Nudging Physicians and Patients With Autopend Clinical Decision Support to Improve Diabetes Management

Laura Panattoni, PhD; Albert Chan, MD, MS; Yan Yang, PhD; Cliff Olson, MBA; and Ming Tai-Seale, PhD, MPH

ABSTRACT

OBJECTIVES: To determine the impact on routine glycated hemoglobin (A1C) laboratory test completion of incorporating an autopend laboratory order functionality into clinical decision support, which (1) routed provider alerts to a separate electronic folder, (2) automatically populated preauthorization forms, and (3) linked the timing and content of electronic patient health maintenance topic (HMT) reminders to the provider authorization.

STUDY DESIGN: Observational pre-post study from November 2011 (1 year before autopend) through June 2014 (1.5 years after).

METHODS: The study included HMT reminders concerning an A1C test for patients with type 1 or type 2 diabetes (N = 15,630 HMT reminders; 8792 patients) in a large multispecialty ambulatory healthcare system. A Cox proportional hazard model, adjusted for patient and provider demographics, estimated the likelihood of laboratory test completion based on 3 HMT reminder characteristics: preautopend versus postautopend period, read versus unread, and the patient's time to reading.

RESULTS: In the postautopend period, the median time for patients to read reminders decreased (1 vs 3 days; *P* <.001) and the median time to complete laboratory tests decreased (40 vs 48 days; *P* <.001). Comparing preautopend HMT reminders with a similar time to reading, the likelihood of A1C laboratory test completion increased after autopend by between 21.1% (hazard ratio [HR], 1.211; *P* = .050), when time to reading was 57 days, and 33.9% (HR, 1.339; *P* = .003), when time to reading was 0 days. This result included 68% of the reminders. There was no statistical difference in A1C laboratory test completion for unread reminders in the preautopend versus postautopend period.

CONCLUSIONS: Automated patient-centered decision support can improve guideline-concordant monitoring of A1C among patients with diabetes, particularly among patients who read reminders in a timely fashion.

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The timely completion of routine preventive care is critical for diabetes management, yet only 39.5% of US patients diagnosed with diabetes have received all guideline-recommended services.[1,2] Stage II of the Meaningful Use legislation, Medicare's Electronic Health Record (EHR) Incentive Program, requires the use of clinical decision support (CDS) to remind patients about preventive care. However, Medicare states that there is no definitive or comprehensive list of what constitutes CDS, partly to encourage the creation of novel and innovative CDS tools.[3]

Various CDS systems have been developed to improve the completion of routine preventive diabetes care. The use of electronic reminders to providers, often in the patient's chart, prompts limited improvement,[4-6] partly because providers respond 30% to 40% of the time.[7,8] Study results have shown that electronic reminders sent directly to patients improve diabetes management.[9,10] However, a randomized controlled trial involving electronic alerts to both patients and providers had mixed findings.[11] This suggests that the interaction between patient and clinician interventions within CDS may be critical, especially if these systems developed independently.

The provider–patient interface can inadvertently generate barriers to preventive care. Providers are required to review and authorize each laboratory order, even if they occur routinely. Providers and patients may fail to perform required tasks (eg, authorization or laboratory test completion) without prompting.[12] However, locating provider alerts in the patient's chart contributes to alert fatigue and creates challenges for patient management between visits.[8] When patient alerts are triggered independently of the clinician authorization, patients may need to complete additional burdensome steps to confirm the laboratory order's authorization, such as checking with the provider's office, the laboratory, or additional websites.

Health information technology leaders at Sutter Health, a large nonprofit integrated healthcare delivery system headquartered in Sacramento, California, designed and incorporated an autopend functionality into the CDS. Autopend aimed to nudge providers and patients by simplifying workflow, removing barriers, and coordinating actions to improve preventive care. We examined

TAKEAWAY POINTS

- Incorporating an autopend functionality into clinical decision support coordinates and streamlines the process of completing routine preventive diabetes care.
- Autopend routed provider alerts to a separate electronic folder for batch completion, automatically populated preauthorization forms, and linked the timing and content of the patient reminder messages to the authorization.
- Among patient reminder messages read within 57 days, the likelihood of glycated hemoglobin laboratory test completion increased by between 21.1% ($P = .050$) and 33.9% ($P = .003$) after autopend. This result included 68% of the reminders.
- Autopend can improve guideline-concordant monitoring of chronically ill patients in the spirit of the Quadruple Aim.

whether incorporating an autopend functionality improved the likelihood of routine glycated hemoglobin (A1C) laboratory test completion for patients with diabetes.

RESEARCH DESIGN AND METHODS

Study Setting

The study was conducted at the Palo Alto Medical Foundation (PAMF), an affiliate of Sutter Health. PAMF is an ambulatory healthcare system serving more than 1 million patients in northern California. It has used a fully integrated EpicCare EHR with electronic health maintenance topic (HMT) patient reminders since 1999. The autopend functionality was activated on November 13, 2012.

Study Design

We conducted an observational pre-post study at the HMT reminder level and tracked associated A1C laboratory test completion. We compared HMT reminders sent in the year before autopend (November 1, 2011-November 13, 2012) with those in the 1.5 years after (November 13, 2012-June 30, 2014). Our data recorded laboratory test completion for an additional 6 months (through December 2014). We included all HMT reminders sent to patients eligible for autopend, who were defined as those with a problem list diagnosis of diabetes mellitus (*International Classification of Diseases, Ninth Revision* codes 250.xx, 401.xx, 790.xx, 272.xx, 791.xx, 790.29), a designated primary care provider (PCP), and an activated patient portal (MyHealthOnline). A total of 8792 patients received 15,630 HMT reminders.

Autopend Functionality and the HMT System

Preautopend. HMT reminders were sent to patients independently of providers' authorization. All HMT reminders included "usual" content, which stated "you are due for" an A1C test and instructed patients to check a website to see if their laboratory tests had been ordered. If not, patients had to contact their provider. The CDS included provider alerts only in the patient's chart. Providers learned about upcoming laboratory tests either when contacted by a patient or if they opened the patient's chart, perhaps during an office visit. The provider then reviewed the order, filled out the authorization form, and contacted the patient.

Postautopend. Autopend (1) routed upcoming laboratory test notifications to a separate electronic folder, in addition to including an alert in the patient's chart; (2) automatically populated or "pended" preauthorization forms in the electronic folder; and (3) linked the timing and content of the patient HMT reminders to the provider authorization. If the provider approved the order, an HMT reminder with autopend content was sent to patients stating "your clinician has ordered" an A1C test and they could proceed directly to the laboratory. In this case, the patient could skip checking the website and potentially following up with their provider. If the provider declined or ignored the notification, an HMT reminder with usual content was sent and patients had to complete the additional steps (**eAppendices A**, **B**, and **C** [eAppendices available at **ajmc.com**] provide further description).

Data

EHR data were combined with HMT metadata. We used a structured text mining process to categorize patient HMT reminders according to autopend and usual content.

Measures

Patient HMT reminders. "Post autopend" indicated all HMT reminders sent after November 13, 2012. "Read reminder" recorded whether the patient clicked on the HMT reminder. "Time to reading" measured the number of days between when the HMT reminder was sent and when the patient clicked on it.

Time to laboratory test completion. This measured the number of days between when the HMT reminder was sent and laboratory test completion.

Statistical Analysis

We examined unadjusted differences in patient, provider, and HMT reminder characteristics for reminders sent in the preautopend and postautopend periods. *P* values were calculated based on the results of χ^2 tests, *t* tests, and nonparametric equality of medians tests.

A Cox proportional hazard model[13] was used to estimate the likelihood of laboratory test completion based on 3 HMT reminder characteristics: preautopend versus postautopend period, read versus unread, and time to reading. The model adjusted for patient's sex, self-reported race/ethnicity, age, insurance type, and Charlson Comorbidity Index score,[14] along with the sex and specialty of the patient's PCP. We addressed missing data in the explanatory variables by including a category for unknown. To account for repeated HMT reminders within patients, we clustered standard errors at the patient level. We included quarter fixed effects to control for secular trends. Schoenfeld tests rejected the proportional hazards assumption, so we added time-varying covariates with a natural log of time specification.[13] We used the STCOX and LINCOM

procedures in Stata 13.1 (StataCorp LP; College Station, Texas) and reported estimates in hazard ratios (HRs).[15]

RESULTS

In the period before autopend, 6329 HMT reminders were sent to 5197 patients (Table 1). Patients who received reminders in the preautopend period had an average age of 59 years and were primarily male (58.7%) and mainly white (46.6%) or Asian (30.9%); almost half (48.5%) were insured by a preferred provider organization. In comparison, patients who received reminders in the postautopend period were more likely to have Medicare fee-for-service or unknown insurance (P <.001) and a female PCP in family medicine (P <.001).

In the preautopend period, all HMT reminders had usual content. Most reminders (85.2%) were read by the end of the study period (Table 1). However, the median time to reading was 3 days, and 75% of the reminders were read within 38 days. Most of the laboratory tests associated with the reminders (81.2%) were completed by the end of the study period. The median time to completion was 48 days, with 75% of the laboratory tests completed within 106 days.

In the postautopend period, 87.0% of the HMT reminders included autopend content, reflecting the proportion of autopended orders approved by the PCPs, whereas 13.0% included usual content, which resulted from rejected orders. HMT reminders in the postautopend period were read slightly sooner than those in the preautopend period (median time to reading, 1 day vs 3 days; P <.001) (Table 1). eAppendix D illustrates that in the first 2 months after a reminder was sent, reminders with either autopend or usual content sent in the postautopend period were slightly more likely to be read than reminders sent in the preautopend period. The median time to laboratory test completion was also 8 days shorter in the postautopend period (40 days vs 48 days; P <.001) (Table 1; eAppendix E). eAppendix D illustrates that 2 months after the reminder was sent, read reminders with autopend content were associated with higher rates of laboratory test completion (59.5%) than read reminders with usual content in either the preautopend period (52.2%) or the postautopend period (42.2%; P <.001).

Next, we compared the adjusted effect of receiving an HMT reminder in the postautopend period for read and unread reminders (Table 2). Comparing reminders read on the same day they were sent (time to reading, 0 days), reminders sent in the postautopend period were associated with a 33.9% increase in the likelihood of laboratory test completion (HR, 1.339; P <.01). However, for reminders read 60 days after being sent, this increase in likelihood was lower, at 20.4% (P = .055). The improvement in the likelihood of an A1C laboratory test being completed in the postautopend period remained significant (HR, 1.211; P = .050) for reminders read up to 57 days after being sent, which included 68.4% of all reminders. For unread reminders, there was no statistically significant difference in A1C laboratory test completion among patients who were sent reminders in the postautopend period.

TABLE 1. Patient, PCP, and HMT Reminder Characteristics

	Preautopend Period (n = 6329 HMT reminders)	Postautopend Period (n = 9301 HMT reminders)	*P*
Patient Characteristics			
Unique patients, n	5197	7712	
Age, years, mean (SD)	59 (13.7)	60 (14.3)	<.001
Female, n (%)	2612 (41.3)	3937 (42.3)	.188
Race/ethnicity, n (%)			
White	2936 (46.4)	4220 (45.4)	.058
Asian	1957 (30.9)	2795 (30.1)	
Hispanic	467 (7.4)	751 (8.1)	
Other	740 (11.7)	1137 (12.2)	
Unknown	229 (3.6)	398 (4.3)	
Insurance, n (%)			
PPO	3070 (48.5)	4158 (44.7)	<.001
HMO	1014 (16.0)	1240 (13.3)	
Medicaid	101 (1.6)	134 (1.4)	
Medicare FFS	1572 (24.8)	2556 (27.5)	
Medicare HMO	387 (6.1)	501 (5.4)	
Unknown	185 (2.9)	712 (7.7)	
CCI score, mean (SD)	2.07 (1.5)	2.04 (1.5)	.227
PCP Characteristics			
Female, n (%)	3105 (49.1)	5058 (54.4)	<.001
Specialty, n (%)			
Family medicine	2758 (43.6)	4335 (46.6)	<.001
Internal medicine	3510 (55.6)	4912 (52.8)	
Other	61 (1.0)	54 (0.6)	
HMT Reminder Characteristics			
Usual content,[a] n (%)	6329 (100)	1208 (13.0)	<.001
Autopend content,[a] n (%)	0 (0)	8093 (87.0)	
Read reminder,[b,c] n (%)	5394 (85.2)	7317 (78.7)	<.001
Time to reading, days, median (25th, 75th percentile)	3 (0, 38)	1 (0, 22)	<.001[d]
A1C laboratory test completion, n (%)	5139 (81.2)	7078 (76.1)	<.001
Time to A1C laboratory test completion, days, median (25th, 75th percentile)	48 (17, 106)	40 (14, 85)	<.001[d]

A1C indicates glycated hemoglobin; CCI, Charlson Comorbidity Index; FFS, fee-for-service; HMO, health maintenance organization; HMT, health maintenance topic; PCP, primary care provider; PPO, preferred provider organization.

[a]Examples of autopend versus usual HMT reminder content are provided in eAppendix C.

[b]Read reminder indicates that the patient clicked on the HMT reminder.

[c]Postautopend period estimates are subject to "right-censoring," because patients in the postautopend period did not have the same amount of follow-up time to read the reminders or complete laboratory tests.

[d]Nonparametric equality of medians test.

TABLE 2. Adjusted Likelihood of A1C Laboratory Test Completion as a Function of 3 HMT Reminder Characteristics[a]

		HR (95% CI)		
	Moderating Characteristic	0 Days to Reading	30 Days to Reading	60 Days to Reading
Postautopend period vs preautopend period	Unread	0.974 (0.792-1.197)	0.974 (0.792-1.197)	0.974 (0.792-1.197)
	Read[b]	1.339** (1.106-1.623)	1.270* (1.050- 1.536)	1.204 (0.996-1.456)
Read vs unread	Preautopend period	1.767*** (1.631-1.915)	1.678*** (1.551-1.815)	1.593*** (1.473-1.723)
	Postautopend period	2.431*** (2.272-2.600)	2.188*** (2.049-2.337)	1.969*** (1.842-2.106)

A1C indicates glycated hemoglobin; HMT, health maintenance topic; HR, hazard ratio.

*P <.05; **P <.01; ***P <.001.

[a]Derived from a Cox proportional hazard model with interactions among the variables postautopend period, read HMT reminder, and time to reading. The postautopend period variable indicated HMT reminders with both autopend and usual content. The model was adjusted for patient's sex, self-reported race/ethnicity, age, insurance type, and Charlson Comorbidity Index score; provider sex and specialty; and quarter fixed effects (**eAppendices F** and **G**).

[b]The improvement in the likelihood of A1C laboratory test completion for postautopend period reminders remained significant (at a P = .05 level) for reminders read up to 57 days after being sent (HR, 1.211; 95% CI, 1.001-1.464).

We also compared the adjusted effect of reading an HMT reminder in the preautopend and postautopend periods (Table 2). In the preautopend period, a read reminder was associated with a 76.7% increase in the likelihood of laboratory test completion (HR, 1.767; P <.001; time to reading, 0 days) compared with an unread reminder. However, in the postautopend period, a similar read reminder was associated with a 143.1% increase in likelihood of completion (HR, 2.431; P <.001; time to reading, 0 days).

DISCUSSION

We evaluated the impact of incorporating a novel autopend functionality into the CDS on routine A1C laboratory test completion. We found that for HMT reminders read within 57 days, reminders sent in the postautopend period were associated with a 21.1% (HR, 1.211; P = .050) to 33.9% (HR, 1.339; P = .003) increase in the likelihood of laboratory test completion. This result included 68% of the HMT reminders. However, the likelihood of laboratory test completion decreased the longer it took the patient to read the reminder. Among unread reminders, we found no statistical difference in A1C laboratory test completion in the postautopend period.

The autopend design was guided by the behavioral economics principle of nudging people to do the right thing. Autopend allowed the majority of patients to skip checking an additional website and potentially contacting their provider to check the laboratory test's authorization status. Relocating provider triggers from the patient's chart to a separate electronic folder for providers to approve, as well as coordinating the timing and content of the patient reminders with the provider authorization, may have minimized alert fatigue,[16] the electronic task demand (eg, clicks, data entry, and time), and the downstream actions required by both parties. This in turn may have reduced providers' workflow interruption and cognitive burden, improving job performance and satisfaction.[17,18] However, the effects of these design features were associated with diminishing improvements for patients who took longer to read their reminders.

Although 87.0% of the postautopend period HMT reminders had autopend content, caution should be exercised before concluding that laboratory test completion rates could have been higher had all patients received autopend content. Patient and provider characteristics associated with the usual-content HMT reminders, and not the actual reminder content, may have contributed to the lower rates. Future research should explore these factors and the CDS designs that address them.

Stage II of the Meaningful Use criteria established expectations of using CDS to engage patients and improve population health.[19] Although technology such as autopend may have an important role in helping health systems realize the potential of EHRs, physicians spend significant time meeting the demands of "desktop medicine."[20-22] Requiring physicians to approve autopend orders for regulatory compliance, rather than allowing them to go directly to patients or to the inboxes of other care team members, may have unintended consequences on physicians' workflow. The functionality may need to be modified to enable other care team members to approve these orders.

Limitations

This study has some limitations. The observational pre-post study design limits our ability to rule out confounding factors. However, we did statistically control for time trends through the use of quarter fixed effects. Secondly, this study took place in a single multispecialty delivery organization, which was an early adopter of EHRs, and autopend was added onto an existing EpicCare-specific HMT reminder system. Furthermore, this study included only patients with an active patient portal, limiting generalizability to other settings and patient populations. However, these principles of CDS design could be applied to other EHR systems.

CONCLUSIONS

Our study results suggest that incorporating an autopend functionality into a CDS system was associated with improvements in A1C laboratory test completion among patients with diabetes who read their HMT reminders in a timely fashion. This multifaceted functionality was designed to simplify workflow, remove barriers, and coordinate the actions of patients and clinicians. Such a CDS tool can improve the care of chronically ill patients in the spirit of the Quadruple Aim.[23] ■

Author Affiliations: Hutchinson Institute for Cancer Outcomes Research, Fred Hutchinson Cancer Research Center (LP), Seattle, WA; Sutter Health Office of Patient Experience (AC), Sacramento, CA; Palo Alto Medical Foundation Research Institute (AC, YY, CO), Palo Alto, CA; University of California San Diego School of Medicine (MT-S), San Diego, CA.

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Address Correspondence to: Laura Panattoni, PhD, Hutchinson Institute for Cancer Outcomes Research, Fred Hutchinson Cancer Research Center, 1100 Fairview Ave N, Seattle, WA 98109. Email: lpanatto@fredhutch.org.

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eAppendix A. Description of Autopend Order Functionality and the Health Maintenance Topic System

Conceptually, the Health Maintenance Topic system sends reminders through the portal to patients who are due for routine, preventative lab tests based on current guidelines. Providers are required to review and authorize each lab test order. Before the addition of the Auto-pend order functionality, when an EHR alert for an upcoming lab was triggered, an HMT reminder with the default content was sent directly to the patient. This reminder instructed patients to check a website ("Tests Ordered page") to see if their lab tests had been ordered and if not, to contact their provider. In this case, the provider would place the order or not, performing the entire workflow manually, and then contact the patient. During this time, providers were *not* notified directly by the HMT system that their patients were due for a lab. The possible mechanisms by which they learned about upcoming lab tests were i) when contacted by a patient; or ii) if the provider happened to open the patient's Epic chart, perhaps during an Office Visit, and noticed the Health Maintenance due alert in the patient header bar.

After the addition of the Auto-pend order functionality, when an EHR alert for an upcoming lab was triggered, the auto pend algorithm automatically created or "pended" the lab order, included a diagnosis code, and sent the prepared lab orders to the provider's in-basket folder for pre-authorization. If the provider approved the order, an HMT reminder with the auto-pend content was sent to the patient stating their clinician had already ordered their lab tests and they could proceed directly to the lab. If the provider declined or ignored the in-basket message, an HMT reminder with the default content was sent to the patient. Providers may have declined the in-basket message because they had already ordered it in another encounter, they no longer thought the patient needed it, they disagreed with the recommendation, or they knew the patient had received a test outside of the medical system or they were no longer a patient. Providers may have ignored the order because they were overwhelmed by other in-basket messages and they didn't bother to read these messages because they were a lower priority than keeping up with more time sensitive medication refill requests, secure-messaging requests, and lab results.

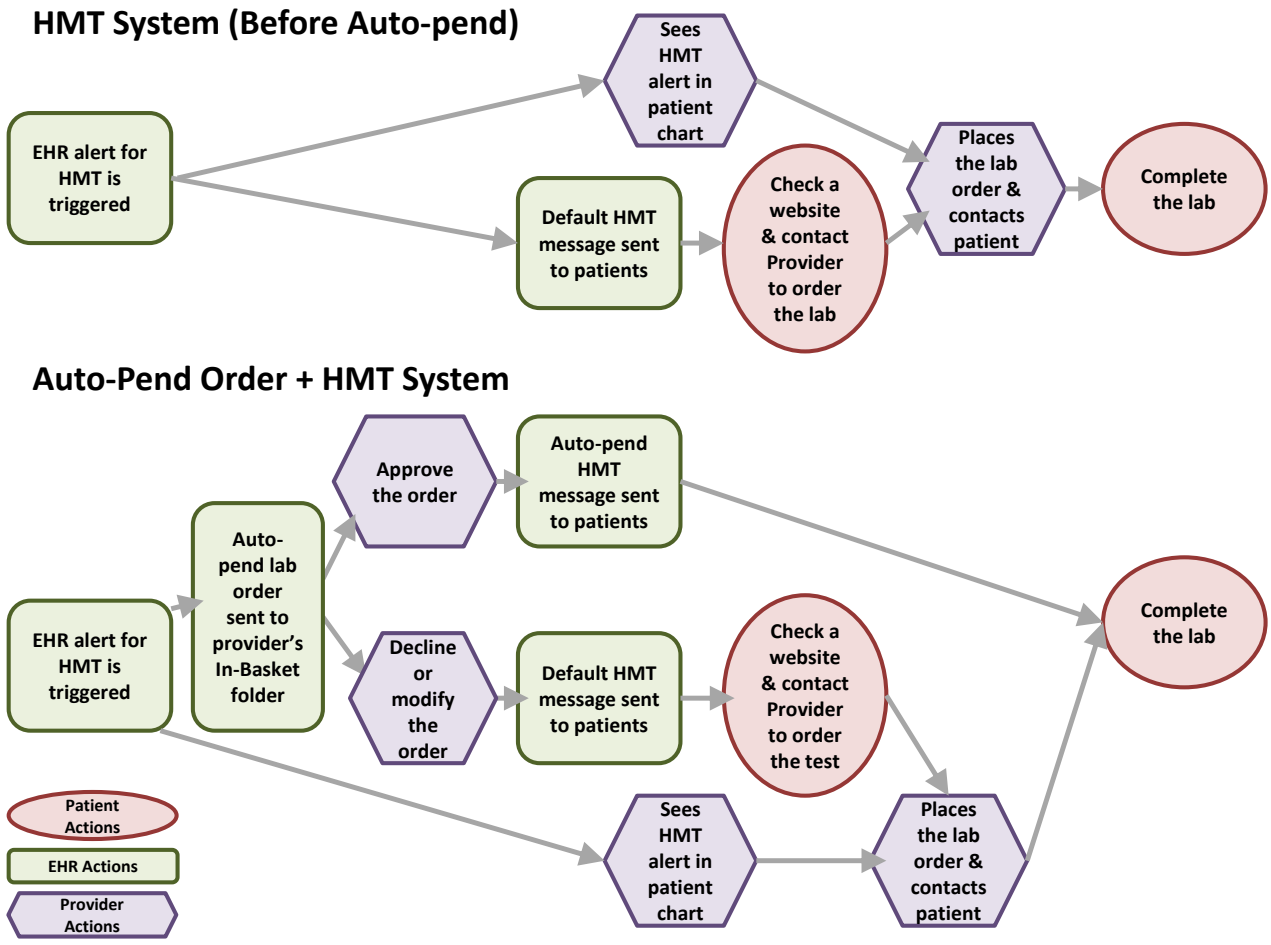
From the patient perspective, the Auto-pend order functionality enabled providers to pre-authorize labs, removing the need to check an additional website and follow up with the office for lab order placement. From the provider perspective, the functionality facilitated patient

management between visits and reduced the cognitive burden and workflow interruptions of completing extra data entry tasks, especially during the visit. eAppendix B provides an overview of the HMT system before and after the Auto-pend order functionality, along with the provider and patient actions required to complete a lab.

Autopend vs usual HMT reminder content: HMT reminders with autopend content stated, "your clinician has ordered" while the reminders with the usual content included, "you are due for." The first step listed in this reminder was for patients to visit the lab, while reminders with the usual content had patients first check the Tests Ordered (eAppendix C) webpage in the patient portal, and if no order existed, they either reminded their care team (Post-period) or contacted their care team's office (Pre-period) for a lab order to be placed, depending on the period. The autopend content also included language about visiting the Tests Ordered webpage, but only for the purpose of providing background information and pre-test instructions, such as fasting requirements.

Timing of the autopend order functionality: Seven days before the lab was due, the system-generated lab orders were routed to a 'HMT Autopend Order' folder in the provider's In-Basket for review. Once the provider approved or rejected the order, a tickler email and a patient HMT reminder message with the corresponding content was sent. The system also searched for any HMT services that were overdue or would be due within the next 30 days or and added these services to the current reminder. If the HbA1c lab test was not completed, the patient received a reminder one day and 30 days after it was overdue. There was a maximum of 37 days between the "first" patient HMT reminder and the final reminder. Once the patient completed the lab, the next due date was set for 6 months in the future, unless it was manually overridden to 3 months. Approved orders expired after 365 days.

eAppendix B. Patient and Provider Actions Required to Complete an HbA1c Test Before and After the Autopend Order Functionality

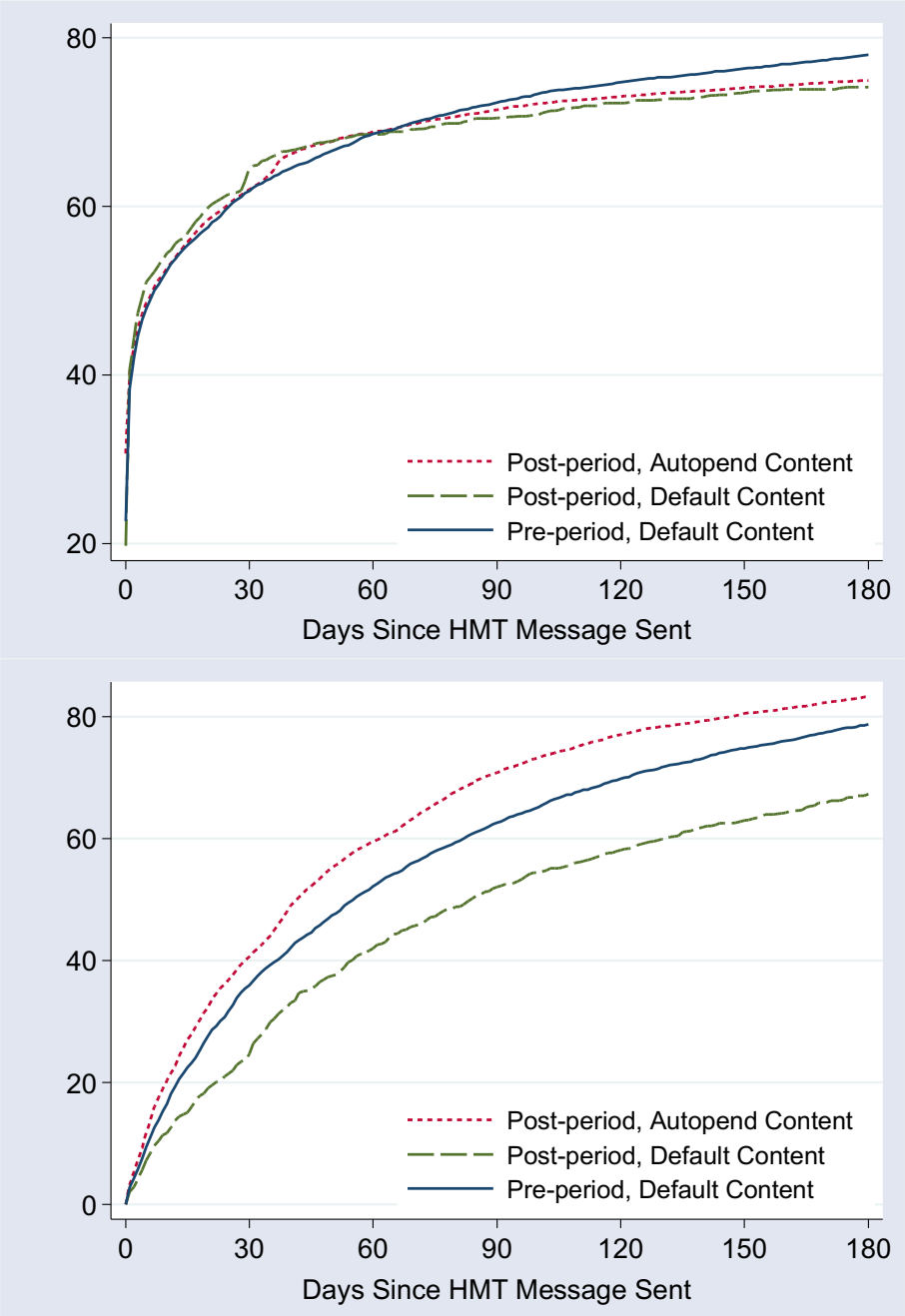


eAppendix C. Examples of HMT Reminders With Autopend and Usual Content Sent to Patients

Pre-period	Post-period	
Usual HMT Reminder	**Usual HMT Reminder**	**Autopend HMT Reminder**
Dear Patient Name, You are due for the following: ----- Glycohemoglobin, a test for your blood sugar Please check the [Tests Ordered] page to see that lab orders have been placed. If not, please [contact your care team's office] to obtain lab orders for these tests prior to coming to the lab. No appointment is necessary for the lab. For lab locations and hours of operation, click here. If you have completed your lab tests recently, please disregard this message. Healthy regards, Your Health Care Team	Dear Patient Name, As a proactive part of your routine care, our records show that you are due for your: -- Glycohemoglobin Please follow these steps: • Visit the [Tests Ordered page] for more information about the test(s) and specific pre-test instructions. • If no order exists, [message your care team] to ask that a lab order be placed if you have not done so already. • If you have had your test(s) completed recently at a non-Sutter Health affiliated lab, please let us know when and where so we can [update your health record]. • If you would like to see your clinician, [make an appointment]. • If you have any questions, call or [contact your clinician]. We hope you find this health reminder helpful. Please disregard this message if you have already scheduled or completed your lab test(s). Healthy regards, My Health Online Care Team	Dear Patient Name, As a proactive part of your care, your clinician has ordered the following lab test(s). -- Glycohemoglobin, a test for your blood sugar Please follow these steps: • Visit a Sutter Health affiliated lab for your lab test(s). You will need to provide your name and show a photo ID. • Visit the [Tests Ordered page] for more information about the test(s), specific pre-test instructions or any additional lab tests. • Please check with your health plan to verify that the test being ordered is covered by your health insurance. • If you have had your test(s) completed recently at a non-Sutter Health affiliated lab, please let us know when and where so we can [update your health record]. • If you have any questions, call or [contact your clinician]. We hope you find this health reminder helpful. Please disregard this message if you

		have already scheduled or completed your lab test(s). Healthy regards, My Health Online Care Team

eAppendix D. Unadjusted Cumulative Percentages of Read HMT Reminders and Completed A1C Laboratory Tests for Read HMT Reminders, by Period and HMT Reminder Content



All preautopend period HMT reminders included Usual content. In the postautopend period, 87.0% of the HMT reminders included Autopend content; 13.0% included Usual content. eAppendix C includes examples of Autopend and Usual HMT Reminder Content. The denominator for the percentage of completed A1C laboratory tests included all HMT Reminders read within 6 months.

eAppendix E. A1C Laboratory Test Completion Associated with HMT Reminder Characteristics

	Pre-period			**Post-period**				
HMT Reminder Content:	**Default (n=6,329)**		**Total**	**Default (n=1,208)**		**Autopend (n= 8,093)**		**Total**
Reminder Read or Not:	**Read**	**Not Read**		**Read**	**Not Read**	**Read**	**Not Read**	
HMT Reminders, # (%)	5,394 (85.2)	935 (14.8)	**6,329**	937 (77.6)	271 (22.4)	6,380 (78.8)	1,713 (21.2)	**9,301**
Lab Completion (%)	83.4	68.6	**81.2**[a,b]	69.6	40.6	84.2	55.2	**76.1**[a,b]
Time to Completion, Days								
Median	44	77	**48**[a]	47	90	35	75	**40**[a]
[25th, 75th]	[15,101]	[32,148]	**[17,106]**	[20, 98]	[42, 149]	[12, 75]	[33, 120]	**[14, 85]**

[a]P-Value (Pre- vs Post-Total) <0.001

[b]Please note that the post-period estimate is subject to some right-censoring of the data, because even with the 6 month follow-up period, patients in the postautopend period did not have the same amount of time to complete labs.

eAppendix F

A. Adjusted Cox Proportional Hazard Model of the Likelihood of A1C Laboratory Completion

	Hazard Ratio	**[95% CI]**
HMT reminder characteristics		
Postautopend period	0.974	[0.792-1.197]
Read Reminder	1.767***	[1.631-1.915]
Postautopend X Read Reminder	1.375***	[1.244-1.520]
Read Reminder X Time to Read	0.998***	[0.998-0.999]
Postautopend X Read Reminder X Time to Read	0.998***	[0.998-0.999]
Patient characteristics		
Age	1.008***	[1.006-1.010]
Female	0.932**	[0.891-0.974]
Asian	1.088***	[1.036-1.142]
Hispanic	1.097*	[1.015-1.186]
Other Ethnicity	1.050	[0.981-1.123]
Unknown Ethnicity	0.917	[0.828-1.015]
HMO Insurance	1.137***	[1.074-1.203]
Medicaid Insurance	1.062	[0.892-1.263]
Medicare FFS Insurance	1.138***	[1.067-1.214]
Medicare HMO Insurance	1.234***	[1.116-1.365]
Unknown Insurance	0.208***	[0.181-0.240]
Charlson Comorbidity Score	0.997	[0.982-1.012]
PCP characteristics		
Female	1.000	[0.957-1.044]
Family Medicine	1.007	[0.967-1.049]
Other Department	0.737**	[0.593-0.917]
N (HMT Reminders)	15,630	
n (Unique Patients)	8,792	

Notes: Results are also adjusted for quarter fixed effects. Omitted categories include White, PPO Insurance, and Internal Medicine Primary Care Provider. The 'X' indicates that the two variables were multiplied together for an interaction term.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

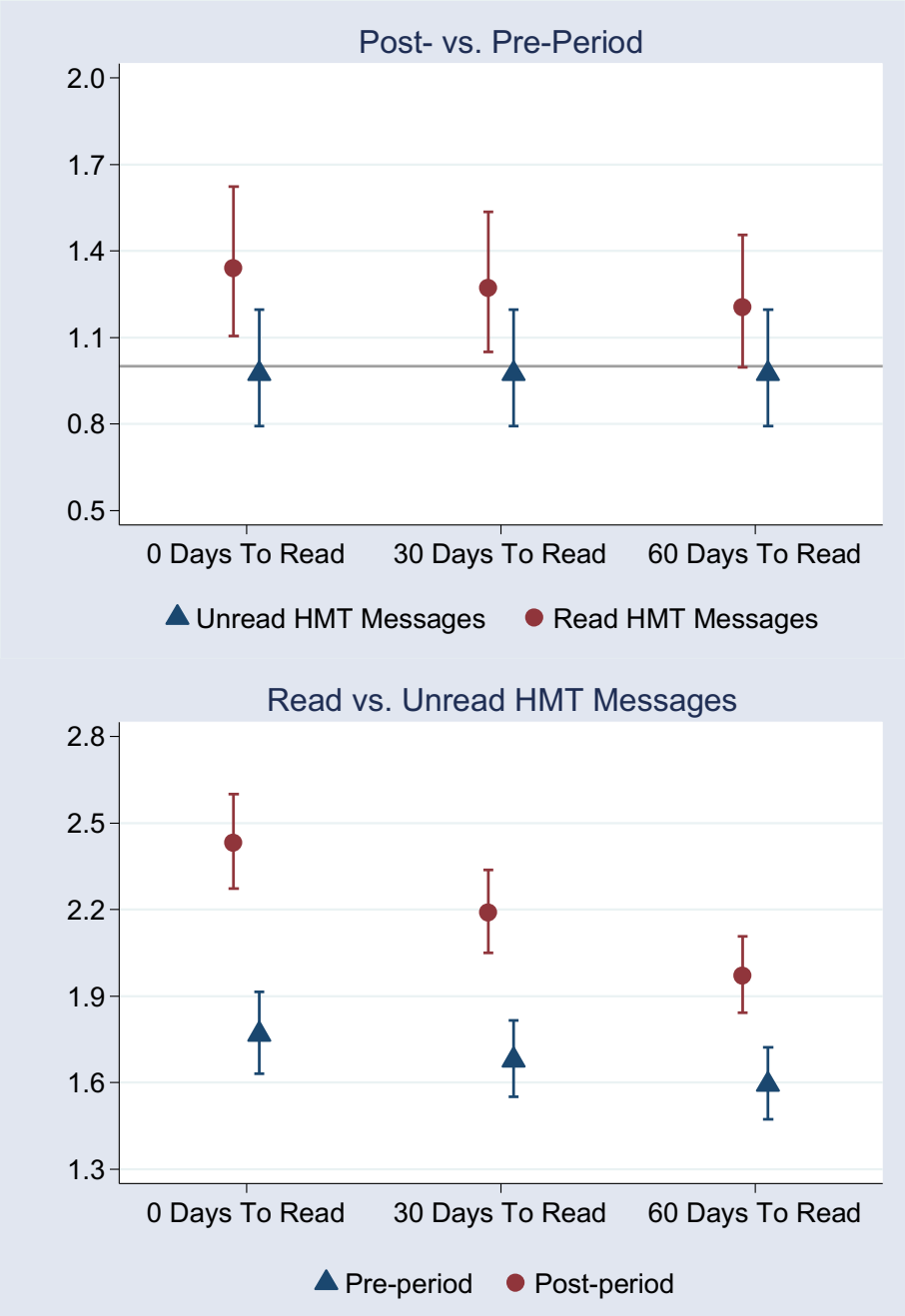
B. Adjusted Cox Proportional Hazard Model Results with Coefficients Estimates

	Marginal Effects	**[95% CI]**
HMT reminder characteristics		
Post-period	-0.027	[–0.233 to 0.180]
Read Reminder	0.569***	[0.489-0.650]
Post-period X Read Reminder	0.319***	[0.219-0.419]
Read Reminder X Time to Read	-0.002***	[–0.002 to –0.001]
Post-period X Read Reminder X Time to Read	-0.002***	[–0.002 to –0.001]
Patient characteristics		
Age	0.008***	[0.006-0.010]
Female	-0.071**	[–0.115 to –0.026]
Asian	0.084***	[0.035-0.133]
Hispanic	0.093*	[0.015-0.171]
Other Ethnicity	0.048	[–0.019 to 0.116]
Unknown Ethnicity	-0.087	[–0.188 to 0.015]
HMO Insurance	0.128***	[0.071-0.185]
Medicaid Insurance	0.060	[–0.114 to 0.234]
Medicare FFS Insurance	0.130***	[0.065-0.194]
Medicare HMO Insurance	0.210***	[0.109-0.311]
Unknown Insurance	-1.570***	[–1.711 to –1.429]
Charlson Comorbidity Score	-0.003	[–0.018 to 0.012]
PCP characteristics		
Female	0.000	[–0.043 to 0.044]
Family Medicine	0.007	[–0.034 to 0.048]
Other Department	-0.305**	[–0.523 to –0.086]
N (HMT Reminders)	15,630	
n (Unique Patients)	8,792	

Notes: Results are also adjusted for quarter fixed effects. Omitted categories include White, PPO Insurance, and Internal Medicine Primary Care Provider. The 'X' indicates that the two variables were multiplied together for an interaction term.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

eAppendix G. Adjusted Adjusted Likelihood of A1C Laboratory Completion as a Function of 3 HMT Reminder Characteristics



Derived from a Cox proportional hazard model with interactions between the variables Postautopend Period, Read HMT Reminder, and Time to Read. The Postautopend Period variable indicated HMT Reminders with both Autopend and Default content. The model was adjusted for patient's sex, self-reported race/ethnicity, age, insurance type, Charlson Comorbidity Score, provider sex and specialty, and quarter fixed effects (eAppendix F).