge and

concerns about information security currently limit their reach. Past Internet use alone may not equip many older adults with the knowledge and skills necessary to use SMR and secure messaging. Although patient education classes focused on SMR and secure messaging use might increase adoption in a segment of the older population, our results also suggest that a significant proportion of older adults choose not to use these services because of differences in preferences for care. As health care organizations offer an increasing array of services online, it is important to keep these preferences in mind so that age-related health disparities do not widen.

Acknowledgements

This study was funded by the Agency for Health Care Research and Quality (R01 H5016759-01).

3.6 WORKS CITED

1 Sloan FA, Bethel MA, Ruiz D Jr, Shea AM, Feinglos MN. The growing burden of diabetes mellitus in the US elderly population. Arch Intern Med 2008;168(2):192-9

2 Mooradian AD, Chehade JM. Diabetes Mellitus in Older Adults. Am J Ther 2012;19(2):145-59

3 Bruce DG, Davis WA, Davis TM. Glycemic control in older subjects with type 2 diabetes mellitus in the Fremantle Diabetes Study.J Am Geriatr Soc 2000;48(11):1449-53

4 Alvarez Guisasola F, Mavros P, Nocea G, Alemao E, Alexander CM, Yin D.Glycaemic control among patients with type 2 diabetes mellitus in seven European countries: findings from the Real-Life Effectiveness and Care Patterns of Diabetes Management (RECAP-DM) study. Diabetes Obes Metab 2008;10 Suppl 1:8-15

5 Selvin E, Coresh J, Brancati FL. The burden and treatment of diabetes in elderly individuals in the U.S. Diabetes Care 2006;29(11):2415-9

6 Goldberg AP, Coon PJ. Non-insulin-dependent diabetes mellitus in the elderly. Influence of obesity and physical inactivity. Endocrinol Metab Clin North Am 1987;16(4):843-65

7 Drab SR. Recognizing the rising impact of diabetes in seniors and implications for its management. Consult Pharm 2009;24 Suppl B:5-10

8 Boult C, Wieland GD. Comprehensive primary care for older patients with multiple chronic conditions: "Nobody rushes you through". JAMA 2010;304(17):1936-43

9 Bayliss EA, Edwards AE, Steiner JF, Main DS. Processes of care desired by elderly patients with multimorbidities. Fam Pract 2008;25(4):287-93

10 Weppner WG, Ralston JD, Koepsell TD, Grothaus LC, Reid RJ, Jordan L, Larson EB. Use of a shared medical record with secure messaging by older patients with diabetes. Diabetes Care 2010;33(11):2314-9

11 Harris Interactive: Patient/physician online communication: many patients want it, would pay for it, and it would influence their choice of doctors and health plans. Health Care News 2002;2(8):1-4

12 Adler KG. Web portals in primary care: an evaluation of patient readiness and willingness to pay for online services. J Med Internet Res 2006;8(4):e26

13 Wagner EH, Austin BT, Korff M. Organizing care for patients with chronic illness. Milbank Q 1996;74(4):511–544

14 Wagner EH, Austin BT, Davis C, Hindmarsh M, Schaefer J, Bonomi A. Improving chronic illness care: translating evidence into action. Health Aff 2001;20(6):64–78

15 American Academy of Family Physicians, American Academy of Pediatrics, American College of Physicians, and American Osteopathic Association. Joint Principles of the Patient-Centered Medical Home. March 2007. Available from http://www.acponline.org/advocacy/where_we_stand/medical_home/approve_jp.pdf

16 McGee MK. Healthcare IT Priorities Survey: A Singular Focus. InformationWeek Analytics. March 2011. Available from http://reports.informationweek.com/abstract/105/5934/Healthcare/research-healthcare-it-priorities-survey.html

17 Brooks RG, Menachemi N. Physicians' use of email with patients: factors influencing electronic communication and adherence to best practices. J Med Internet Res 2006;8(1):e2

18 Pew Internet & American Life Project. (2010). "Updated: Change in internet access by age group, 2000-2010." Available from http://www.pewinternet.org/Infographics/2010/Internet-acess-by-age-group-over-time-Update.aspx

19 Ralston JD, Carrell D, Reid R, Anderson M, Moran M, Hereford J: Patient web services integrated with a shared medical record: patient use and satisfaction. J Am Med Inform Assoc 2007;14(6):798-806

20 Ralston JD, Martin DP, Anderson ML, Fishman PA, Conrad DA, Larson EB, Grembowski D. Group health cooperative's transformation toward patient-centered access. Med Care Res Rev 2009;66(6):703-24

21 Ralston JD, Coleman K, Reid RJ, Handley MR, Larson EB. Patient experience should be part of meaningful-use criteria. Health Aff (Millwood) 2010;29(4):607-13

22 The National Committee for Quality Assurance. HEDIS 2010 Final NDC Lists. Table CDC-A: Prescriptions to Identify Members with Diabetes. Available from http://www.ncqa.org/tabid/1091/Default.aspx

23 Dillman DA, Smyth JD, Christian LM. Internet, Mail and Mixed-Mode Surveys: The Tailored Design Method, 3rd edition. Hoboken, NJ, John Wiley & Sons, 2007

24 Carrell D, Ralston J: Messages, strands and threads: measuring use of electronic patient-provider messaging. AMIA Annu Symp Proc 2005;913

25 Starfield B, Weiner J, Mumford L, Steinwachs D: Ambulatory care groups: a categorization of diagnoses for research and management. Health Serv Res 1991;26(1):53-74

26 Young BA, Lin E, Von Korff M, Simon G, Ciechanowski P, Ludman EJ, Everson-Stewart S, Kinder L, Oliver M, Boyko EJ, Katon WJ. Diabetes complications severity index and risk of mortality, hospitalization, and healthcare utilization. Am J Manag Care 2008;14(1):15-23

27 Agency for Health Research and Quality. CAHPS Clinician & Group Visit Survey. Available from https://www.cahps.ahrq.gov/Surveys-Guidance/CG/Visit.aspx

28 Siva C, Lawlor K, Smarr K, Ge B, Fleming D. E-mail communication with patients: a survey of the American College of Physicians, Missouri Chapter. Mo Med 2011;108(2):136-40

29 Boukus ER, Grossman JM, O'Malley AS. Physicians slow to e-mail routinely with patients. Issue Brief Cent Stud Health Syst Change 2010;(134):1-5

30 Center for eHealth Information Adoption and Exchange of the Patient-Centered Primary Care Collaborative. Transforming Patient Engagement: Health IT in the Patient Centered Medical Home. October 2010. Available from http://www.pcpcc.net/guide/health-it-pcmh

31 Tang P. Meaningful Use Workgroup Recommendations. June 8, 2011. Available from http://healthit.hhs.gov/portal/server.pt/community/healthit_hhs_gov__policy_past_meetings/1814

32 Harris LT, Haneuse SJ, Martin DP, Ralston JD. Diabetes quality of care and outpatient utilization associated with electronic patient-provider messaging: a cross-sectional analysis. Diabetes Care. 2009 Jul;32(7):1182-7

33 Shaw RJ, Ferranti J. Patient-Provider Internet Portals-Patient Outcomes and Use. Comput Inform Nurs 2011;29(12):714-8

34 Zhou YY, Kanter MH, Wang JJ, Garrido T. Improved quality at Kaiser Permanente through e-mail between physicians and patients. Health Aff (Millwood) 2010 Jul;29(7):1370-5

Table 3.1 Demographic and health characteristics of survey respondents.

		Age 18-50		Age 51-65		Age 66-75		Over Age 75	
		Non-User	SMR User	Non-User	SMR User	Non-User	SMR User	Non-User	SMR User
Sample Size (n, %)		19 (26)	53 (74)	84 (36)	149 (64)	76 (47)	87 (53)	97 (65)	53 (35)
Age (years)		45	43	59	59	71	70	82	82
Male (%)		58	40	48	50	45	62	40	58
Race	White, Non-Hispanic (%)	26	60	36	70	61	83	64	67
	Black	26	15	29	10	20	3	14	10
	Asian	32	9	17	6	11	3	12	13
	Other	16	15	19	14	8	10	9	10
Email and Internet Use	Any Internet Use (%)	58	100	50	97	32	98	14	73
	Any E-mail Use	53	96	46	95	22	92	13	71
Internet at Home[1]	No Access (%)	0	4	3	4	11	4	0	8
	Non-Broadband	10	4	15	8	16	7	27	19
	Broadband	90	92	82	88	74	89	73	73
Distance to Clinic (miles)		5.3	6.2	4.9	6.5	4.6	7.0	4.8	4.8
Income[2]	< $20,000 (%)	33	10	14	6	30	11	41	15
	$20-$49,999	39	20	39	24	41	42	47	54
	$50-$100,000	17	59	38	48	25	32	13	26
	> $100,000	11	12	8	22	4	15	0	4
Education	< HS Grad (%)	0	0	12	1	13	7	17	4
	HS, 2yr Degree	63	53	60	56	71	48	66	53
	4yr Degree	32	30	11	22	7	13	6	11
	> 4yr Degree	5	17	17	21	9	33	11	32
History of Treated Depression (%)		5	19	12	15	9	10	3	4
Overall Comorbidity	Low (%)	37	15	15	6	7	2	0	4
	Moderate	42	57	56	54	47	47	43	40
	High	16	23	19	28	26	25	31	38
	Very High	5	6	10	12	20	25	26	19
Diabetes Complications (0-13)		0.5	0.5	0.8	0.8	1.2	1.3	1.7	1.5
Treatment Intensity	Diet Alone (%)	11	6	5	1	3	2	2	2
	Oral Hypoglycemics	68	26	52	50	46	38	47	47
	Insulin	21	68	43	49	51	60	51	51
Type of SMR Use	SMR Users (n)		53		143		80		43
	Infrequent (%)		23		21		26		19
	Frequent		77		76		70		53
	By Proxy		0		3		4		28
PCP Messaging: All Encounters (ratio)		28	34	29	32	29	32	32	31
Provider Encouragement	None (%)	22	8	27	9	34	19	54	30
	Infrequent	39	49	34	53	51	56	38	47
	Frequent	39	43	39	38	15	26	8	23

[1]This question was asked of Internet users only. [2]Percent missing: 18-50: 4.1%, 51-65: 6.0%, 66-75: 8.0%, over 75: 16.7%.

Table 3.2 Odds ratios for shared electronic medical record use by age.

		Age 18-50[1]		Age 51-65		Age 66-75		Over Age 75		Trend
	N	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	p-value
Unadjusted (All Users)	618	1.0		0.6		0.4		0.2		
Unadjusted (Internet Users)	432	1.0		0.7		0.8		0.8		
Adjusted for: Medical Need, Gender, Race (Internet Users)	408	1.0	-	0.6	(0.3-1.1)	0.4	(0.2-1.0)	0.5	(0.2-1.3)	0.02
+ Education, Broadband	371	1.0	-	0.7	(0.3-1.5)	0.6	(0.2-1.8)	0.5	(0.2-1.6)	0.03
+ Provider Encouragement	362	1.0	-	0.7	(0.3-1.5)	0.7	(0.2-2.0)	0.6	(0.2-1.7)	0.06

[1]Reference group.

Table 3.3 Odds ratios for secure messaging use by age.

		Age 18-50[1]		Age 51-65		Age 66-75		Over Age 75		Trend
	N	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	p-value
Unadjusted (All Users)	618	1.0		0.6		0.4		0.2		
Unadjusted (Internet Users)	432	1.0		0.7		0.6		0.4		
Adjusted for: Medical Need, Gender, Race (Internet Users)	408	1.0	-	0.5	(0.3-1.0)	0.4	(0.2-0.8)	0.2	(0.1-0.5)	< 0.01
+ Education, Broadband	371	1.0	-	0.5	(0.3-1.2)	0.4	(0.2-1.0)	0.3	(0.1-0.8)	< 0.01
+ Provider Encouragement	362	1.0	-	0.6	(0.3-1.2)	0.4	(0.2-1.1)	0.3	(0.1-0.8)	< 0.01

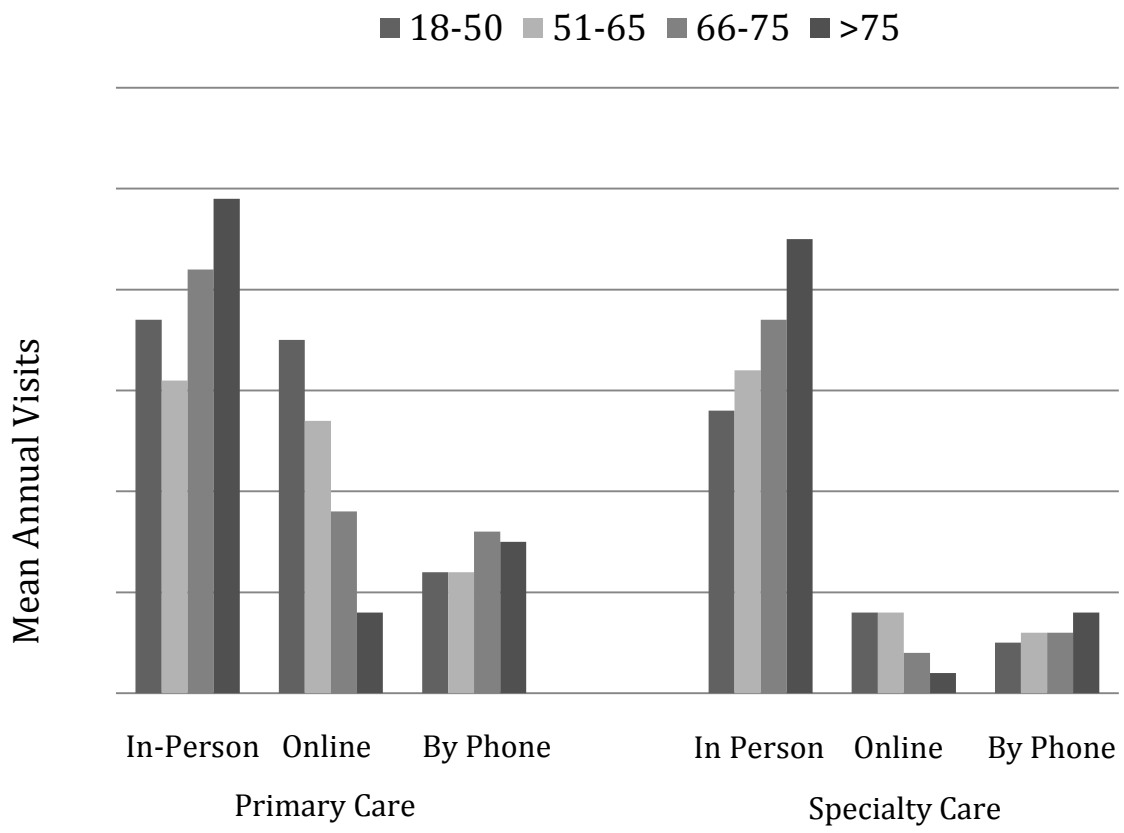
[1]Reference group.

Table 3.4 Reasons for nonuse of the Internet and shared electronic medical record.

	Age			
	18-50	51-65	66-75	Over 75
Reasons for Nonuse of the Internet and/or E-mail Reported by Internet Nonusers (n)	3	31	44	75
Computer and/or Internet Access	100%	81%	61%	65%
Preferences or Attitudes	0%	42%	43%	35%
Lack of Knowledge	0%	19%	30%	29%
Physical limitation	0%	0%	9%	11%
Other	0%	26%	16%	19%
Reasons for Nonuse of the SMR[1] Reported by Internet Users (n)	5	43	27	17
Preferences or Attitudes	40%	53%	33%	41%
Lack of Knowledge	0%	16%	22%	24%
Concerned about Information Security	0%	23%	19%	29%
Computer and/or Internet Access	0%	7%	26%	12%
Didn't Know about the SMR	20%	7%	4%	6%
Physical Limitation	0%	2%	0%	0%
Family Member Uses It For Me	0%	2%	0%	0%
Other	20%	12%	11%	12%

[1]SMR = Shared electronic medical record.

Figure 3.1 Distribution of visit types by age.



4 Glycemic Control Associated with Secure Patient-Provider Messaging by Users of a Shared Electronic Medical Record: A Longitudinal Analysis

4.1 ABSTRACT

Objective: To study differences in glycemic control and glycated hemoglobin (HbA1c) testing associated with use of secure electronic patient-provider messaging. We hypothesized that secure messaging would be associated with better glycemic control and a higher rate of adherence to HbA1c testing recommendations.

Research Design and Methods: Retrospective observational study of secure messaging at Group Health, a large nonprofit health care system. Our analysis included adults with diabetes who had registered for access to a shared electronic medical record (SMR) during the period of 2003-2006. We used robust Poisson regression models within a GEE framework to estimate the adjusted rate ratio of meeting three indicators of glycemic control (HbA1c < 7%, HbA1c < 8%, and HbA1c > 9%) and HbA1c testing adherence by level of prior secure messaging use. Multiple imputation and inverse probability weights were used to account for missing data.

Results: 6,301 adults with diabetes registered for access to the SMR during the study period, 74% of whom used secure messaging at least once during that time. Frequent use of secure messaging during the prior calendar quarter was associated with a higher rate of good glycemic control (HbA1c < 7%: RR 1.26, 95% CI 1.15-1.37) and a higher rate of HbA1c testing adherence (RR 1.20, 95% CI 1.15-1.25).

Conclusions: Among SMR users, recent and frequent secure messaging use was associated with better glycemic control and a higher rate of HbA1c testing adherence. These results

suggest that secure messaging may facilitate important processes of care and help some patients to achieve or maintain adequate glycemic control.

4.2 INTRODUCTION

An increasing number of health care organizations are providing patients with access to their personal health data and care providers through the World Wide Web. Some of these sites, often termed "patient portals", allow patients and providers to exchange secure electronic messages between office visits. Although most patients still do not have the option to communicate with their care providers electronically (1, 2), more practices are transitioning to comprehensive clinical information systems with built-in messaging capabilities. The diffusion of new management paradigms such as the Chronic Care Model (3, 4) and the Patient-Centered Medical Home (5) has also driven interest in electronic patient-provider messaging. Electronic messaging has potential to bridge the communication gap between home and clinic, help patients to articulate their goals, assist with team-based care, and improve the timeliness and efficiency of care. How online care interacts with "traditional" outpatient care is still largely unknown. Several studies have found cross-sectional associations between secure messaging and higher diabetes care quality (6-9). A cross-sectional study at a large integrated delivery system found that patients who used the most messaging had higher levels of comorbidity and outpatient utilization (6), but there is also evidence from a longitudinal study that clinic visits decrease over time with increased participation in secure messaging (10). Given that secure messaging is a new care modality, most prior studies have been time-limited in scope.

The primary objective of this analysis was to determine the extent to which participation in secure messaging would be associated with subsequent changes in process and outcome measures related to diabetes care during a three-year period after implementation. By using longitudinal as opposed to cross-sectional data, we were able to separate exposure from time and provide some evidence for a causal inference between secure messaging and our outcomes of interest. Specifically, we tested the hypothesis that secure messaging is associated with better glycemic control and a higher rate of adherence to HbA1c testing recommendations following exposure to secure messaging. We looked at secure messaging in a population of adults with diabetes in a large integrated delivery system. To increase

comparability to quality evaluations in other practice settings, we used the 2012 HEDIS measures for Comprehensive Diabetes Care to assess glycemic control (11). Clinical practice recommendations from the American Diabetes Association were used to define testing adherence (12).

4.3 RESEARCH DESIGN AND METHODS

Setting

The study was conducted at Group Health, a mixed-model health care financing and delivery organization in Washington State and North Idaho. Approximately 460,000 members receive care through Group Health's Integrated Delivery System, which includes 25 Group Health–owned facilities and over 550 Group Health physicians (13). Beginning in August of 2003, all patients in the Integrated Delivery System were able to access patient Web services through the MyGroupHealth website. These services included prescription refills, appointment scheduling, medical record access, and secure messaging to contact health care team members as previously described (14). The MyGroupHealth patient website had two levels of security. At the initial level, a patient created a password-protected account which could be used to access health-related discussion groups. A second, higher level of security provided access to the medical record, secure messaging, and other advanced Web services. Access to this security level required each patient to complete an additional step verifying their identity ("ID verification"). Initially, this entailed presenting a legal form of identification in person or by mail. Currently, new users are required to visit a website to obtain an ID verification code that is mailed to their home address.

Inclusion Criteria

We included patients at least 18 years of age with a diagnosis of diabetes mellitus. For each study year, data were included from patients who had a primary care provider in Group Health's Integrated Group Practice for two out of three months of each quarter, and three out of four quarters. Because patients without a registered primary care provider do not have access to secure messaging, this requirement ensured that patients had access to

secure messaging for a majority of each year. Short discontinuities in enrollment were allowed because they could reflect changes in employment or plan type rather than an actual lapse in coverage. Diabetes diagnoses were determined by enrollment in the Group Health diabetes registry. Prescription, diagnostic, and laboratory data were used to determine registry eligibility. Analyses were restricted to patients who obtained ID verification to use the shared medical record, all of whom had access to secure messaging and some of whom elected to use it. We excluded HbA1c measurements taken within 6 months of a new diabetes diagnosis, during which time rapid changes in glycemic control would likely reflect the initiation of a treatment plan. Although secure messaging may indeed have a role in the optimization of initial treatment plans, our primary aim was to look at the role of secure messaging in the long-term maintenance of glycemic control rather than its role at the time of diagnosis. Measurements were censored if the patient developed end stage renal disease.

Data Source

All data were abstracted from clinical and administrative data warehouses maintained by Group Health Research Institute (Seattle, WA). Pharmacy data were used to identify enrollees using oral diabetes medications or insulin.

Primary Outcomes

We estimated the association between secure messaging use and three indicators of glycemic control (HbA1c < 7%, HbA1c < 8%, and HbA1c > 9%). Because HbA1c reflects the average blood glucose over the previous two to three months, outcomes were assessed quarterly. The person-quarter was the primary unit of analysis for all models. In quarters where a patient received multiple tests, the latest measurement was used. We also estimated the association between secure messaging use and adherence to HbA1c testing recommendations. A patient was classified as either adherent or nonadherent in every quarter depending on whether he or she had at least two HbA1c tests recorded during the prior year as recommended under clinical guidelines (12)

Measurement of Secure Messaging Exposure

Secure messaging use was modeled as a four-level, ordered categorical variable based on the total number of threads sent or received by the patient during the exposure period. A thread was defined as the set of messages related to an original message by successive replies. Prior analysis of patient-provider messaging patterns at Group Health has suggested that a message thread is most conceptually similar to a single episode of clinical care (15).

Separate models were constructed to relate short-term or long-term exposure to secure messaging. Short-term exposure was defined as messaging during the quarter immediately prior to the quarter in which the outcomes were assessed, and long-term exposure was defined as messaging during the year prior to outcome assessment.

Control Variables

Models were adjusted for age, gender, plan type, overall medical comorbidity, baseline HbA1c, diabetes severity, diabetes treatment type, diabetes duration, history of treated depression, and calendar time. Twelve Aggregated Diagnostic Groups (ADGs) were selected a priori to control for medical comorbidity (16, 17). The Diabetes Complication Severity Index, a 13-point scale, was used to measure diabetes severity (18). Depression was included because it has been associated with poor glycemic control (19, 20). A history of depression was defined by an antidepressant prescription associated with a visit diagnosis of a depressive disorder. To ensure a flexible specification and minimize residual confounding, age, diabetes severity, and diabetes duration were modeled as continuous variables using linear splines. For each spline, the function being smoothed was visually assessed and knots were placed in regions of rapid variation.

Adherence models were adjusted for the same set of variables as the models for glycemic control with the addition of a categorical variable modeling the HbA1c testing frequency of the patient's primary care provider. This variable was intended to control for provider-level variation in HbA1c testing frequency. To operationalize this construct, providers were divided into quartiles of testing frequency based on the mean HbA1c testing interval across

their panel of patients with diabetes. Preliminary models for all outcome measures permitted effect modification by prior level of glycemic control.

Statistical Analysis

Poisson regression models were used to estimate adjusted rate ratios for each binary outcome measure in each quarter over a three-year period from the time of secure messaging implementation (2004-2006) (21-24). These models yielded estimates of the rate of achieving each outcome measure by level of secure messaging use, relative to ID-verified patients without secure messaging during the exposure period. We chose not to use logistic regression because the outcomes were common (p 0.10-0.75), and odds ratios would therefore not approximate the underlying probability ratios. The Huber-White robust sandwich estimator was used for variance estimates (25). A generalized estimating equation framework was used to estimate population-averaged effects while accounting for correlation between multiple observations over time on the same individual (26). An exchangeable correlation structure was specified. Trend tests were used to assess the statistical significance of secure messaging in each model. Stata Version 11.1 and R Version 2.14.0 were used for statistical analyses (27, 28).

Missing Data Methods

For analyses of glycemic control, the outcome was considered to be missing in quarters where no HbA1c measurement was recorded. Based on this definition, the proportion of missing outcome data was 54%. This reflects an average HbA1c testing frequency of approximately twice per year. All other model covariates were complete or had a low amount of missingness. Given the high amount of outcome missingness and the high likelihood that these data were not missing completely at random, we felt that a complete case analysis would likely have yielded biased results. We therefore used two approaches to address missingness: inverse probability weights (29) and multiple imputation (30). Two approaches were chosen because similar results from both methods would support the validity of our inferences.

Inverse probability weights were calculated from a logistic regression model which predicted HbA1c testing in a particular 3-month period for a particular person (a "person-quarter") as a function of age, time since the last HbA1c test, the value of the last HbA1c test, diabetes treatment type, diabetes severity, diabetes duration, comorbidity, prior outpatient utilization rate, intensity of prior SMR use, and the primary care provider's HbA1c testing frequency. Comorbidity was modeled using three indicator variables: a history of cardiovascular complications and assignment to ADGs 11 or 18 (Chronic Unstable Medical or Specialty/Eye). Analyses using inverse probability weights were run in R, using the geeglm function from the geepack package.

Three variables contained missing values: Hemoglobin HbA1c (54% missing), treatment type (2.1% missing), and plan type (< 0.01% missing). Missing values were multiply imputed using the "chained equations" method. Each variable was imputed with a prediction model containing the following variables (excluding the variable being predicted): HbA1c (values of prior, current, and future tests), diabetes treatment type (prior and current), diabetes duration, intensity of prior SMR use, age, plan type, and inclusion in the Aggregated Diagnostic Group 11 (Chronic Unstable Medical). Five imputations were done. Imputations and analyses on imputed datasets were run in Stata, using user-written program ice for imputations and Stata's mi and xtgee commands for primary analysis models.

4.4 RESULTS

Population Characteristics

15,438 adults with diabetes were enrolled in the Integrated Group Practice during the study period. Of these, 6,638 (43%) were ID-verified. 296 (4%) of ID-verified patients were excluded due to a recent diabetes diagnosis. Forty-one patients (< 1%) had observations which were censored due to end stage renal disease. 6,301 patients met all eligibility criteria for inclusion. There was an average of eight quarterly observations per individual (range 1-12).

In unadjusted analyses, person-quarters with higher expected resource use were associated with greater SM use (Table 4.1). Person-quarters with higher outpatient utilization rates were also associated with greater SM use. Finally, person-quarters characterized by use of insulin, a greater number of diabetic complications, and better glycemic control were associated with greater SM use.

Relationship between Secure Messaging and Glycemic Control

The adjusted rate of good glycemic control was monotonically higher in relation to higher levels of secure messaging in the prior quarter or prior year (HbA1c < 7% and < 8%: $p < 0.05$). The adjusted rate of poor control was monotonically lower in relation to higher levels of secure messaging in the prior quarter (HbA1c > 9%: $p < 0.005$). A comparison of point estimates for all three outcomes suggested a larger effect when exposure to secure messaging was assessed during the prior quarter rather than the prior year (Table 4.2).

We had initially hypothesized that secure messaging might have a greater effect in individuals with poor control. Accordingly, preliminary models included an interaction between prior secure messaging exposure and prior glycemic control. Interaction terms were nonsignificant, however, and were therefore excluded from final regression models.

Final models were adjusted for age, gender, plan type, overall medical comorbidity, baseline HbA1c, diabetes severity, diabetes treatment type, diabetes duration, history of treated depression, and calendar time. Results from completely unadjusted models were similar to results from adjusted models, with the estimated relative risks differing by a mean absolute difference of 6%.

Relationship between Secure Messaging and HbA1c Testing

The adjusted rate of adherence to HbA1c testing twice yearly was monotonically higher in relation to higher levels of secure messaging ($p < 0.005$). Adjusted relative rates were similar whether exposure to secure messaging was assessed during the prior quarter or the prior year.

Similar to models of glycemic control, preliminary models included an interaction between prior secure messaging exposure and prior glycemic control. Interaction terms were nonsignificant and excluded from final regression models.

Final models included the same set of control variables as the models for glycemic control with the addition of the HbA1c testing frequency of the patient's primary care provider. Results from completely unadjusted models were similar to results from adjusted models, with the estimated relative risks differing by a mean absolute difference of 12%.

Treatment of Missing Data

Relative risks estimated from multiply imputed datasets and inverse probability-weighted models differed by a mean absolute difference of 3%. Statistical significance was concordant in 11 of 12 trend tests (Table 4.3).

4.5 CONCLUSIONS

In this analysis, patients with frequent use of secure messaging were more likely to achieve glycemic targets. The fact that more recent exposure was associated with a slightly larger effect would be compatible with a causal role of messaging. Overall, our results suggest that secure messaging may have a small, positive, effect on glycemic control, and that continued participation may be important for maximal benefit. Future work including content analyses of SM threads could explore this issue in greater depth.

Frequent participation in secure messaging was also associated with increased adherence to testing recommendations, and the effects were similar when secure messaging exposure was assessed over the prior quarter or prior year. Secure messaging may modify testing frequency by promoting patient engagement or continuity of care. Alternatively, reverse causality may explain part of the observed association with testing frequency. For this outcome, there was some temporal overlap between the secure messaging exposure period and the period over which adherence was assessed, because adherence was defined by HbA1c testing over the past 12-month period. Patients who had HbA1c tests may have used the SMR to view their lab results, and may have been more likely to engage in secure

messaging while they were logged in to the portal. Likewise, providers may have used secure messaging to comment on lab results, resulting in a positive association between messaging and testing frequency.

Strengths of our analysis include the large sample size, longitudinal design, heterogeneous population, and long duration of exposure to secure messaging. Our analysis has several limitations. Randomized assignment to secure messaging was not feasible, and observational analyses have a higher potential for bias. There could be several important unmeasured potential confounders, including race, ethnicity, income, and education. In particular, nonwhite patients have been found to be less likely to use secure messaging, and also more likely to have poor glycemic control (31, 32). Although we were able to use Medicaid enrollment as a proxy for low income, residual confounding due to income may be present. We sought to minimize, but may not have eliminated, the effects of self-selection by restricting our analysis to patients who signed up for secure access to the shared electronic medical record. Patients who sign up for the shared medical record, but do not use secure messaging, may be more similar to those who do use secure messaging in terms of unmeasured characteristics such as health-related self-efficacy and self-care behavior. In addition, use of secure messaging is highly correlated with use of other services available from the shared medical record. We did not control for this use, and it is possible that use of these services, rather than secure messaging itself, explained part of the observed association. In addition, we treated all secure message threads equally regardless of subject content or length.

Given that variables were collected at a quarterly frequency, we were unable to determine the temporal sequence of clinic visits and message threads within the same quarter. Clinic visits shortly after engagement in messaging could mediate changes in glycemic control or HbA1c testing. In contrast, visits shortly prior to secure messaging could represent a source of residual confounding. Patients with high levels of utilization may have systematically different outcomes than those with little or no utilization. Because we could not distinguish between mediation and confounding, we chose not to control for outpatient utilization.

We faced a significant missing data problem due to the fact that HbA1c was measured at irregular intervals and with a highly variable frequency across the diabetes population. A complex mix of patient and provider factors, including the underlying value of the measure itself, influences the measurement periodicity of HbA1c. We addressed this problem with two strategies: inverse probability weights and multiple imputation. The high concordance of results from these two approaches is reassuring.

Our findings are consistent with previous observational studies which have found an association between secure messaging and higher quality diabetes care (6, 7, 9). Secure messaging has also been associated with better performance on process measures including HbA1c, nephropathy, and retinopathy screening (7). Randomized controlled trials that have used secure messaging as part of diabetes case management have had mostly positive results (33-36). Our study adds to a growing body of evidence that secure messaging may have a small, beneficial effect on process and outcome measures related to diabetes care. These findings may not generalize to settings with different payment models and plan types. Care providers in this study were salaried, and received a small financial incentive for secure messages that were sent during the study period. Secure messaging was free to patients and widely advertised.

Our results cannot exclude the possibility that patients who participate in secure messaging achieve better outcomes simply because they are more engaged in their own self-care to begin with. Further research is needed to disentangle these mechanisms, and to determine how secure messaging interacts with the delivery of traditional outpatient services. As clinical information systems continue to evolve, it is likely that an increasing array of Web-based health care services will be available to patients in the coming years. Future studies should also carefully assess patient preferences for these new care modalities and rates of access, particularly in underserved populations. Previous work suggests that several higher-risk subgroups, including nonwhite, older, and low-income patients have a significantly lower propensity to use Web-based patient resources (31, 36, 37). As online health care grows, it is important to remain cognizant of these differences in use so that existing disparities in diabetes outcomes do not widen.

4.6 WORKS CITED

1 Beckjord EB, Finney Rutten LJ, Squiers L, Arora NK, Volckmann L, Moser RP, Hesse BW. Use of the internet to communicate with health care providers in the United States: estimates from the 2003 and 2005 Health Information National Trends Surveys (HINTS). J Med Internet Res 2007;9(3):e20

2 Sciamanna CN, Rogers ML, Shenassa ED, Houston TK. Patient access to U.S. physicians who conduct internet or e-mail consults. J Gen Intern Med 2007;22(3):378-81

3 Wagner EH, Austin BT, Korff M. Organizing care for patients with chronic illness. Milbank Q 1996;74(4):511–544

4 Wagner EH, Austin BT, Davis C, Hindmarsh M, Schaefer J, Bonomi A. Improving chronic illness care: translating evidence into action. Health Aff 2001;20(6):64–78

5 American Academy of Family Physicians, American Academy of Pediatrics, American College of Physicians, and American Osteopathic Association. Joint Principles of the Patient-Centered Medical Home. March 2007. Available from http://www.acponline.org/advocacy/where_we_stand/medical_home/approve_jp.pdf

6 Harris LT, Haneuse SJ, Martin DP, Ralston JD. Diabetes quality of care and outpatient utilization associated with electronic patient-provider messaging: a cross-sectional analysis. Diabetes Care 2009;32(7):1182-7

7 Zhou YY, Kanter MH, Wang JJ, Garrido T. Improved quality at Kaiser Permanente through e-mail between physicians and patients. Health Aff (Millwood) 2010;29(7):1370-5

8 Baer D. Patient-physician e-mail communication: the Kaiser Permanente experience. J Oncol Pract 2011;7(4):230-3

9 Bredfeldt CE, Compton-Phillips AL, Snyder MH. Effects of between visit physician-patient communication on Diabetes Recognition Program scores. Int J Qual Health Care 2011;23(6):664-73

10 Bergmo TS, Kummervold PE, Gammon D, Dahl LB: Electronic patient-provider communication: will it offset office visits and telephone consultations in primary care? Int J Med Inform 2005;74(9):705-10

11 The National Committee for Quality Assurance. HEDIS 2012. Available online from http://www.ncqa.org/tabid/78/Default.aspx#Vol_1

12 Sacks DB, Arnold M, Bakris GL, Bruns DE, Horvath AR, Kirkman MS, Lernmark A, Metzger BE, Nathan DM; National Academy of Clinical Biochemistry. Position statement executive summary: guidelines and recommendations for laboratory analysis in the diagnosis and management of diabetes mellitus. Diabetes Care 2011;34(6):1419-23

13 Group Health Physicians. Quick Facts. Available from http://www.grouphealthphysicians.org/about/faqs.html

14 Ralston JD, Carrell D, Reid R, Anderson M, Moran M, Hereford J: Patient web services integrated with a shared medical record: patient use and satisfaction. J Am Med Inform Assoc 2007;14(6):798-806

15 Carrell D, Ralston J: Messages, strands and threads: measuring use of electronic patientprovider messaging. 2005;AMIA Annu Symp Proc 913

16 Clinical Groups (ACG) Assignment Software (Version 7.0 for Windows) [computer program]. Baltimore: Johns Hopkins University, 1990-2006

17 Weiner JP, Starfield BH, Steinwachs DM, Mumford LM. Development and application of a population-oriented measure of ambulatory care case-mix. Med Care 1991;29(5):452-472

18 Young BA, Lin E, Von Korff M, Simon G, Ciechanowski P, Ludman EJ, Everson-Stewart S, Kinder L, Oliver M, Boyko EJ, Katon WJ. Diabetes complications severity index and risk of mortality, hospitalization, and healthcare utilization. Am J Manag Care 2008;14(1):15-23

19 Dirmaier J, Watzke B, Koch U, Schulz H, Lehnert H, Pieper L, Wittchen HU. Diabetes in primary care: prospective associations between depression, nonadherence and glycemic control.Psychother Psychosom 2010;79(3):172-8

20 Papelbaum M, Moreira RO, Coutinho W, Kupfer R, Zagury L, Freitas S, Appolinário JC. Depression, glycemic control and type 2 diabetes. Diabetol Metab Syndr 2011;7;3(1):26

21 Barros AJ, Hirakata VN. Alternatives for logistic regression in cross-sectional studies: an empirical comparison of models that directly estimate the prevalence ratio. BMC Med Res Methodol 2003 Oct;3:21

22 Petersen MR, Deddens JA. A comparison of two methods for estimating prevalence ratios. BMC Med Res Methodol 2008;8:9

23 Zou G. A modified poisson regression approach to prospective studies with binary data. Am J Epidemiol 2004;159(7):702-6

24 Yelland LN, Salter AB, Ryan P. Performance of the modified Poisson regression approach for estimating relative risks from clustered prospective data. Am J Epidemiol 2011;174(8):984-92

25 White HA: Heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. Econometrica 1980;48:817-830

26 Liang KY, Zeger SL: Longitudinal data analysis using generalized linear models. Biometrika 1989; 73:13-22

27 StataCorp. 2009. *Stata Statistical Software: Release 11*. College Station, TX: StataCorp LP

28 R Development Core Team. 2011. *R: A Language and Environment for Statistical Computing: Release 2.14.0.* Vienna, Austria: R Foundation for Statistical Computing

29 Robins JM, Hernán MA, Brumback B. Marginal structural models and causal inference in epidemiology. Epidemiology 2000;11(5):550-60

30 Rubin DB. *Multiple Imputation for Nonresponse in Surveys*. J. Wiley & Sons, New York. 1987

31 Lyles CR, Harris LT, Jordan L, Grothaus L, Wehnes L, Reid RJ, Ralston JD. Patient race/ethnicity and shared medical record use among diabetes patients. Med Care 2012;50(5):434-40

32 Harris MI. Racial and ethnic differences in health care access and health outcomes for adults with type 2 diabetes. Diabetes Care 2001;24(3):454-9

33 Goldberg HI, Ralston JD, Hirsch IB, Hoath JI, Ahmed KI. Using an Internet comanagement module to improve the quality of chronic disease care. Jt Comm J Qual Saf 2003;29(9):443-51

34 Ralston JD, Hirsch IB, Hoath J, Mullen M, Cheadle A, Goldberg HI. Web-based collaborative care for type 2 diabetes: a pilot randomized trial. Diabetes Care 2009;32(2):234-9

35 McCarrier KP, Ralston JD, Hirsch IB, Lewis G, Martin DP, Zimmerman FJ, Goldberg HI. Web-based collaborative care for type 1 diabetes: a pilot randomized trial. Diabetes Technol Ther 2009;11(4):211-7

35 Lorig K, Ritter PL, Laurent DD, Plant K, Green M, Jernigan VB, Case S. Online diabetes self-management program: a randomized study. Diabetes Care 2010;33(6):1275-81

36 Weppner WG, Ralston JD, Koepsell TD, Grothaus LC, Reid RJ, Jordan L, Larson EB. Use of a shared medical record with secure messaging by older patients with diabetes. Diabetes Care 2010;33(11):2314-9

36 Ralston JD, Rutter CM, Carrell D, Hecht J, Rubanowice D, Simon GE. Patient use of secure electronic messaging within a shared medical record: a cross-sectional study. J Gen Intern Med 2009;24(3):349-55

Table 4.1 Demographic and health characteristics
(n = 50,354 person-quarters).

	Percent[1]	SM Use[1]	SM Intensity[2]
Male	55	31	2.5
Female	45	33	2.5
Age			
< 35 (%)	1.0	32	2.1
35-49	11	34	2.6
50 – 64	51	35	2.5
65 – 74	20	29	2.6
75 +	16	25	2.6
Plan Type			
Commercial	77	34	2.5
Medicare	22	25	2.6
Medicaid or Basic Health Plan	0.9	31	2.3
Expected Resource Use			
None or Low	6	17	1.7
Moderate	49	29	2.1
High	26	37	2.7
Very High	19	37	3.3
Primary Care Visits			
None	69	30	2.5
One to Two	29	33	2.3
At Least Three	11	39	3.0
Specialty Care Visits			
None	71	30	2.4
One to Two	22	33	2.5
At Least Three	7	40	3.4
Emergency Visits			
None	97	32	2.5
One to Two	2	36	3.1
At Least Three	0.4	36	2.9
No History of Treated Depression	93	31	2.5
History of Treated Depression	7	39	3.2
Diabetes Treatment Intensity			
Diet Alone	27	29	2.5
Oral Hypoglycemics and Diet Alone	42	30	2.3
Insulin	31	37	2.7
Diabetic Complications			
None	31	28	2.1
One	24	33	2.4
Two to Three	25	34	2.7
At Least Four	20	34	3.1
HbA1c			
< 7	39	35	2.7
7 – 8	31	32	2.5
8 – 9	16	32	2.6
> 9	14	30	2.5

[1]Percent of person-quarters.
[2]Mean number of threads sent or received per person-quarter.

Table 4.2 Glycemic control in relation to secure messaging use.
Inverse probability weighted observations. Crude and adjusted rate ratios.

			Model A: Unadjusted n = 21,527 person-quarters			Model B: Adjusted[1] n = 21,507 person-quarters		
Outcome	SM Exposure[2]	Exposure Period	RR[3]	95% CI	P[4]	RR[3]	95% CI	P[4]
HbA1c < 7	1	Quarter	1.06	1.02-1.09	< 0.005	1.05	1.02-1.09	< 0.005
	2-3		1.08	1.04-1.12		1.09	1.04-1.13	
	4-7		1.15	1.09-1.21		1.11	1.06-1.17	
	8+		1.24	1.13-1.35		1.26	1.16-1.38	
	1	Year	1.01	0.97-1.06	< 0.005	0.99	0.95-1.03	< 0.005
	2-4		1.11	10.7-1.15		1.06	1.02-1.10	
	5-11		1.19	1.34-1.25		1.08	1.04-1.13	
	12+		1.34	1.26-1.42		1.14	1.08-1.20	
HbA1c < 8	1	Quarter	1.02	1.00-1.04	< 0.005	1.02	1.00-1.03	< 0.005
	2-3		1.02	1.00-1.05		1.04	1.01-1.06	
	4-7		1.07	1.04-1.10		1.06	1.03-1.09	
	8+		1.08	1.02-1.14		1.07	1.03-1.09	
	1	Year	1.02	1.00-1.04	< 0.005	1.00	0.98-1.02	0.009
	2-4		1.04	1.02-1.07		1.02	1.00-1.04	
	5-11		1.07	1.04-1.09		1.03	1.00-1.05	
	12+		1.14	1.10-1.18		1.04	1.01-1.07	
HbA1c > 9	1	Quarter	0.92	0.85-1.01	< 0.005	0.93	0.85-1.01	< 0.005
	2-3		0.85	0.76-0.95		0.84	0.76-0.94	
	4-7		0.68	0.57-0.82		0.72	0.60-0.85	
	8+		0.70	0.48-1.01		0.78	0.60-1.00	
	1	Year	0.93	0.84-1.03	0.205	1.01	0.92-1.11	0.205
	2-4		0.89	0.81-0.98		0.97	0.89-1.05	
	5-11		0.78	0.68-0.89		0.92	0.83-1,02	
	12+		0.61	0.47-0.79		0.84	0.72-1.00	

[1]Models were adjusted for age, gender, plan type, prior HbA1c, diabetes treatment, duration, and severity, overall comorbidity, history of treated depression, and time.
[2]Total number of secure messaging threads sent or received by the patient.
[3]Rate of patients meeting each HbA1c indicator, relative to a reference group of ID-verified patients without any secure messaging during the exposure period.
[4]Test for trend.

Table 4.3 Glycemic control in relation to secure messaging use.
Multiply imputed data. Crude and adjusted rate ratios.

			Model A: Unadjusted n = 50,354 person-quarters			Model B: Adjusted[1] n = 49,410 person-quarters		
Outcome	SM Exposure[2]	Exposure Period	RR[3]	95% CI	P[4]	RR[3]	95% CI	P[4]
HbA1c < 7	1	Quarter	1.04	1.00-1.08	< 0.005	1.03	0.99-1.07	< 0.005
	2-3		1.04	1.01-1.08		1.05	1.01-1.08	
	4-7		1.12	1.04-1.19		1.11	1.05-1.18	
	8+		1.12	1.08-1.27		1.16	1.08-1.26	
	1	Year	1.02	0.99-1.05	< 0.005	1.00	0.97-1.03	< 0.005
	2-4		1.08	1.04-1.11		1.04	1.00-1.07	
	5-11		1.14	1.09-1.19		1.06	1.03-1.10	
	12+		1.27	1.20-1.35		1.13	1.08-1.19	
HbA1c < 8	1	Quarter	1.02	1.00-1.04	< 0.005	1.01	1.00-1.03	< 0.005
	2-3		1.03	1.00-1.05		1.03	1.00-1.05	
	4-7		1.07	1.03-1.11		1.07	1.03-1.10	
	8+		1.08	1.03-1.13		1.07	1.02-1.11	
	1	Year	1.02	1.00-1.04	< 0.005	1.01	0.99-1.02	< 0.005
	2-4		1.04	1.02-1.06		1.02	1.00-1.04	
	5-11		1.08	1.05-1.11		1.04	1.02-1.06	
	12+		1.14	1.09-1.18		1.06	1.02-1.09	
HbA1c > 9	1	Quarter	0.93	0.85-1.00	< 0.005	0.93	0.85-1.01	< 0.005
	2-3		0.88	0.81-0.96		0.87	0.80-0.95	
	4-7		0.79	0.69-0.90		0.79	0.70-0.90	
	8+		0.74	0.58-0.94		0.75	0.61-0.95	
	1	Year	0.91	0.85-0.98	< 0.005	0.96	0.89-1.02	0.006
	2-4		0.86	0.80-0.94		0.92	0.86-0.99	
	5-11		0.76	0.68-0.85		0.87	0.80-0.94	
	12+		0.65	0.52-0.82		0.80	0.68-0.94	

[1]Models were adjusted for age, gender, plan type, prior HbA1c, diabetes treatment, duration, and severity, overall comorbidity, history of treated depression, and time.
[2]Total number of secure messaging threads sent or received by the patient.
[3]Rate of patients meeting each HbA1c indicator, relative to a reference group of ID-verified patients without any secure messaging during the exposure period.
[4]Test for trend.

Table 4.4 HbA1c testing adherence in relation to secure messaging use.
Crude and adjusted rate ratios (n=45,431 person-quarters).

		Model A: Unadjusted n = 50,354 person-quarters			Model B: Adjusted[1] n = 45,431 person-quarters		
SM Exposure[2]	Exposure Period	RR[3]	95% CI	P[4]	RR[3]	95% CI	P[4]
1	Quarter	1.12	1.10-1.14	< 0.005	1.08	1.07-1.10	< 0.005
2-3		1.16	1.14-1.18		1.11	1.09-1.13	
4-7		1.21	1.18-1.24		1.14	1.11-1.17	
8+		1.19	1.13-1.25		1.12	1.07-1.17	
1	Year	1.05	1.02-1.08	< 0.005	1.02	0.99-1.04	< 0.005
2-4		1.13	1.11-1.16		1.08	1.05-1.10	
5-11		1.21	1.17-1.24		1.13	1.10-1.16	
12+		1.23	1.18-1.28		1.14	1.10-1.20	

[1]Models were adjusted for age, gender, plan type, prior HbA1c, diabetes treatment, duration, and severity, overall comorbidity, history of treated depression, primary care provider's HbA1c testing frequency, and time.
[2]Total number of secure messaging threads sent or received by the patient.
[3]Rate of patients with two HbA1c tests in the last 12 months, relative to a reference group of ID-verified patients without any secure messaging during the exposure period.
[4]Test for trend.

5 Conclusions

5.1 INTRODUCTION

In this dissertation, I have examined processes and outcomes of diabetes care in a large delivery system where electronic patient-provider messaging was available at no charge to all adult enrollees. The opportunity to communicate electronically with health care providers is uncommon today. Despite strong consumer demand (1-5), the vast majority of patients in the U.S. and Europe can only contact their providers during scheduled office visits or occasional phone consults (6-8). Both patients and providers who have used electronic patient-provider communication typically report high levels of satisfaction (2, 9, 10). Yet wide adoption has been stymied by a complex mix of factors ranging from deficient reimbursement and provider resistance to an inadequate technical infrastructure and general clinical inertia (1, 11, 12). Promotion of electronic patient-provider communication is currently being discussed at the federal policy level, and health care organizations may soon be eligible to receive financial incentives for demonstrating "meaningful use" of secure messaging in their practices.

5.2 SECURE MESSAGING: THE PATIENT EXPERIENCE

This work provides some insight into the extent to which chronically ill patients tend to use online communication services when they are available. In the studies presented in Chapter 2, 19% of adults with diabetes used secure messaging at least once during the five-quarter period of observation. A study of all adult enrollees at the same health care system found that 14% had participated in messaging during the same time period (13). In the study presented in Chapter 4, 26% of adults with diabetes had used secure messaging at least once over a three-year period of observation. These results suggest that chronically ill patients are more likely to use secure messaging, and that uptake continues to increase during the first several years after implementation.

This research also highlights characteristics of patients that are most likely to use secure messaging. In Chapter 2, we found that diabetes patients who participated in secure messaging tended to be younger on average. In Chapter 3, we explored age-related differences in further detail, finding that diabetes patients over age 65 were approximately half as likely to use secure messaging to communicate with their care providers. This difference persisted after restricting our sample to Internet users and adjusting for sociodemographic and health characteristics. Previous studies have found similar age-related differences in use of electronic health records (13, 14). This finding is important given that older adults account for the majority of chronically ill patients and consume the vast majority of health care resources.

In Chapter 2, we found that patients who were the most active participants in secure messaging had higher expected resource use, a higher number of diabetes complications, and a higher incidence of depression. They attended a greater number of primary care, specialty care, and emergency visits. In adjusted models, those with the highest levels of messaging were estimated to have a 40% higher outpatient utilization rate. This rate was predicted for patients with at least 12 secure message threads per year, which described 1.4% of our baseline population and 7.5% of the patients who used secure messaging. In the same study, the less active 65% of messaging participants exchanged 1-3 threads per year. These patients were predicted to attend approximately 5% more in-person visits when compared to patients who had obtained access to the electronic medical record but did not participate in messaging. In this study, most secure messaging users had a greater total number of clinical contacts when electronic, telephone, and in-person visits were combined. Because our study was cross-sectional, however, we could not any draw causal inferences between messaging and utilization patterns. We also studied secure messaging shortly after its implementation, and it is likely that utilization patterns had not yet stabilized. Future work using qualitative methods may help to provide more insight into the patient experience of using secure messaging, and particularly how its use affects their disease management, their relationship with care providers, and their overall care experience.

5.3 THE ROLE OF HEALTH CARE PROVIDERS IN ADOPTION

Results presented in Chapters 2 and 3 highlight provider-level factors that relate to secure messaging. We observed significant variation in the extent to which individual providers used messaging with their patients. For approximately one-quarter of the 186 PCPs studied in Chapter 2, secure messaging threads accounted for at least one in five patient encounters. This group of "high-messaging" PCPs was different in several measurable ways. High-messaging providers were twice as likely to be female and three times less likely to have a large patient panel. Female providers in our sample were more likely to have smaller panels, however, and in the absence of further analysis we cannot exclude the possibility that one association is an artifact of the other, rather than a causal factor. We also found that high-messaging providers were approximately four times more likely to initiate at least 15% of all threads, and tended to respond to incoming messages more quickly. We did not explore whether these differences were related to factors at the patient, provider, or clinic level. Future studies should explore these differences in depth.

These studies also highlight the role that providers play in encouraging their patients to use electronic messaging. Previous studies have found that some patients have concerns about bothering physicians with extra questions or appointment requests (15). These attitudes may be impediments to use of secure messaging among some patients, and suggest a role for providers in improving patient willingness to engage. In Chapter 3, we found lower rates of shared medical record (SMR) use in all age groups when provider encouragement to use the SMR was absent or infrequent. Patients over 75 who did not use the SMR were three times less likely to report frequent provider encouragement to use the electronic record compared with SMR users of the same age. This is concordant with previous work associating provider enthusiasm for email with rates of use among patients over age 65 (6). Surprisingly, however, we found patients under 65 were equally likely to report frequent provider encouragement regardless of their SMR use. It is also notable that 40% of patients over age 75 reported no provider encouragement to use the SMR, whereas only 20% of patients under age 50 reported this experience. This suggests that older individuals may be more sensitive to the effects of frequent provider encouragement and

less likely to receive it. This may reflect an underlying bias on the part of providers about the likelihood of older patients to find value in electronic health care. Responses to open-ended survey questions also suggested that older patients were less likely to feel that these services would benefit them, expressed a stronger preference for in-person care, and were more likely to experience technical or physical limitations related to computer use. It is important to keep these differences in mind so that the migration of health care services online does not threaten to widen existing age-related disparities in care.

5.4 SECURE MESSAGING AND CARE QUALITY

Of particular relevance to payers and policymakers, I found in Chapter 2 that typical users of secure messaging had similar outcomes related to hypertension, lipids, and glycemic control. For these users, electronic message threads accounted for 1 in 5 clinical encounters. In adjusted models, more frequent secure messaging use was associated with improved glycemic control. Specifically, the most active 7.5% of secure messaging users was approximately 35% more likely to have a HbA1c < 7%. These patients had more clinical contacts overall; they attended more visits and had an average of one message thread for every visit. Given the cross-sectional design of this study, we could not determine if these results simply highlighted preexisting differences or were causally related to participation in secure messaging.

In Chapter 4, the topic of diabetes care quality was revisited with the advantage of a longitudinal dataset. This approach had the advantage of minimizing self-selection bias and providing some evidence for a causal relationship between messaging and our outcomes of interest. In this study, recent, frequent, use of secure messaging was associated with better adherence to testing recommendations, a higher incidence of good control (HbA1c < 7%), and a lower incidence of poor control (HbA1c > 9%). These results suggest that secure messaging may have a small, beneficial effect on process and outcome measures related to diabetes care. Two recent studies at Kaiser Permanente have also found a small beneficial effect of secure messaging on diabetes care quality (16, 17). Randomized controlled trials that have examined quality and secure messaging have also found improvements in

glycemic control (18-20). Taken together, these preliminary results are encouraging and provide a strong justification for future research.

5.5 OFFICE VISITS IN THE ERA OF E-HEALTH

Broad availability of electronic health care services will likely have a profound impact on the overall health care experience of patients and providers alike. Integration of electronic communication into care management may change the nature of in-person and telephone contacts by increasing care continuity and strengthening patient-provider relationships. Recent data from Group Health suggest that 6 years after implementation, electronic visits now account for approximately 30 percent of all primary care encounters in the overall adult patient population (13). In addition to the potential effects on care quality and health outcomes, provider efficiency and patterns of traditional utilization may be impacted as a result of this shift. These issues are of particular relevance to payers who are evaluating the cost impact of electronic visits and how to reimburse for such services.

Several longitudinal studies have provided preliminary evidence about the impact of secure messaging on office visits. In a modeling study commissioned by the Future of Family Medicine Project, it was predicted that E-visits would substitute directly for office visits, with no net impact on the volume of encounters (21). In a small clinical study conducted over a decade ago, physicians from two primary care clinics were randomized to either use of a secure email system or usual care. Changes in outpatient utilization were not directly measured, but the authors used visit no-show rates, telephone contacts, and survey data to support the conclusion that patient-provider email was unlikely to offset the need for other clinic resources and would likely increase the volume of total clinical contacts (22). In a small randomized controlled trial of patients seen at a primary care clinic in Norway, office visits decreased by approximately 25% one year after implementation of a secure messaging system (23). More recently, a large retrospective study of HMO outpatients found that secure messaging was associated with a 7 to 10% decrease in annual primary care visits (24). None of these studies focused on chronically ill

populations, who arguably have the highest need for patient-provider communication between visits. Future studies should address this gap.

5.6 REIMBURSEMENT: CHALLENGES AND OPPORTUNITIES

Without a significant shift in reimbursement policies, wider diffusion of electronic messaging is unlikely to occur. CPT code 99444 for online patient services was introduced in 2008. However, Medicare and most other payers do not currently pay for this code. Aetna and Cigna are two exceptions in the private insurance industry, both of which began reimbursing for electronic encounters in 2006 (25). Secure messaging through secure Web portals is also available at several integrated delivery systems and the Veterans Health Administration (26-28). Payers may be justifiably hesitant to pay for secure messaging without clearer evidence of effectiveness and cost impact. Few studies have examined these issues in detail. In one pilot study, reimbursing e-Visits at a rate of $25 per encounter resulted in savings of $3.69 per patient per month (29). Further research on the cost impact is clearly a prerequisite to a broad shift in reimbursement.

Delivery system redesign is another factor that could catalyze a change in reimbursement practices and support greater use of secure messaging. For example, due to its potential to facilitate care coordination and decision support, secure messaging may be considered a component of medical homes (30). Performance incentives for medical home implementation related to care coordination might therefore include measures of secure messaging use. The Chronic Care Model also places a strong priority on transforming delivery processes to increase patient-centeredness (31, 32), support self-management, and promote team-based chronic disease care. Secure messaging may play a role in achieving all of these objectives.

Recent federal legislation and technology incentive programs may also play a role in promoting delivery system redesign and shifting reimbursement policies. Although the Patient Protection and Affordable Care Act ("The Affordable Care Act") of 2010 does not directly address electronic patient-provider communication, many of the Act's provisions concern the use of health information technology (HIT) for quality reporting, quality

improvement, or administrative simplification (33, 34). For example, beginning in 2014, Medicare Advantage Plans will be eligible for performance bonuses related to HIT that is used for clinical decision support or the promotion of patient-centered care. Patient-provider electronic messaging is likely to be a component of these performance measures.

In addition, The Center for Medicare and Medicaid Innovation (CMI), established by The Affordable Care Act, may promote changes in care delivery that would enable wider implementation of electronic patient-provider communication. The CMI has been charged with the primary mission to test and evaluate new payment and delivery models (35, 36). Some of these models may make extensive use of HIT that is used for care coordination and remote monitoring of chronically ill patients (37). Based on the results of these evaluations, the HHS could recommend the expansion of successful models to any of the programs of the CMS (CMS website). These programs collectively cover approximately one quarter of the U.S. population and account for over half of all health care spending (38, 39).

Finally, the 2009 Recovery Act (a.k.a. "the Stimulus") included a provision to establish an EHR incentive program at the CMS. This program has authorized $39 billion to reward the effective implementation of HIT from 2009-2019 (40). Health care organizations are eligible for incentive payments if they can fulfill a set of objectives which demonstrates "meaningful use" of HIT. Although online messaging is not part of the current set of meaningful use criteria, it is has been proposed for inclusion in the criteria to be released in 2013. To fulfill the objective related to secure messaging, an organization will need to attest that patients have been offered the opportunity to use messaging and that at least 25 patients have sent messages to their care providers (41). This program may provide some impetus to organizations that have been previously hesitant to invest in modern HIT infrastructure.

5.7 CONCLUSIONS AND FUTURE DIRECTIONS

This research adds to the growing body of research on electronic patient-provider communication. Our work has several important implications for providers and payers. First, we found that approximately a quarter of all adults with diabetes used secure

messaging when available over a three-year period. Concordant with prior research, older adults were less likely to use electronic messaging. Active users tended to have more complex medical histories; they had a higher expected resource use, a higher number of diabetes complications, and a higher incidence of treated depression. We found that the majority of patients who used secure messaging had relatively modest levels of use (1-3 threads per year), slightly more frequent clinic visits, and a greater number of total clinical contacts. We did not, however, study changes in outpatient utilization over time in the context of secure messaging. This is an important area for further study. Research on the impact of electronic patient-provider communication on diabetes-related care quality is limited but growing. In Chapters 4, analysis of a longitudinal dataset suggested that secure messaging may have a small, positive, effect on process and outcome measures related to diabetes care. These findings suggest that electronic messaging may play a role in meeting unmet needs and improving care quality. We hope that these results suggest areas for further research, and provide useful information to providers and payers who may be considering broader implementation of electronic patient-provider communication.

5.8 WORKS CITED

1 Moyer CA, Stern DT, Dobias KS, Cox DT, Katz SJ. Bridging the electronic divide: patient and provider perspectives on e-mail communication in primary care. Am J Manag Care 2002;8(5):427-33

2 Harris Interactive: Patient/physician online communication: many patients want it, would pay for it, and it would influence their choice of doctors and health plans. Health Care News 2002;2(8):1-4

3 Adler KG. Web portals in primary care: an evaluation of patient readiness and willingness to pay for online services. J Med Internet Res 2006;26;8(4):e26

4 Baer D. Patient-physician e-mail communication: the Kaiser Permanente experience. J Oncol Pract 2011;7(4):230-3

5 Virji A, Yarnall KS, Krause KM, Pollak KI, Scannell MA, Gradison M, Østbye T. Use of email in a family practice setting: opportunities and challenges in patient- and physician-initiated communication. BMC Med 2006;15;4:18

6 Singh H, Fox SA, Petersen NJ, Shethia A, Street RL Jr. Older patients' enthusiasm to use electronic mail to communicate with their physicians: cross-sectional survey. J Med Internet Res 2009;11(2):e18

7 Santana S, Lausen B, Bujnowska-Fedak M, Chronaki C, Kummervold PE, Rasmussen J, Sorensen T. Online communication between doctors and patients in Europe: status and perspectives. J Med Internet Res 2010;12(2):e20

8 Menachemi N, Prickett CT, Brooks RG. The use of physician-patient email: a follow-up examination of adoption and best-practice adherence 2005-2008. J Med Internet Res 2011;13(1):e23

9 Houston TK, Sands DZ, Jenckes MW, Ford DE. Experiences of patients who were early adopters of electronic communication with their physician: satisfaction, benefits, and concerns. Am J Manag Care 2004;10(9):601-8

10 Liederman EM, Lee JC, Baquero VH, Seites PG. Patient-physician web messaging. The impact on message volume and satisfaction. J Gen Intern Med 2005;20(1):52-7

11 Gaster B, Knight CL, DeWitt DE, Sheffield JV, Assefi NP, Buchwald D. Physicians' use of and attitudes toward electronic mail for patient communication. J Gen Intern Med 2003;18(5):385-9

12 Tufano JT, Ralston JD, Martin DP. Providers' experience with an organizational redesign initiative to promote patient-centered access: a qualitative study. J Gen Intern Med 2008;23(11):1778-83

13 Ralston JD, Rutter CM, Carrell D, Hecht J, Rubanowice D, Simon GE. Patient use of secure electronic messaging within a shared medical record: a cross-sectional study. J Gen Intern Med 2009;24(3):349-55

14 Weppner WG, Ralston JD, Koepsell TD, Grothaus LC, Reid RJ, Jordan L, Larson EB. Use of a shared medical record with secure messaging by older patients with diabetes. Diabetes Care 2010;33(11):2314-9

15 Bayliss EA, Edwards AE, Steiner JF, Main DS. Processes of care desired by elderly patients with multimorbidities. Fam Pract 2008;25(4):287-93

16 Zhou YY, Kanter MH, Wang JJ, Garrido T. Improved quality at Kaiser Permanente through e-mail between physicians and patients. Health Aff (Millwood) 2010;29(7):1370-5

17 Bredfeldt CE, Compton-Phillips AL, Snyder MH. Effects of between visit physician-patient communication on Diabetes Recognition Program scores. Int J Qual Health Care 2011;23(6):664-73

18 Goldberg HI, Ralston JD, Hirsch IB, Hoath JI, Ahmed KI. Using an Internet comanagement module to improve the quality of chronic disease care. Jt Comm J Qual Saf 2003;29(9):443-51

19 Ralston JD, Hirsch IB, Hoath J, Mullen M, Cheadle A, Goldberg HI. Web-based collaborative care for type 2 diabetes: a pilot randomized trial. Diabetes Care 2009;32(2):234-9

20 Lorig K, Ritter PL, Laurent DD, Plant K, Green M, Jernigan VB, Case S. Online diabetes self-management program: a randomized study. Diabetes Care 2010;33(6):1275-81

21 Spann SJ; Task Force 6 and the Executive Editorial Team. Report on financing the new model of family medicine. Ann Fam Med 2004;2 Suppl 3:S1-21

22 Katz SJ, Moyer CA, Cox DT, Stern DT. Effect of a triage-based E-mail system on clinic resource use and patient and physician satisfaction in primary care: a randomized controlled trial. J Gen Intern Med 2003;18(9):736-44

23 Bergmo TS, Kummervold PE, Gammon D, Dahl LB: Electronic patient-provider communication: will it offset office visits and telephone consultations in primary care? Int J Med Inform 2005;74(9):705-10

24 Zhou YY, Garrido T, Chin HL, Wiesenthal AM, Liang LL: Patient access to an electronic health record with secure messaging: impact on primary care utilization. Am J Manag Care 2007;13(7):418-24

25 iHealthBeat. Cigna HealthCare, Aetna To Offer Online Physician Visits. April 5, 2006. Available from http://www.ihealthbeat.org/Articles/2006/4/5/Cigna-HealthCare-Aetna-To-Offer-Online-Physician-Visits.aspx?topic=Chronic%20Disease%20Care

26 United States Department of Veterans Affairs. My HealtheVet. Available from https://www.myhealth.va.gov/index.html

27 Kaiser Permanente. My health manager. Available from https://healthy.kaiserpermanente.org/health/care/consumer/my-health-manager

28 Group Health. MyGroupHealth Tour. Available from https://member.ghc.org/public/cddemo/member/MyGHTour.jhtml

29 American College of Physicians Medical Service Committee. The changing face of ambulatory medicine – reimbursing physicians for computer-based care. Policy Paper. American College of Physicians Medical Service Committee, March 2003

30 American Academy of Family Physicians, American Academy of Pediatrics, American College of Physicians, and American Osteopathic Association. Joint Principles of the Patient-Centered Medical Home. March 2007. Available from http://www.acponline.org/advocacy/where_we_stand/medical_home/approve_jp.pdf

31 Wagner EH, Austin BT, Korff M. Organizing care for patients with chronic illness. Milbank Q 1996;74(4):511–544

32 Wagner EH, Austin BT, Davis C, Hindmarsh M, Schaefer J, Bonomi A. Improving chronic illness care: translating evidence into action. Health Aff 2001;20(6):64–78

33 Kocher R, Emanuel EJ, DeParle NA. The Affordable Care Act and the future of clinical medicine: the opportunities and challenges. Ann Intern Med 2010;153(8):536-9

34 Davis K, Abrams M, Stremikis K. How the Affordable Care Act will strengthen the nation's primary care foundation. J Gen Intern Med 2011;26(10):1201-3

35 Ferman JH. Healthcare reform: Medicare & Medicaid Innovation Center. CMS provision will test new payment and service delivery models. Healthc Exec 2010;25(4):58, 60

36 Baron RJ. New pathways for primary care: an update on primary care programs from the innovation center at CMS. Ann Fam Med 2012;10(2):152-5

37 Foley & Lardner LLP. PPACA Emphasizes Use of Health Information Technology. Legal News: Health Care. May 13, 2010. Available from http://www.foley.com/ppaca-emphasizes-use-of-health-information-technology-05-13-2010/

38 Centers for Medicare & Medicaid Services. Available from http://www.cms.gov/

39 Selden TM, Sing M. The distribution of public spending for health care in the United States, 2002. Health Aff (Millwood) 2008;27(5):w349-59

40 Cunningham R. Stimulus bill implementation: expanding meaningful use of health IT. NHPF Issue Brief 2009;(834):1-16

41 Tang P. Meaningful Use Workgroup Recommendations. June 8, 2011. Available from http://healthit.hhs.gov/portal/server.pt/community/healthit_hhs_gov__policy_past_meetings/1814

BIBLIOGRAPHY

1 Adler KG. Web portals in primary care: an evaluation of patient readiness and willingness to pay for online services. J Med Internet Res 2006;26;8(4):e26

2 Agency for Health Research and Quality. CAHPS Clinician & Group Visit Survey. Available from https://www.cahps.ahrq.gov/Surveys-Guidance/CG/Visit.aspx

3 Alvarez Guisasola F, Mavros P, Nocea G, Alemao E, Alexander CM, Yin D.Glycaemic control among patients with type 2 diabetes mellitus in seven European countries: findings from the Real-Life Effectiveness and Care Patterns of Diabetes Management (RECAP-DM) study. Diabetes Obes Metab 2008;10 Suppl 1:8-15

4 American Academy of Family Physicians, American Academy of Pediatrics, American College of Physicians, and American Osteopathic Association. Joint Principles of the Patient-Centered Medical Home. March 2007. Available from http://www.acponline.org/advocacy/where_we_stand/medical_home/approve_jp.pdf

5 American College of Physicians Medical Service Committee. The changing face of ambulatory medicine – reimbursing physicians for computer-based care. Policy Paper. American College of Physicians Medical Service Committee, March 2003

6 American Diabetes Association. Diabetes Statistics: Data from the 2011 National Diabetes Fact Sheet (released Jan. 26, 2011) Available from http://www.diabetes.org/diabetes-basics/diabetes-statistics/

7 American Diabetes Association. Economic costs of diabetes in the U.S. In 2007. Diabetes Care 2008;31(3):596-615. Erratum in: Diabetes Care. 2008;31(6):1271

8 American Diabetes Association: Standards of Medical Care for Patients with Diabetes Mellitus. Diabetes Care 2003;26:S33-50

9 Baer D. Patient-physician e-mail communication: the Kaiser Permanente experience. J Oncol Pract 2011;7(4):230-3

10 Baron RJ. New pathways for primary care: an update on primary care programs from the innovation center at CMS. Ann Fam Med 2012;10(2):152-5

11 Barros AJ, Hirakata VN. Alternatives for logistic regression in cross-sectional studies: an empirical comparison of models that directly estimate the prevalence ratio. BMC Med Res Methodol 2003 Oct;3:21

12 Bayliss EA, Edwards AE, Steiner JF, Main DS. Processes of care desired by elderly patients with multimorbidities. Fam Pract 2008;25(4):287-93

13 Beckjord EB, Finney Rutten LJ, Squiers L, Arora NK, Volckmann L, Moser RP, Hesse BW. Use of the internet to communicate with health care providers in the United States: estimates from the 2003 and 2005 Health Information National Trends Surveys (HINTS). J Med Internet Res 2007;9(3):e20

14 Bergmo TS, Kummervold PE, Gammon D, Dahl LB: Electronic patient-provider communication: will it offset office visits and telephone consultations in primary care? Int J Med Inform 2005;74(9):705-10

15 Boukus ER, Grossman JM, O'Malley AS. Physicians slow to e-mail routinely with patients. Issue Brief Cent Stud Health Syst Change 2010;(134):1-5

16 Boult C, Wieland GD. Comprehensive primary care for older patients with multiple chronic conditions: "Nobody rushes you through". JAMA 2010;304(17):1936-43

17 Bredfeldt CE, Compton-Phillips AL, Snyder MH. Effects of between visit physician-patient communication on Diabetes Recognition Program scores. Int J Qual Health Care 2011;23(6):664-73

18 Brooks RG, Menachemi N. Physicians' use of email with patients: factors influencing electronic communication and adherence to best practices. J Med Internet Res 2006;8(1):e2

19 Bruce DG, Davis WA, Davis TM. Glycemic control in older subjects with type 2 diabetes mellitus in the Fremantle Diabetes Study.J Am Geriatr Soc 2000;48(11):1449-53

20 Carrell D, Ralston J: Messages, strands and threads: measuring use of electronic patientprovider messaging. 2005;AMIA Annu Symp Proc 913

21 Center for eHealth Information Adoption and Exchange of the Patient-Centered Primary Care Collaborative. Transforming Patient Engagement: Health IT in the Patient Centered Medical Home. October 2010. Available from http://www.pcpcc.net/guide/health-it-pcmh

22 Centers for Medicare & Medicaid Services. Available from http://www.cms.gov/

23 Cheung BM, Ong KL, Cherny SS, Sham PC, Tso AW, Lam KS Diabetes prevalence and therapeutic target achievement in the United States, 1999 to 2006. Am J Med 2009;122(5):443-453

24 Clinical Groups (ACG) Assignment Software (Version 7.0 for Windows) [computer program]. Baltimore: Johns Hopkins University, 1990-2006

25 Cunningham R. Stimulus bill implementation: expanding meaningful use of health IT. NHPF Issue Brief 2009;(834):1-16

26 Davis K, Abrams M, Stremikis K. How the Affordable Care Act will strengthen the nation's primary care foundation. J Gen Intern Med 2011;26(10):1201-3

27 Dillman DA, Smyth JD, Christian LM. *Internet, Mail and Mixed-Mode Surveys: The Tailored Design Method, 3rd edition.* Hoboken, NJ, John Wiley & Sons, 2007

28 Dirmaier J, Watzke B, Koch U, Schulz H, Lehnert H, Pieper L, Wittchen HU. Diabetes in primary care: prospective associations between depression, nonadherence and glycemic control. Psychother Psychosom 2010;79(3):172-8

29 Drab SR. Recognizing the rising impact of diabetes in seniors and implications for its management. Consult Pharm 2009;24 Suppl B:5-10

30 Ferman JH. Healthcare reform: Medicare & Medicaid Innovation Center. CMS provision will test new payment and service delivery models. Healthc Exec 2010;25(4):58, 60

31 Foley & Lardner LLP. PPACA Emphasizes Use of Health Information Technology. Legal News: Health Care. May 13, 2010. Available from http://www.foley.com/ppaca-emphasizes-use-of-health-information-technology-05-13-2010/

32 Gaster B, Knight CL, DeWitt DE, Sheffield JV, Assefi NP, Buchwald D. Physicians' use of and attitudes toward electronic mail for patient communication. J Gen Intern Med 2003;18(5):385-9

33 Goldberg AP, Coon PJ. Non-insulin-dependent diabetes mellitus in the elderly. Influence of obesity and physical inactivity. Endocrinol Metab Clin North Am 1987;16(4):843-65

34 Goldberg HI, Ralston JD, Hirsch IB, Hoath JI, Ahmed KI. Using an Internet comanagement module to improve the quality of chronic disease care. Jt Comm J Qual Saf 2003;29(9):443-51

35 Group Health Physicians. Quick Facts. Available from http://www.grouphealthphysicians.org/about/faqs.html

36 Group Health. MyGroupHealth Tour. Available from https://member.ghc.org/public/cddemo/member/MyGHTour.jhtml

37 Harris Interactive: Patient/physician online communication: many patients want it, would pay for it, and it would influence their choice of doctors and health plans. Health Care News 2002;2(8):1-4

38 Harris LT, Haneuse SJ, Martin DP, Ralston JD. Diabetes quality of care and outpatient utilization associated with electronic patient-provider messaging: a cross-sectional analysis. Diabetes Care 2009;32(7):1182-7

39 Harris MI. Racial and ethnic differences in health care access and health outcomes for adults with type 2 diabetes. Diabetes Care 2001;24(3):454-9

40 Houston TK, Sands DZ, Jenckes MW, Ford DE. Experiences of patients who were early adopters of electronic communication with their physician: satisfaction, benefits, and concerns. Am J Manag Care 2004;10(9):601-8

41 iHealthBeat. Cigna HealthCare, Aetna To Offer Online Physician Visits. April 5, 2006. Available from http://www.ihealthbeat.org/Articles/2006/4/5/Cigna-HealthCare-Aetna-To-Offer-Online-Physician-Visits.aspx?topic=Chronic%20Disease%20Care

42 Institute of Medicine: Crossing the Quality Chasm: A New Health System for the 21st century. National Academies Press, 2001

43 Kaiser Permanente. My health manager. Available from https://healthy.kaiserpermanente.org/health/care/consumer/my-health-manager

44 Katz SJ, Moyer CA, Cox DT, Stern DT. Effect of a triage-based E-mail system on clinic resource use and patient and physician satisfaction in primary care: a randomized controlled trial. J Gen Intern Med 2003;18(9):736-44

45 Kocher R, Emanuel EJ, DeParle NA. The Affordable Care Act and the future of clinical medicine: the opportunities and challenges. Ann Intern Med 2010;153(8):536-9

46 Kreiger N: Overcoming the Absence of Socioeconomic Data in Medical Records: Validation and Application of a Census-Based Methodology. Am J Public Health 1992;82(5):703-710

47 Liang KY, Zeger SL: Longitudinal data analysis using generalized linear models. Biometrika 1989; 73:13-22

48 Liederman EM, Lee JC, Baquero VH, Seites PG. Patient-physician web messaging. The impact on message volume and satisfaction. J Gen Intern Med 2005;20(1):52-7

49 Lorig K, Ritter PL, Laurent DD, Plant K, Green M, Jernigan VB, Case S. Online diabetes self-management program: a randomized study. Diabetes Care 2010;33(6):1275-81

50 Lyles CR, Harris LT, Jordan L, Grothaus L, Wehnes L, Reid RJ, Ralston JD. Patient race/ethnicity and shared medical record use among diabetes patients. Med Care 2012;50(5):434-40

51 McCarrier KP, Ralston JD, Hirsch IB, Lewis G, Martin DP, Zimmerman FJ, Goldberg HI. Web-based collaborative care for type 1 diabetes: a pilot randomized trial. Diabetes Technol Ther 2009;11(4):211-7

52 McGee MK. Healthcare IT Priorities Survey: A Singular Focus. InformationWeek Analytics. March 2011. Available from http://reports.informationweek.com/abstract/105/5934/Healthcare/research-healthcare-it-priorities-survey.html

53 Menachemi N, Prickett CT, Brooks RG. The use of physician-patient email: a follow-up examination of adoption and best-practice adherence 2005-2008. J Med Internet Res 2011;13(1):e23

54 Mooradian AD, Chehade JM. Diabetes Mellitus in Older Adults. Am J Ther 2012;19(2):145-59

55 Moyer CA, Stern DT, Dobias KS, Cox DT, Katz SJ. Bridging the electronic divide: patient and provider perspectives on e-mail communication in primary care. Am J Manag Care 2002;8(5):427-33

56 O'Connor PJ, Rush WA, Davidson G, Louis TA, Solberg LI, Crain L, Johnson PE, Whitebird RR: Variation in quality of diabetes care at the levels of patient, physician, and clinic. Prev Chronic Dis 2008;5(1):A15

57 Papelbaum M, Moreira RO, Coutinho W, Kupfer R, Zagury L, Freitas S, Appolinário JC. Depression, glycemic control and type 2 diabetes. Diabetol Metab Syndr 2011;7;3(1):26

58 Petersen MR, Deddens JA. A comparison of two methods for estimating prevalence ratios. BMC Med Res Methodol 2008;8:9

59 Pew Internet & American Life Project. (2010). "Updated: Change in internet access by age group, 2000-2010." Available from http://www.pewinternet.org/Infographics/2010/Internet-acess-by-age-group-over-time-Update.aspx

60 R Development Core Team. 2011. *R: A Language and Environment for Statistical Computing: Release 2.14.0.* Vienna, Austria: R Foundation for Statistical Computing

61 Ralston JD, Carrell D, Reid R, Anderson M, Moran M, Hereford J: Patient web services integrated with a shared medical record: patient use and satisfaction. J Am Med Inform Assoc 2007;14(6):798-806

62 Ralston JD, Coleman K, Reid RJ, Handley MR, Larson EB. Patient experience should be part of meaningful-use criteria. Health Aff (Millwood) 2010;29(4):607-13

63 Ralston JD, Hirsch IB, Hoath J, Mullen M, Cheadle A, Goldberg HI. Web-based collaborative care for type 2 diabetes: a pilot randomized trial. Diabetes Care 2009;32(2):234-9

64 Ralston JD, Martin DP, Anderson ML, Fishman PA, Conrad DA, Larson EB, Grembowski D. Group health cooperative's transformation toward patient-centered access. Med Care Res Rev 2009;66(6):703-24

65 Ralston JD, Rutter CM, Carrell D, Hecht J, Rubanowice D, Simon GE. Patient use of secure electronic messaging within a shared medical record: a cross-sectional study. J Gen Intern Med 2009;24(3):349-55

66 Robins JM, Hernán MA, Brumback B. Marginal structural models and causal inference in epidemiology. Epidemiology 2000;11(5):550-60

67 Rubin DB. *Multiple Imputation for Nonresponse in Surveys*. J. Wiley & Sons, New York. 1987

68 Sacks DB, Arnold M, Bakris GL, Bruns DE, Horvath AR, Kirkman MS, Lernmark A, Metzger BE, Nathan DM; National Academy of Clinical Biochemistry. Position statement executive summary: guidelines and recommendations for laboratory analysis in the diagnosis and management of diabetes mellitus. Diabetes Care 2011;34(6):1419-23

69 Santana S, Lausen B, Bujnowska-Fedak M, Chronaki C, Kummervold PE, Rasmussen J, Sorensen T. Online communication between doctors and patients in Europe: status and perspectives. J Med Internet Res 2010;12(2):e20

70 Sciamanna CN, Rogers ML, Shenassa ED, Houston TK. Patient access to U.S. physicians who conduct internet or e-mail consults. J Gen Intern Med 2007;22(3):378-81

71 Selden TM, Sing M. The distribution of public spending for health care in the United States, 2002. Health Aff (Millwood) 2008;27(5):w349-59

72 Selvin E, Coresh J, Brancati FL. The burden and treatment of diabetes in elderly individuals in the U.S. Diabetes Care 2006;29(11):2415-9

73 Shaw RJ, Ferranti J. Patient-Provider Internet Portals-Patient Outcomes and Use. Comput Inform Nurs 2011;29(12):714-8

74 Simon G, Katon W, Lin E, Ludman E, Von Korff M, Ciechanowski P, Young B: Diabetes complications and depression as predictors of health care costs. Gen Hosp Psychiatry 2005;27:344-351

75 Singh H, Fox SA, Petersen NJ, Shethia A, Street RL Jr. Older patients' enthusiasm to use electronic mail to communicate with their physicians: cross-sectional survey. J Med Internet Res 2009;11(2):e18

76 Siva C, Lawlor K, Smarr K, Ge B, Fleming D. E-mail communication with patients: a survey of the American College of Physicians, Missouri Chapter. Mo Med 2011;108(2):136-40

77 Sloan FA, Bethel MA, Ruiz D Jr, Shea AM, Feinglos MN. The growing burden of diabetes mellitus in the US elderly population. Arch Intern Med 2008;168(2):192-9

78 Spann SJ; Task Force 6 and the Executive Editorial Team. Report on financing the new model of family medicine. Ann Fam Med 2004;2 Suppl 3:S1-21

79 Sperl-Hillen JM, Solberg LI, Hroscikoski MC, Crain AL, Engebretson KI, O'Connor PJ: The effect of advanced access implementation on quality of diabetes care. Prev ChronicDis 2008;5(1):A16

80 Starfield B, Weiner J, Mumford L, Steinwachs D: Ambulatory care groups: a categorization of diagnoses for research and management. Health Serv Res 1991;26(1):53-74

81 StataCorp. 2009. *Stata Statistical Software: Release 11*. College Station, TX: StataCorp LP

82 Stratton, Irene, et al, Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): prospective observational study, BMJ 2000;321:405–12

83 Tang P. Meaningful Use Workgroup Recommendations. June 8, 2011. Available from http://healthit.hhs.gov/portal/server.pt/community/healthit_hhs_gov__policy_past_meetings/1814

84 The Diabetes Control and Complications Trial Research Group. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. N Engl J Med 1993;329(14):977-86

85 The National Committee for Quality Assurance. HEDIS 2010 Final NDC Lists. Table CDC-A: Prescriptions to Identify Members with Diabetes. Available from http://www.ncqa.org/tabid/1091/Default.aspx

86 The National Committee for Quality Assurance. HEDIS 2012. Available online from http://www.ncqa.org/tabid/78/Default.aspx#Vol_1

87 Tufano JT, Ralston JD, Martin DP. Providers' experience with an organizational redesign initiative to promote patient-centered access: a qualitative study. J Gen Intern Med 2008;23(11):1778-83

88 United States Department of Veterans Affairs. My HealtheVet. Available from https://www.myhealth.va.gov/index.html

89 Virji A, Yarnall KS, Krause KM, Pollak KI, Scannell MA, Gradison M, Østbye T. Use of email in a family practice setting: opportunities and challenges in patient- and physician-initiated communication. BMC Med 2006;15;4:18

90 Wagner EH, Austin BT, Davis C, Hindmarsh M, Schaefer J, Bonomi A. Improving chronic illness care: translating evidence into action. Health Aff 2001;20(6):64–78

91 Wagner EH, Austin BT, Korff M. Organizing care for patients with chronic illness. Milbank Q 1996;74(4):511–544

92 Weiner JP, Starfield BH, Steinwachs DM, Mumford LM. Development and application of a population-oriented measure of ambulatory care case-mix. Med Care 1991;29(5):452-472

93 Weppner WG, Ralston JD, Koepsell TD, Grothaus LC, Reid RJ, Jordan L, Larson EB. Use of a shared medical record with secure messaging by older patients with diabetes. Diabetes Care 2010;33(11):2314-9

94 White HA: Heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. Econometrica 1980;48:817-830

95 Wielawski IM: *Improving Chronic Illness Care. To Improve Health and Health Care, The Robert Wood Johnson Foundation Anthology, Volume X.* Jossey-Bass, 2006

96 Yelland LN, Salter AB, Ryan P. Performance of the modified Poisson regression approach for estimating relative risks from clustered prospective data. Am J Epidemiol 2011;174(8):984-92

97 Young BA, Lin E, Von Korff M, Simon G, Ciechanowski P, Ludman EJ, Everson-Stewart S, Kinder L, Oliver M, Boyko EJ, Katon WJ. Diabetes complications severity index and risk of mortality, hospitalization, and healthcare utilization. Am J Manag Care 2008;14(1):15-23

98 Zhou YY, Garrido T, Chin HL, Wiesenthal AM, Liang LL: Patient access to an electronic health record with secure messaging: impact on primary care utilization. Am J Manag Care 2007;13(7):418-24

99 Zhou YY, Kanter MH, Wang JJ, Garrido T. Improved quality at Kaiser Permanente through e-mail between physicians and patients. Health Aff (Millwood) 2010;29(7):1370-5

100 Zou G. A modified poisson regression approach to prospective studies with binary data. Am J Epidemiol 2004;159(7):702-6

VITA

Lynne Harris grew up in New Jersey. She received her high school diploma and postgraduate certificate in music performance from Interlochen Arts Academy in 1997. She received a Bachelor of Science degree in Neurobiology from the University of Washington in 2002. She continued her studies at the University of Washington as a medical student, and began a doctoral degree in Health Services in 2004. She received a Master's Degree in Biomedical and Health Informatics in 2011, and completed her doctoral dissertation in Health Services in 2012. Her research has been focused on patient use of information technology in diabetes care.