FINAL REPORT

Impact of office-based e-prescribing on prescribing processes and outcomes

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Structured Abstract

Purpose: We sought to evaluate the implementation of an e-prescribing system in ambulatory settings, evaluating how physicians use the systems, how the systems fit into the workflow in a primary care office, and the impact of e-prescribing on medication decisions.

Scope: Qualitative evaluation included physicians, nurses, and office staff from multiple practices in Massachusetts and a nationwide survey of over 1,000 physicians using outpatient e-prescribing systems. Quantitative evaluation included e-prescription data and medical claims data for physicians and patients covered by two major insurance plans in Massachusetts.

Methods: Several different analyses were performed. Focus groups, direct observation, and semi-structured interviews were conducted with physicians, practice managers, nurses, and other medical staff. Data were evaluated to identify technological frames that shaped the use of the data. Large-sample survey was mailed to physicians using e-prescribing systems. Survey results evaluated the relationship between measures of e-prescribing system use and the types of e-prescribing systems used and physician and patient characteristics. E-prescribing records were evaluated to identify patterns of how physicians used the features of the system and how these correlated with medications used by patients.

Results: Qualitative analyses identified seven frames technological frames, ranging from positive to neutral to negative, that affect how physicians adopt new technologies. Survey results found that physicians using e-prescribing systems that were part of an integrated electronic health record were more likely to use advanced e-prescribing features than were physicians using stand-alone e-prescribing systems. Quantitative analyses showed that over time physicians used e-prescribing systems more frequently and used more of the features.

Key Words: electronic prescribing, medication costs, medication safety, medication errors, health information technology

Purpose

Health information technology (HIT) holds tremendous promise for improving the quality of medical care in the United States, but that promise has not yet been realized. Although previous research suggests benefits of HIT, these early studies generally have taken place in large integrated systems or inpatient settings. Yet the bulk of medical care occurs in community-based settings, and for HIT to reach its full potential, it must be effective for ambulatory care.

Sub-optimal prescribing practices in outpatient settings can result in preventable errors and excessive costs under current systems of care delivery. One promising technology that has emerged is electronic prescribing (e-prescribing), a technology that allows prescribers to write prescriptions electronically. For this to occur, effective e-prescribing systems must have utility for prescribers and must be integrated into the workflow of routine medical practice. For e-prescribing to improve quality and safety, it must have valid and usable decision support capabilities and these must be demonstrated to be available at the point of care.

The primary aim of this study was to evaluate the implementation of an e-prescribing system in ambulatory settings. ZixCorp's PocketScript system was one of the most widely used outpatient e-prescribing systems during the period of this study. The e-prescribing system included functions that address multiple clinical safety and efficiency issues, including safety alerts, formulary decision support, and drug history.

Our study sought to evaluate how this e-prescribing system affected the processes of prescribing for physicians in order to assess characteristics of successful and productive adoption. We further sought to evaluate how physicians used the functionality of the e-prescribing system and how these choices affected the medications used by patients.

Scope

Despite many advances in medical care, significant problems in the safety and quality of ambulatory care persist. Many have called for greater use of HIT to improve the quality of care. A large body of research has demonstrated that HIT can improve quality of care and promote patient safety, although most such improvements have been for hospitalized patients. In ambulatory care, prescribing of medications represents one of the most common and potentially beneficial interventions, but medication use is an area with particularly persistent inadequacies. While HIT has the potential to improve medication use in ambulatory care, many important questions about the effects of HIT remain, and prior studies on the benefits of HIT did not provide definitive information.

We established a collaboration including a major provider of outpatient e-prescribing systems, two large private health insurers in Massachusetts, and a technology company (SureScripts) in order to evaluate multiple aspects of e-prescribing. We focused on physicians who had begun using e-prescribing in the outpatient setting, so that we could understand the predictors of effective use of these systems. There have been

many recent provisions aimed at increasing the use of e-prescribing by physicians, so understanding how these systems are implemented and used has important implications for physicians, health systems, patients and payors.

Our qualitative evaluations included physicians and practices in multiple settings, small and large practices and health systems, from across the country. Our quantitative evaluations focused on Massachusetts, which had high initial adoption of e-prescribing and thus allowed for quantitative data on a large number of physicians and e-prescriptions to be obtained and analyzed.

Methods

A. Focus groups, interviews, case studies:
Design
We designed and executed a three-stage qualitative study with the intent of obtaining a more grounded understanding of e-prescribing. In the first stage, we conducted four focus groups with members of physician practices: two with groups of physicians and two with groups of office managers (OM) and staff to examine their attitudes towards the technology and patterns of use.

The second stage consisted of detailed interviews with adopters and non-adopters of e-prescribing. In this portion of the study, our goal was to delve more deeply into the beliefs and behaviors of the subjects as a means of informing the final stage of the study in which we performed day-long observations at two urban practices, shadowing the clinicians and staff as they interacted with patients, prescribed medications, responded to refill requests, and managed charts. The project was approved by institutional review boards at the University of Maryland and Brigham and Women's Hospital.

Analytical approach
To understand variation in the conceptualization of e-prescribing, that is, the frames held by individual users, we used qualitative methodologies to analyze focus group and interview transcripts and researchers' notes from the field visits. In qualitative research, to reach an appropriate degree of internal validity, multiple sources of data should be used, such as focus groups, direct observation, and interviews. We applied a triangulation methodology where data obtained from one collection method were cross-validated with data from the other two methods to identify the full range of conceptualizations that existed. We began this process with two of the co-authors and two PhD-trained research assistants experienced with qualitative methods independently reviewing the transcripts of the focus groups. The goal was to immerse oneself in the data and search for patterns or surprising inconsistencies between people/groups while also identifying keywords, topics, and/or themes. After receiving input from each of the researchers and following discussions with the other co-authors, the research assistants combined all of the newly generated information and created a table that included the themes and representative quotes. Using this table as a reference, the second stage of data collection began in which we interviewed adopters and non-adopters. The initial themes

provided a basis for the interviews and site visits; however, we did not specifically direct the conversations toward any of the aforementioned topics or themes. We chose not to formally code our data because we did not want to hold too firmly to our initial classifications. As several qualitative researchers have noted, coding schemes provide a 'powerful conceptual grid' that is difficult to escape and deflects attention away from uncategorized activities. Rather than compiling all of the data from the three sources (focus groups, interviews, site visits) and analyzing it in its entirety after all steps were complete, our approach followed an analytical induction process in which we developed some broad hypotheses prior to beginning the study that were based on assumptions, prior knowledge, and literature. Following several iterations between the researchers and assistants we revised our hypotheses -which eventually became the frames - as more data were collected and emerging interpretations were formulated. The two co-authors who were not deeply involved with the data analysis then performed additional credibility checks through a process of peer debriefing on the frames extracted during the analysis.

B. Survey

<u>Survey Development</u>

The survey we developed, the National Survey of E-Prescribing Physicians, was informed by focus groups, cognitive testing, and site visits to practices using e-prescribing (described in Section A above). The survey was approved by the Institutional Review Board at Massachusetts General Hospital and Brigham and Women's Hospital.

The final survey consisted of thirty-seven multipart questions on the following topics: practice characteristics; use of computerized systems in clinical practice; experience, satisfaction, and beliefs about e-prescribing; barriers and incentives to the implementation of these systems; and respondents' demographics. Responses were either dichotomous (that is, yes or no) or on a Likert-style scale (with answers such as very satisfied, somewhat satisfied, somewhat dissatisfied, very dissatisfied).

We drew our sample of practicing physicians from a comprehensive list maintained by SureScripts, which operates the largest e-prescribing network in the United States. SureScripts lists all physicians enrolled in all US e-prescribing systems. We included only physicians affiliated with one of the fifteen largest e-prescribing vendors as of April 2009.

We included a low-usage stratum to ensure that our sample had sufficient variance in technology use. We defined low usage as physicians who had used the e-prescribing system fewer than ten times per month in the three months prior to the selection of our sample. Our final list included 3,010 regular-use and 954 low-use physicians with accounts established more than three months prior to the sample's selection.

From this list, we selected a random sample of 2,000 physicians practicing in outpatient settings from our two strata (1,540 regular users and 460 low users).We mailed

the physicians a notification letter, followed by a survey packet containing a cover letter, the survey, a "frequently asked questions" sheet about our study, and a $20 check as an incentive for participation. We mailed non-responders two additional survey packets, and we attempted to reach by telephone all of the physicians who still did not respond. We conducted the survey between April and September 2009.

Independent Variables: Our primary independent variable was the type of e-prescribing system used in the physician's main practice site. To categorize the systems, we asked respondents: "Is the electronic prescribing system at your main practice site integrated with an electronic health record or a 'stand-alone' electronic prescribing system?" Other independent variables were respondents' sex, race, ethnicity, specialty, number of years in practice, practice size, clinical setting, location, and region of the country.

Dependent Variables: We assessed ease of prescribing through a series of questions. We asked respondents about the effect of their e-prescribing system on taking care of prescription refill requests; having staff take care of refills; processing refill requests in batches; writing an initial prescription for a new patient; and prescribing within a patient's formulary. We also asked respondents to rate the effect of e-prescribing on the number of phone calls their practice received about formulary errors and about prescription refills (from patients).

We asked physicians to rate their level of satisfaction with their e-prescribing system overall and with certain aspects of it: reliability, flexibility, cost, number of available functions, amount of time it took to learn, quality of the medication database—or the number and types of medications available in the e-prescribing system—and perceived satisfaction of patients.

We examined the effect of e-prescribing on perceived prescribing safety through several questions. First, what effect did the e-prescribing system have on reconciling a patient's medication list—that is, enabling physicians to confirm all medications being taken (made it much harder, or somewhat harder, made no difference, made it somewhat easier, or much easier)? What effect did the system have on the number of phone calls their practice received from pharmacies about prescribing errors? And had physicians avoided triggering a drug allergy or a potentially dangerous drug interaction because of a prompt from their e-prescribing system?

Analysis
We first examined bivariate relationships between the type of e-prescribing systems (stand-alone versus integrated), physician and practice characteristics, and our dependent variables. Finally, we applied a logistic regression model to examine associations between our dependent variables and type of system, after controlling for characteristics of physicians and their practices.

C. Evaluation of e-prescriptions

We obtained data on e-prescriptions written with the Zix PocketScripte-prescribing system in 2008 and 2009. Data files included records of e-prescriptions written and finalized, defined as being printed out, sent to pharmacies, or sent to mail-order services. We also obtained records of alerts that were issued in the process of issuing an e-prescription. These warnings included drug-drug interaction alerts and drug-allergy interactions alerts. Records from Zix also included provider files that contained the characteristics of clinicians using the e-prescribing system.

We obtained claims data from Blue Cross Blue Shield of Massachusetts and Tufts Health Plan of Massachusetts. These files included information on patients and providers, including prescriptions filled and other medical activity. Patient and provider records were merged across the e-prescribing and claims files by the health insurance companies. Crosswalk files were prepared using scrambled versions of the patient and provider identifiers. The research team was provided with these crosswalk files in order to completely protect the privacy of patient data. The quantitative analyses were approved by the Brigham and Women's Hospital Institutional Review Board.

E-prescribing records were analyzed to evaluated how often advanced function of the electronic prescribing system were used and how trends in use of the e-prescribing system changed over time. Additional analyses of how the use patterns of the e-prescribing were reflected in the eventual medications used by patients and the outcomes for those patients are being completed and will be reflected in later manuscripts.

Study Limitations

Our qualitative study approach had several limitations. First, our sample included only physicians who were signed up with an e-prescribing service, so we cannot generalize our results to the entire population of physicians. Second, although we adhered to the best practices of focus group and survey research—for example, sending incentive checks made out to the physicians for the surveys—to ensure that the survey reached our intended respondents, we cannot verify that the survey was completed by the physicians themselves. It is possible that an office manager or other staff member filled out the survey. Third, although we achieved a reasonable response rate for a physician survey, we cannot rule out the possibility that the physicians who responded were different from those who did not. To the extent that there are systematic, rather than random, differences between the two groups, non-response bias could exist. Finally, we could not verify the accuracy of respondents' reports of e-prescribing or reductions in errors using survey methods. In both the surveys and the focus group and observational studies it is possible that respondents gave responses that they thought would be desirable in the study analyses, rather than those reflecting their actual beliefs or behaviors.

Our quantitative study has different limitations. The study population was drawn largely from early adopters of e-prescribing in a state that has a very high rate of penetration by HIT. The matching of physicians and patients across systems was done by the vendors before data was provided to the research team, so we could not trouble-shoot

these linkages. The e-prescribing records do not capture changes that were made in response to call backs to the doctor by the pharmacy or the patients, so our assessments of how physicians used the safety features of the e-prescribing system may not reflect all of the changes in prescriptions relevant for safer prescribing.

Results

A. Focus groups, interviews, case studies:
　　　We identified seven distinct frames about e-prescribing, ranging from positive to neutral to negative.

Positive frames
1) e-prescribing as an efficiency and effectiveness enhancing tool: Efficiency is frequently one of the first effects to be noted when IT is used in place of previously non-automated processes. In our observations, e-prescribing was often noted to significantly influence the productivity of the practice in a positive way. Office personnel were discovering valuable new ways to use it and thinking ahead to what features they would like to see in the future. Several people commented that e-prescribing improved both quality and safety.

2) e-prescribing as the harbinger of new practices: In this frame, people viewed e-prescribing as one component toward the important step of 'connecting everything together'. The term 'transition' was mentioned several times in the context that people viewed e-prescribing as a somewhat simple first step towards adopting more advanced information technologies such as EMRs. They observed that this was going to be the way medical practice would operate in the future. In contexts where such frames exist, the uptake of e-prescribing was significant and there appeared to be few barriers to use. As with the first frame, this frame created an environment where e-prescribing implementation was generally viewed as desirable.

Neutral frames
3) e-prescribing as core to the clinical workflow:
It has been argued that IT is an agent of change, particularly in professional jobs. One significant frame that emerged from our analysis suggested that e-prescribing triggered changes in workflow. This pattern is reflected in extensive use of the technology, seamlessly integrated into the practice workflow. Our analysis suggests that the frame is driven by key decision-makers such as a physician, owners or practice managers, and these opinion leaders encourage other doctors and staff to adopt a similar frame. Actions that emerged as a result of this frame included carrying laptops and personal digital assistants (PDAs) everywhere within the practice: clinicians and staff folded the laptops or left them open and walked with them cradled in the crook of their arm. In several cases, we observed the doctor greeting the patient, then sitting down with the computer at a desk near the patient. While some doctors had the computer opened or immediately opened it on arrival in the room, most did not open it immediately but instead engaged in conversation. After information was received, the doctor used the laptop to enter

pertinent information in the chart. After information was documented, in most cases, the doctor engaged in a brief physical exam. While discussing prescriptions with the patient, the doctor altered the script in the exam room with the patient involved in the conversation. The doctor then confirmed the location of the pharmacy of choice and sent the script. Other examples reinforcing the 'core workflow' frame were queuing up refill and renewal notices by the medical staff, allowing the treating physician to approve the requests electronically in batches. One medical assistant informally responded "I don't even think about it. I'm really not sure how this office would run without it"; it is important to note that integration into the workflow does not necessarily translate into improvement in processes. In fact, some suggested a somewhat ambivalent view of the changes in workflow. One doctor pulled a paper prescription pad from his coat and stated, "it's still a lot easier and faster to just pull this out and write it up", yet he was quick to point out the advantages of e-prescribing. While this theme could be regarded to be positive in nature, there were some instances when it was neutral and even negative.

4) e-prescribing as an administrative tool: Embedded within this frame is the conceptualization of e-prescribing being used primarily by the office staff; physicians are either reluctant to learn or do not believe that it is the best use of their time. As opposed to the example noted above wherein the pharmacy electronically sends renewals and refills to the doctor's office, in this case the medical assistants will consolidate all prescriptions and put them in the doctor's queue, allowing her/him to conduct batched approvals. Interestingly, we noted that both staff and clinicians conceptualized e-prescribing using this frame.

5) e-prescribing as an artifact: We found that viewing e-prescribing purely as a device or tool generated specific feelings and influenced use. Further, the form-factor itself elicited strong feelings, with some envisioning e-prescribing as a PDA-based device, while others viewed it as a PC-based software application. The frames varied with respect to individual conceptualizations of the artifact. An interesting dynamic we observed among the individuals participating in the OM focus groups was that they typically mimed an interaction with a keyboard and/or mouse when they conveyed their use of the system. Often we heard phrases like, "we just click, click, click and it's sent" while moving and clicking an invisible mouse. The clinicians, on the other hand, demonstrated their use by either holding the actual PDA device or mimicking their behavior by holding a tiny invisible device in their hand. There were multiple variations across users from the perspective of this frame. With the administrative staff, we observed two divergent views. Some staff viewed e-prescribing as a 'tethered' activity in which their use would be confined to a physical space in the practice. Other staff acknowledged that certain workstations were reserved for e-prescribing (i.e., "that's where the medical assistants queue up the scripts"), but they did not limit their view of e-prescribing to a specific location. They did, however, suggest that their use of e-prescribing was limited to interactions with a large-screen terminal found on laptops or desktop PCs. In contrast, clinicians believe the technology to be something more mobile - in some cases a small tablet PC but more often a PDA device - that oftentimes provides the clinician with remote capabilities allowing them to log-in away from the office. In most cases with the clinicians, the frame of reference seemed to suggest a small-screen device. This contrast

is notable because it generated opportunities for comments that were specific to the user. For example, clinicians commented on the mobility of the technology (e.g., one doctor said his PDA was as much a part of his attire as his stethoscope), but also the annoyance of using a 'tiny screen'. The staff never commented on small screens but a few nurses mentioned that they 'sit at the computer' longer now.

Negative frames

6) e-prescribing as a necessary evil: The public discourse on HIT in general and e-prescribing in particular has been surrounded by much talk about mandates and incentives to promote use. Thus, it is not surprising that both adopters and non-adopters viewed digitization of healthcare as inevitable. In the case of adopters of e-prescribing, people engaged with the technology because of fiat, mandate, or the desire to receive an incentive for something that they viewed as inevitable. Potential users who had not begun to use e-prescribing experienced significant pressure to adopt, but were often resistant. Illustrative comments included: "We have to do it, but we don't have to like it" (Clinician Interview A); and "This is the way it is all going, whether we like it or not" (Clinician Focus Group A). Overall, users with this frame expressed the sentiment of apathy towards the technology. They may adopt it because they have limited choice in the decision, but their use of it is limited. An office manager described this apathy: "[the e-prescribing package] is up on our computers all day long. But we still use sticky notes and write notes on the chart. No one can believe it."

7) e-prescribing as an unwelcome disruption: Health information technology applications have been classified as disruptive innovations. The adjective 'disruptive' is used in prior work to describe technological innovations in two ways. From one perspective, disruptive innovations are typically inferior to the practice or process they replace in the short term, they introduce new performance dimensions to an industry, and their benefits are not immediately evident to the user population. A second perspective asserts that technologies are disruptive as a result of the upheaval they create in established work patterns and routines. Our analysis revealed both views of a disruptive technology as prevalent among users: some clinicians and OMs believe that e-prescribing use impedes their work, and they see limited or no value in it. Finally, we encountered an interesting subset of clinicians who had very strong feelings about e-prescribing. We term these clinicians, 'near-retirement doctors' who have grandfathered themselves out in that they will retire at the point when e-prescribing becomes fully mandated.

This portion of the analysis shows that technological frames provide a basis for understanding why some practices adopt e-prescribing rapidly while others continue to resist or delay adoption. When decision makers have no frame on which to base adoption and use decisions (e.g., they have little knowledge of the technology and no experience with its use), they will delay or defer the adoption decision until they are able to acquire knowledge about the system. When forced to adopt a technology by external mandate, users may actively resist the technology, misuse it, or otherwise not utilize it in the manner intended by its designers. Thus, the gains realized from technology use are likely to be minimal. Creating an organizational culture that is positively framed may be a precursor to meaningful use. This frame could be accomplished through strong and

frequent messaging about the value of e-prescribing that impacts users in a more visceral way than an operational benefit such as improvements in workflow. One suggestion is to post messages (posters, emails, notepads, etc) about the social welfare aspect of using e-prescribing or identify situations in which safety could have been compromised had it not been for e-prescribing. Thus, practice managers must pay attention to insuring that the benefits and relative advantage of e-prescribing over non-automated prescribing are clearly, consistently, and unambiguously communicated and that the possible limitations are acknowledged in a way that reassures prescribers. In addition, technology vendors must continue to seek guidance from users through all phases of development and implementation in order to fully incorporate best practices in workflow, organizational culture, and usability within the IT design to engender positive frames.

B. Survey

Of the 1,947 eligible respondents, 1,011 completed the survey, which yielded a response rate of 52 percent. Response rates by survey strata were equivalent: 51 percent for physicians in the regular-use stratum and 53 percent in the low-use stratum. Sixty percent of our respondents reported having an integrated e-prescribing system; the rest had a stand-alone system. Those with integrated systems were more likely than those with stand-alone systems to be primary care physicians, to practice in larger groups and in a hospital or medical center, and to have practiced for fewer years. They were also more likely to be regular users of e-prescribing.

<u>Characteristics of E-Prescribing Systems</u>
Nearly all respondents (97 percent) reported that they were able to send prescriptions electronically; 87 percent had e-prescribing systems that included drug warnings or contraindications and the ability to manage refill authorizations. Fewer physicians, although still a majority, reported that their system included access to patients' drug history (62 percent) and formulary (60 percent). Physicians using an integrated e-prescribing system were significantly more likely than those using a stand-alone system to report having the following functionalities: access to patients' drug history, warnings of drug interactions or contraindications, and refill authorizations.

<u>Use of The E-Prescribing System</u>
Physicians with integrated systems were significantly more likely than those with stand-alone systems to report writing prescriptions electronically most or all of the time. Regardless of the type of system used, the majority of physicians also sent prescriptions to the pharmacy electronically. However, those with integrated systems were significantly more likely than those with stand-alone systems to report using this function. Overall, only 56 percent of physicians said that they checked a patient's drug history most or all of the time. Those with integrated systems were significantly more likely than their counterparts with stand-alone systems to report doing this. We found a similar pattern for checking patients' formulary information, although far fewer physicians reported using this functionality.

<u>Ease of Prescribing</u>

We asked physicians about the effect of their e-prescribing system on ease of prescribing. At least half said that their use of e-prescribing made it easier for them to take care of prescription refills themselves, have staff take care of refills, batch process refills, write an initial prescription for a new patient, and prescribe within a patient's formulary. Physicians with an integrated system were significantly more likely than those with a standalone system were to report that e-prescribing made it somewhat or much easier to take care of refill requests themselves, have staff take care of refill requests, and write an initial prescription for a new patient. There were no significant differences between the two groups on the other measures. Approximately one-third of physicians reported reductions in calls about formulary issues, and nearly half reported fewer calls from patients about prescription refills. There were no significant differences on these measures between system types.

Satisfaction with E-Prescribing

The majority of physicians (88 percent) were satisfied with their e-prescribing system overall. Physicians with integrated systems were significantly more likely than those with stand-alone systems were to be satisfied. When asked about specific aspects of their systems, physicians reported high levels of satisfaction on average. At least three-quarters of physicians were satisfied with all of the specific aspects of e-prescribing included in the survey. There were no significant differences between physicians with stand-alone as compared to integrated systems, with one exception: Physicians with stand-alone systems were significantly more likely to be satisfied with the cost of the system.

Effect on Prescribing Safety

Overall, physicians reported that their use of e-prescribing had a positive effect on the safety of their prescribing practices. Sixty-eight percent of physicians reported that their system made it easier to reconcile a patient's medication list, and 57 percent reported a reduction in the number of calls the practice received from pharmacies about prescribing errors. Physicians with an integrated system were significantly more likely than those with a stand-alone system to report these benefits. Half of physicians reported avoiding a drug allergy or a potentially dangerous medication interaction as the result of a prompt from their e-prescribing system. Approximately one-third credited their system with preventing one of these two problems in the six months prior to the survey. Physicians with integrated systems were significantly more likely than those with stand-alone systems to report avoiding a drug allergy or a dangerous medication interaction.

The findings from our survey have important implications for physicians attempting to meet new requirements for meaningful use of e-prescribing. Our data suggest that physicians who already have systems with the required functionalities might not be using them to the extent required by the meaningful-use criteria. This provides further evidence that adoption of technology alone is not enough. Simply transferring functions from paper to an electronic system is not likely to result in substantial improvements in care. Clinicians will need to make changes to their work flow in order to capture the full benefits of the technology. Whether the meaningful-use incentives are enough to encourage physicians to make these changes is not yet clear. This question is

particularly salient in areas with direct financial gains for physicians (efficiency) and payers (formulary checks). Here we did not find a large return on the additional investment that integrated systems require. However, we did see substantial benefits in the area of prescribing safety. If these benefits can be confirmed, and if the financial incentives available to physicians are enough to offset the additional investment in an integrated system, that would strongly support the policy case for incentives to move prescribers toward adoption of integrated systems.

Overall, we found that integrated e-prescribing systems offered incremental benefits over stand-alone systems. Whether these benefits and the meaningful-use incentives offered by the federal government will be sufficient to overcome the cost of moving to an integrated system will be a critical factor in whether the technology is widely adopted. If the incentives function in their intended manner, it is likely that stand-alone e-prescribing systems will become obsolete, replaced by those that can be used to conform to the meaningful use criteria.

C. Evaluation of e-prescriptions

We identified 5,124 physicians who enrolled with the e-prescribing system. There were 1,207 physicians who did not actually initiate use of the system or used the system for very short periods of time, so we did not include these physicians in the subsequent analyses. Among the remaining physicians there were 2,213 who used e-prescribing for 6-12 months, 1,220 who used e-prescribing for 1 to 3 years, and 1,636 who had been using e-prescribing for 3 or more years.

Use of e-prescribing system increased with duration of experience with the system. While physicians who had been using the system for less than a year averaged less than 5 e-prescriptions per week, those using e-prescribing for more than one year averaged 17 per week and those using e-prescribing for more than three years averaged 33 e-prescriptions per week.

As physicians used e-prescribing for longer periods of time, they also became more "active" users. The rate at which physicians used automated features such as preferred pharmacy list and prescription shortcuts increased as duration of system experience increased. Over time physicians changed the method by which they sent e-prescriptions. Initially over 80% of e-prescriptions were converted to faxes for sending to the pharmacy, but during the first year of use this rate decreased and after two years the rates of faxed prescriptions stabilized at 20%. About 15-20% of e-prescriptions were printed to give to the patient and this remained consistent throughout the study period, likely reflecting prescriptions that needed to be in hard copies, such as controlled substances, or medications that patients were mailing to specific services for filling. Electronically delivered prescriptions increased with duration of use and after more than two years of system use between 60% and 70% of e-prescriptions were delivered to pharmacies electronically with no paper involved.

Alerts for drug-drug interactions were commonly displayed to physicians. The most common alerts were for cardiovascular medications (including angiotensin-converting enzyme inhibitors and beta blockers) and psychiatric medications (mostly selective serotonin reuptake inhibitors). The rates were very similar across prescriptions that were completed and prescriptions that were cancelled, suggesting that physician responses to safety alerts may not have varied based on the level of acuity of the medications being prescribed or the alerts being presented.

Additional analyses are currently taking these results for how physicians used the e-prescribing system and its advanced features and correlating them to the prescriptions eventually filled by patients and their clinical outcomes. These analyses will shed light on how the elements of e-prescribing use identified in our analyses relate to patient outcomes.

Overall conclusions and implications

We evaluated the implementation of e-prescribing systems in outpatient medical practices. Our findings have important implications for the future uptake of HIT innovations in outpatient settings and their possible impact. We found that when e-prescribing functionality was integrated into a comprehensive electronic health record, then physicians used more functions of the system and used them more effectively. This finding must be considered as new HIT systems are developed for other medical areas, such as test ordering. If these new systems are done as additional "stand-alone" systems, they are likely to be less effective than if they are integrated well into existing systems. However, our results also showed that the costs of integrated systems are a concern for physicians and practices, which must be considered if new HIT systems are to be mandated. Our quantitative results show that with time using systems, physicians increase the volume and sophistication of their use. Our results indicate that, as more physicians use HIT systems, attention to integration and design will be important to ensure robust uptake and appropriate use by clinicians.

<u>List of Publications</u>

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