CancelRx: A Health IT tool to decrease medication discrepancies in the outpatient setting

Final Report

STRUCTURED ABSTRACT

Purpose: Within the last decade, a new health information technology functionality, CancelRx, emerged to electronically send a medication cancellation message from the clinic's electronic health record (EHR) to the pharmacy's dispensing software to discontinue the prescription. The objective of this study was to measure the impact of CancelRx on reducing medication list discrepancies between the clinic and pharmacy, and to describe the impact of CancelRx implementation on outpatient clinic and community pharmacy work systems.

Scope: CancelRx was implemented in October 2017 at an academic health system, UW Health. Data included patients aged 18+ who had one or more medication discontinuations for an e-prescription that originated from the EHR and was sent to one of UW Health's 15 community pharmacies.

Methods: A interrupted time series analysis (ITSA) was conducted on medication discontinuation data 12-months prior and 12-months after implementation. Interviews were conducted with pharmacy and clinic staff and observations were conducted with pharmacy staff pre-implementation and 3- and 9-months post-implementation.

Results: Pre-CancelRx, 34% of medications that were canceled at the clinic were also canceled at the pharmacy. Post-CancelRx, there was an immediate and significant increase in the proportion of successful medication discontinuations to 93%. Clinic interviews pre- and post-CancelRx revealed a lack of standardized workflow – who, how, and when medications should be discontinued and communicated. Post-CancelRx, pharmacists noted an increase in medication discontinuation messages, not all of which were useful. All participants recognized the implications of CancelRx for patient safety.

Key Words: Medication Discontinuation, Implementation Science, Pharmacy, Health Information Technology

PURPOSE

Despite the implementation of health information technology (health IT) targeting medication safety, ambulatory adverse drug events (ADEs) prompt over four million people to seek medical care[1,2] and result in $8 billion in health care expenditures annually.[3] One enormous and critical gap that health IT has not meaningfully addressed is the electronic communication of medication discontinuation orders between prescribers and pharmacists in the outpatient setting.[4-9]

Prescribers routinely discontinue prescriptions electronically in the electronic health record (EHR) during outpatient clinic visits. Although these modifications are automatically documented in the EHR, medication discontinuation orders are often not communicated to the pharmacy's management software. Instead, such communication is a manual process, delegated to clinic staff who call or fax the pharmacy to notify them of the discontinuation. Given the many demands already placed on clinic staff, these orders are rarely communicated to the pharmacy. Thus, despite being removed from the EHR, discontinued medications remain on the pharmacy list, resulting in medication list discrepancies. EHR and pharmacy medication list discrepancies create a serious and alarming vulnerability that allows discontinued medications, even those discontinued due to a serious adverse drug reaction, to be repeatedly dispensed.[4-9] Indeed, up to 5% of discontinued medications are later dispensed, with 34% of medications meeting the high risk criteria for potential ADEs.[4]

CancelRx is an e-prescribing functionality that communicates a medication discontinuation order between the EHR and pharmacy management software. For over a decade, the National Council for Prescription Drug Programs (NCPDP), which creates pharmacy health IT standards, has recommended the implementation of CancelRx,[10,11] an electronic message generated by the prescriber's EHR to cancel a patient's existing prescription on file in the pharmacy's management software, following the same pathway as an e-prescription. CancelRx has the potential to reduce medication discrepancies in the pharmacy management software and improve medication safety. Previously, CancelRx had not been implemented widely by health systems or pharmacy corporations due to cost and unknown but perceived workflow concerns. However, SureScripts, a major e-prescription vendor, announced that it would remove its financial barrier to CancelRx implementation in community pharmacies. Further, the Centers for Medicaid and Medicare Systems have added CancelRx to the 2017 Stage 3 Meaningful Use criteria to qualify for their EHR incentive program.[12,13] Thus, there is a timely and critical need to determine CancelRx efficacy and impact on work systems.

Our long-term goal is to improve patient safety by implementing health IT tools to facilitate the dissemination of accurate medication information between all modes of health care delivery. Our central hypothesis is that, by

prompting removal of discontinued medications from the pharmacy management software, CancelRx will reduce medication discrepancies, prevent discontinued medications from being dispensed, and reduce ADEs. The rationale for this research is that, once the impact of CancelRx implementation on medication safety and work systems are determined, studies focusing on how to effectively facilitate widespread dissemination and implementation in multiple settings may begin. Specifically, we aim:

Aim 1. To measure the impact of CancelRx on reducing medication discrepancies in the pharmacy management software. We used an interrupted time series design to determine if CancelRx leads to the removal of medications electronically discontinued by prescribers in an outpatient clinic from the medication list in the community pharmacy, and prevents discontinued medications from being dispensed.

Aim 2. To describe the impact of CancelRx implementation on outpatient clinic and community pharmacy work systems. Prior to CancelRx implementation, we interviewed pharmacy and clinic staff and observed pharmacy staff to record baseline work processes. We repeated observations and interviews at 3 and 9 months following CancelRx implementation to understand the intervention's impact.

SCOPE

Background and Context

Adverse drug events (ADEs) prompt four million people to seek medical care, costing the U.S. health care system over $8 billion annually, despite the implementation of health IT.[1-3] The implementation of health IT applications, such as e-prescribing and clinical decision support, has been proven effective at decreasing ADEs and improving medication safety.[14,15] However, a health IT tool has not yet been implemented to address the potential ADEs associated with the dispensing of discontinued medications. The need to address this source of ADEs is critical given that up to 5% of discontinued prescriptions were later dispensed,[9] and that 34% of discontinued prescriptions met the high risk criteria for potential ADEs.[4] Perhaps most alarming, numerous cases have been reported illustrating potentially disasterous consequences of dispensing discountinued medications to patients.[6]
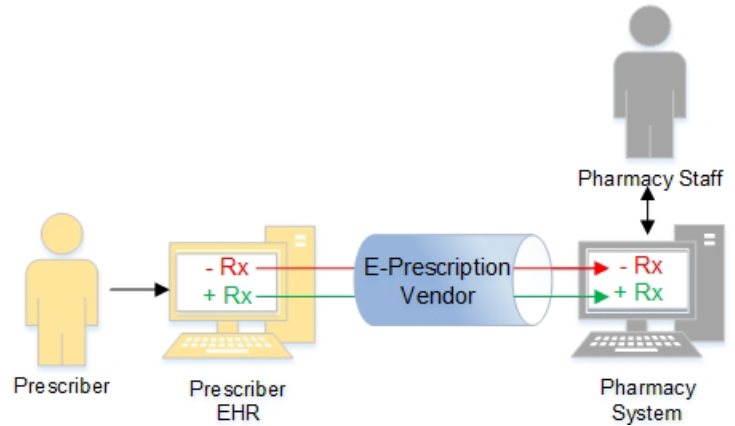
Prior to CancelRx, medication discontinuation orders were rarely communicated to the community pharmacy. The primary responsibility of communicating discontinued prescriptions to the pharmacy resided within the outpatient clinical staff pool. When prescriptions were modified or discontinued by the prescriber, a message was sent to the outpatient clinical staff, made up of primarily medical assistants, to call or fax the pharmacy to inform them of the discontinued medication. However, medical assistants' primary responsibility is to maintain efficient clinic flow.[16] To do this, they are asked to prioritize and perform many tasks. Because the message is sent to a pool of individuals, it is frequently unclear who will accept responsibility for completing the task. This is made even more difficult because the medical assistants had received virtually no training on how to efficiently complete the task, thus implying that the task is not of high priority. Consistent with all patient care responsibilities, prescribers were ultimately accountable. Yet one study found that prescribers attempted to communicate with pharmacists to discontinue a medication in just 0.2% of new prescription orders.[17]

The lack of communication between prescribers and pharmacists when medications are electronically discontinued led to EHR and pharmacy management software medication list discrepancies. Indeed, one study found that 41% of medication discrepancies between the clinic and pharmacy medication lists were from discontinued medications.[18] Another study showed that over 10% of dispensing errors in a community pharmacy were due to a pharmacist selecting a discontinued drug or dose still listed in the pharmacy management software.[5]

Intervention

Within the last decade, a new health IT functionality has emerged to electronically send a medication cancellation message from the clinic's electronic health record (EHR) to the pharmacy's dispensing software and automatically discontinue the prescription record.[10] This functionality, termed CancelRx, could reduce medication list discrepancies by automating the previously manual process of pharmacy staff discontinuing cancelled prescriptions.

CancelRx functions by automatically sending an electronic notification of a medication discontinuation from a clinic's EHR to a pharmacy's dispensing software. After a clinic prescriber has discontinued a medication and indicated that the pharmacy should be notified, the order is processed by SureScripts. If the medication was originally ordered as an electronic prescription, it contains an e-prescription order ID that acts as an electronic 'trail' to connect the medication in the clinic EHR to the prescription in the pharmacy dispensing software. The original e-prescription Order ID allows for the pharmacy dispensing software to automatically match the CancelRx message with the associated original e-prescription and discontinue/suspend it in the system—preventing it from future processing. For the cancellation message to be electronically transmitted via CancelRx, the functionality must be turned on for both the clinic sending the message and the pharmacy receiving the message. In the event an electronic Order ID is not available or cannot find an automatic match, the pharmacy staff can manually match a CancelRx message with an associated prescription. If the prescription 1) cannot be matched to a prescription in the pharmacy management software; or 2) is no longer active or valid, was transferred to another pharmacy, or another such appropriate scenario; then a CancelRx 'Denied' response is sent back to the prescriber's EHR.

In 2017, a large e-prescribing vendor removed the financial restraints on the use of CancelRx and implementation began to spread. E-prescribing vendors act as a third party mediator that allows the communication between the clinic EHR and pharmacy dispensing platform to take place.

Setting

UW Health is the integrated health system of the University of Wisconsin-Madison serving more than 600,000 patients each year in the Upper Midwest and beyond with 1,400 physicians and 16,500 staff at six hospitals and 80 outpatient sites. UW Health has 15 pharmacies

UW Health began implementing the Healthlink EHR (Epic Systems Inc., Verona, WI) system-wide in 2006. E-prescribing is currently the preferred route of prescribing at their outpatient clinics. UW Health clinicians e-prescribe over 1.5 million prescriptions annually.

UW Health community pharmacies implemented Enterprise Rx (McKesson, San Francisco, CA) in 2008. Enterprise is a pharmacy management software and is a different system than Healthlink EHR. Enterprise serves as the primary health IT tool to verify the accuracy and appropriateness of, and dispense prescription medications in the community pharmacy. The patient information that resides in Enterprise includes patient demographics, allergies, and the medication list. The patient's problem list, diagnoses, or laboratory values are not documented in Enterprise. Clinical decision support exists within Enterprise but primarily addresses drug-drug and drug-allergy interactions. The patient's medication list includes all prescription medications that have been dispensed from a UW Health community pharmacy. UW Health pharmacists have read-only access to the EHR and thus can view the medication list in the EHR, but doing so requires logging into a separate system and departs from their normal workflow. They cannot edit the medication list; however, they do have in-basket messaging capabilities. E-prescribing is currently the preferred route of receiving new or refilled prescriptions. UW Health Pharmacies fill approximately 500,000 prescriptions annually.

CancelRx was introduced as part of a larger health IT update in October of 2017 at UW Health Hospital and Clinics, with all prescribers gaining access to this functionality at the same time.

Participants

Participant data included in the data pull were adult patients aged 18+ who had one or more medication discontinuations for an e-prescription that originated from the UW Health EHR and was sent to one of UW Health's 15 community pharmacies (accounting for approximately 10% of all ambulatory prescriptions generated by UW Health). At the time CancelRx was implemented, the e-prescribing of controlled substances

was not available for all UW Health prescribers. Due to this uncertainty of controlled substance e-prescribing practices, controlled substances were excluded.

Three medical assistants (MAs) at each of three UW Health clinics were recruited to participate in interviews at the three time points. MAs are the individuals in the outpatient clinics who are primarily responsible for contacting the pharmacy when a medication is discontinued (pre-intervention), and who we anticipated would be the most likely individuals responsible for addressing CancelRx 'denial' messages once CancelRx was implemented.

Three pharmacy personnel at each of the three UW Health were recruited to participate in observations and interviews at the same time points. Individuals recruited were responsible for accepting electronic prescriptions and CancelRx orders. Pharmacy administrators were also interviewed 9 months post-implementation.

METHODS

Study Design

The conceptual model for this study is adapted from the Interactive Sociotechnical Analysis (ISTA) framework. ISTA has been applied to understand why and how unintended consequences of health information technology occur.[19-21]

The ISTA framework is a conceptual model that uses a work system approach to understand how unintended consequences arise from the implementation of health IT. Its premise is that undesirable outcomes flow from the interplay between the new health IT and the work system. The work system is divided into two components: the health care organization's existing technology (referred to as the technical system), and the health care organization's existing workers, workflow, culture, tasks and work processes, and social interactions (referred to as the social system). These interactions together are referred to as sociotechnical interactions. The ISTA framework recognizes that the "actual use" of the health IT must be examined, not just the health IT "as designed." It also emphasizes the recursive nature in which the social system interacts with the health IT to mediate how it is used, which can then change the social system.

The ISTA framework was appropriate for this study because it emphasized the importance of examining how CancelRx is actually used, and the impact of CancelRx use on both the technical and social components of the two work systems: the outpatient clinic where CancelRx is generated, and the community pharmacy where CancelRx is received.
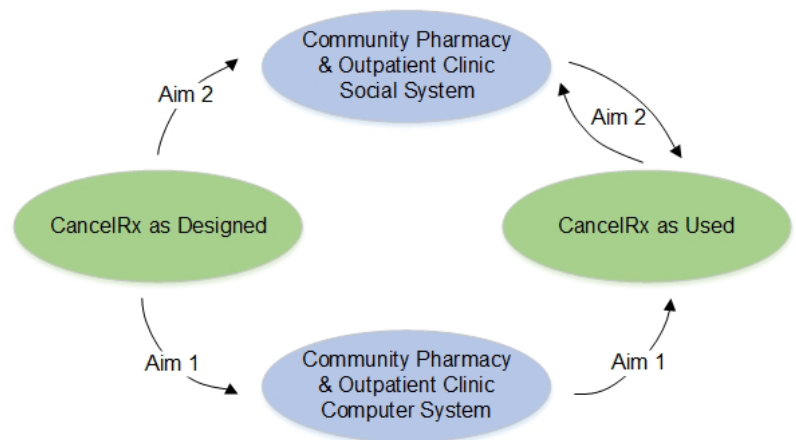
In Aim 1, we examined the effect of CancelRx on removing discontinued medications from the community pharmacy management software. A CancelRx transaction is generated and sent from the EHR when medications are electronically discontinued. Successful transmission required that the community pharmacy management software be modified to allow for incoming CancelRx messages, allow for messages to be generated by the community pharmacy computer system back to the EHR, and provide an efficient way to deactivate the discontinued medications. Therefore, the design of community pharmacy management software mediated how CancelRx is operationalized in the community pharmacy.

For Aim 1, an interrupted time series pre (control) / post (intervention) test was conducted to determine the impact of CancelRx on decreasing medication discrepancies in the pharmacy management software. We measured the percentage of discontinued prescriptions from the pharmacy management software each week for 12 months (i.e., 52 observations), both pre-intervention and post-intervention, in order to minimize threats to internal validity. This design is robust because it evaluates the longitudinal effect of CancelRx and controls for trends in the outcome.[22] It is appropriate when the measurement is unobtrusive and respondents are not reacting to multiple testings.

In Aim 2, we identified how CancelRx implementation impacts both the outpatient clinic and the community pharmacy social systems (focusing on the people in the system, the tasks they perform, and the organizational culture). The clinic and pharmacy social systems interacted with CancelRx as designed to affect how CancelRx was used. Because the ISTA framework emphasizes the recursive and iterative nature of these relationships, we collected data following CancelRx implementation to assess how the outpatient clinic and community pharmacy social systems shaped CancelRx over time. Interviews with medical assistants at three UW Health outpatient clinics, and interviews and observations in three UW Health community pharmacies were conducted prior to CancelRx implementation to collect baseline work processes. Two additional rounds of interviews in the outpatient clinics, and observations and interviews in pharmacies were conducted at 3 months and 9 months following implementation.

Aim 1 Data Sources, Data Collection, and Measures

The research team used an interrupted time series analysis (ITSA), a longitudinal quasi-experimental design, to evaluate the effect of CancelRx to decrease medication discrepancies in the EHR and pharmacy management software.[22-25]

Data collection took place during a 12-month pre-intervention and 12-month post-intervention period. Each measurement constituted one week in the time series. The post-intervention period started 4 weeks after CancelRx implementation, as an a priori burn-in period to allow for resolution of technical problems after CancelRx go-live.

Data were extracted and merged from the clinic EHR and pharmacy dispensing software using an e-prescription order ID when available. To account for instances when an e-prescription order ID did not exist, EHR and pharmacy dispensing data were matched on the following variables: patient gender, drug description (name, strength), ordering department, and a drug discontinuation time within a 72-hour window between the clinic and pharmacy systems. For this study, only cancellation messages in which a prescriber indicated that the pharmacy should be contacted were included in the analysis.

Interrupted Time Series Analysis (ITSA)

The research team conducted the ITSA to model the occurrence of "successful" discontinuations in which a medication that was discontinued in the clinic's EHR was also discontinued in the pharmacy's management system. For this study, "successful" discontinuation was one in which 1) discontinuation data matched 2) the medication was discontinued in EHR, and 3) the medication was discontinued in the pharmacy dispensing software within 72 hours. The team used Prais-Winsten estimation for the ITSA.[26] The analysis was conducted in STATA.[27]

Sample Subsets

In addition to the overall ITSA comparing the discontinuation of medications over time, the research team also compared the proportion of successful cancels for various subsets: patient comorbidity status and clinic type.

Patient comorbidity was calculated as part of the initial data pull request, utilizing ICD-9 and ICD-10 administrative data to calculate a Charlson Comorbidity Index.[28,29] Patients were dichotomized as high- or low-comorbidity status by comparing each individual's value to the sample mean, Comorbidity Index = 2.94.

The research team subset the data based on the type of clinic in which the cancellation message originated. A clinic was deemed as either primary care—consisting of internal medicine, family medicine, general pediatric, general geriatric or obstetrics/gynecology—or specialty practice (e.g. gastroenterology, cardiology, endocrinology, etc.).

Time to Discontinuation

The research team conducted the time-to-discontinuation analysis by comparing the date of discontinuation in the EHR data to the pharmacy data. The time to discontinuation was aggregated and averaged for each week in the study period and compared over time using Regression with Newey-West standard errors.[30,31]

Aim 2 Data Sources, Data Collection, and Measures

In order to understand the clinic and pharmacy work systems and how its characteristics facilitate and hinder implementation and use of CancelRx, data were collected at three time points: pre-intervention, 3-months post-intervention, and 9-months post-intervention.

The focus on the pre-intervention data collection was to gather baseline information about current work processes, workflow, and workload. The focus of the 3-month post-intervention data collection was to understand adoption and implementation of CancelRx in the clinic and pharmacy work systems. The focus of the 9-month data collection was to understand how the work systems reshaped to facilitate maintenance of effective CancelRx use.

Medical Assistant Interviews: A total of 27 interviews with end users were conducted (three interviews pre-intervention, three interviews 3-months, and three interviews 9-months post-intervention at each of 3 outpatient clinics). The focus of the medical assistant interviews was to understand how medication discontinuation orders are communicated to the medical assistants, how they respond to said orders, facilitators and barriers to timely response, impact of orders on their workflow and workload, and perceived outcomes. Each interview lasted about 30 minutes and was audio recorded and transcribed.

Pharmacist/Technician Observations: The purpose of the observations was to gain insight on fit and compatibility of the intervention within the pharmacy work system. A total of 27 3-hour observations (three pre-intervention, three 3-months, and three 9-months post-intervention) were conducted at each of the three UW Health pharmacies. Prior to CancelRx implementation, the focus of the observations was to understand the current work system with an emphasis on how pharmacy personnel accept e-prescriptions, how they inactivate discontinued prescriptions, and who is responsible for these tasks. The focus of the observations after CancelRx implementation was to witness firsthand how pharmacists and technicians respond to and use CancelRx. We observed how the intervention impacts pharmacists' and technicians' work with a focus on how they incorporate this added responsibility into their workflow. Observational data were recorded by hand. Immediately after each observation, the researcher took time for reflection to make comments in her journal regarding her experiences and the data that was collected. The data were then transcribed into typed notes.

Pharmacist Interviews: The purpose of the interviews was to understand how medication discontinuation orders are received and responded to by pharmacy staff, facilitators and barriers to discontinuing the orders in the pharmacy management software, and the impact of those orders on their workflow and workload. A total of 27 interviews with end users were conducted (three interviews pre-intervention, three interviews 3-months, and three interviews 9-months post-intervention at each pharmacy). The interviewee was asked to think about instances when medications were or were not discontinued and to describe the circumstances surrounding those events. At 9-months post-CancelRx, three pharmacy administrators were interviewed (replacing three community pharmacists) to gain additional administrative insight into CancelRx implementation, best practices, and additional recommendations. The interviewer also incorporated examples and factors that contributed to use (witnessed during the observations); this helped frame the discussion so the interviewee understood that the focus was on the work system factors as contributors to CancelRx use. Interviews also elicited descriptions of each respondent's role and how the intervention was implemented in their pharmacy. Guided by the ISTA framework, unintended consequences related to more/new work, the organizational culture and expectations were also explored.[32]

Proactive Risk Assessment: A multi-step analysis process was used to conduct a proactive risk assessment that included: 1) generation of a process map iteratively refined through several full research team meetings, 2) identification of vulnerabilities and consequences associated with each step in the process map initially by the engineers, public health researcher, and pharmacists, and further refined by the physicians, 3) identification of actors (pharmacy staff, prescriber, clinic staff, patient, technology) involved with each vulnerability by the research team, 4) identification of vulnerability themes by research team.

Limitations

This study is limited in its generalizability to the extent that it occurred within one health system. Additionally, the outpatient community UW Health pharmacies had access to EHR records, a resource that is often not available to retail community pharmacies. This access may have influenced the medication discontinuation process in the pre-CancelRx period in which pharmacies could refer to the patient's EHR record instead of calling or contacting the clinic directly. Future studies must assess the impact of CancelRx across health

systems and pharmacies—studying how CancelRx functions and communicates between two disparate organizations.

A second limitation of this study is how the medication orders were matched between the clinic and pharmacy systems, especially in the pre-period. The attempt to merge data from two separate systems (the clinic EHR and pharmacy dispensing software) was challenging as prior to CancelRx, little record of this third-party medication order ID existed. The research team utilized a rigorous matching process to link the two datasets as defined in the methods, however; some of the successful matches may have been missed or underrepresented.

A third limitation, specifically related to the qualitative data, was the nature of the pharmacist staffing throughout UW Health. Pharmacists often "floated" or worked at several of the 15 UW Health Community Pharmacies. This made it difficult, at times, to locate and observe the same pharmacist at the same location across all three time points. For example, one pharmacist may have worked at three different pharmacies pre-CancelRx, 3-months post-CancelRx, and 9-months-post-CancelRx. Beyond the difficulties of data collection, this proved to be a limitation when trying to isolate CancelRx variability based on pharmacy location, alone. This limitation was minimized because pharmacy policies and procedures were often set by UW Health administration, at large, but the impact of location-specific variability cannot be entirely discredited.

RESULTS

Aim 1 Principal Findings and Outcomes

Outcome 1: Percentage of Successful Discontinuations Over Time

The ITSA for the entire dataset is illustrated in Figure 1— the x-axis depicts time (in weeks) with a vertical line at Week 56 indicating CancelRx implementation, and the y-axis depicts the proportion of successful medication discontinuations between the clinic and pharmacy system.
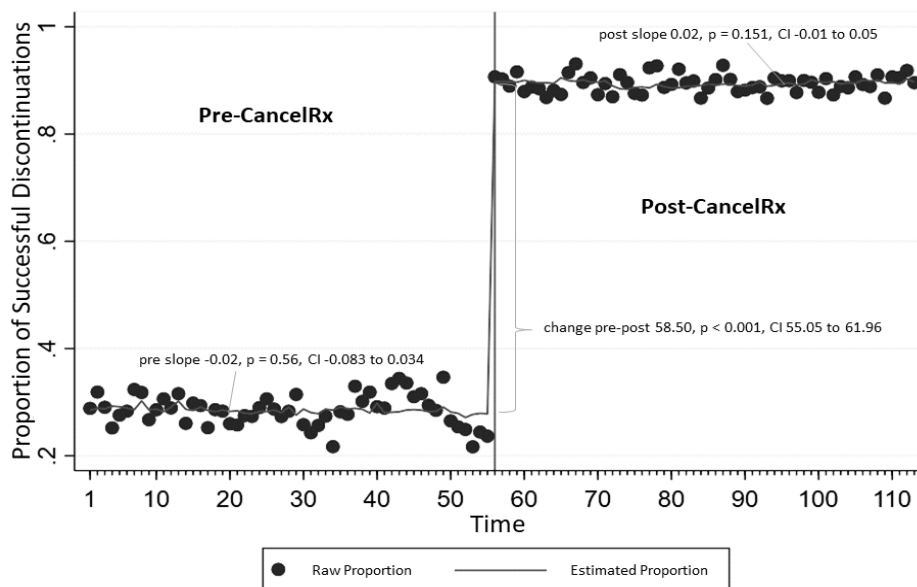

Pre-CancelRx

post slope 0.02, p = 0.151, CI -0.01 to 0.05

Post-CancelRx

change pre-post 58.50, p < 0.001, CI 55.05 to 61.96

pre slope -0.02, p = 0.56, CI -0.083 to 0.034

● Raw Proportion ——— Estimated Proportion

Figure 1 Successful Medication Discontinuations Pre- and Post-CancelRx Implementation

Figure 1 illustrates several pertinent findings. First, in the year prior to CancelRx implementation, the trend (i.e. slope) was fairly stable, with the y-intercept at 34%. There was, however, slight variance in the 15 weeks prior to implementation. Second, there was an immediate and significant increase in the proportion of successful medication discontinuations after CancelRx implementation, with an average of 92.78% prescriptions successfully discontinued in the post-period. Third, in the year after CancelRx implementation, the trend post-intervention was stable, suggesting that the technological intervention and impact were sustained.

Outcome 2: Subgroup Analyses of Percentage of Successful Discontinuations Over Time

Patient Comorbidity:

Figure 2 illustrates the ITSA comparing the proportion of successful medication discontinuations for individuals with low comorbidity status (Charlson Comorbidity Index < 2.94), or high comorbidity status (Charlson Comorbidity Index ≥ 2.94). The ITSA found that there were significant differences between the proportion of successful medication discontinuations pre- and post- CancelRx. High-comorbid patients had a significantly greater percentage of medications that were discontinued in the clinic and pharmacy system in the year prior to CancelRx implementation.

In the year following CancelRx implementation, however; patients with low-comorbidity had a significantly greater percentage of medications that were successfully discontinued at the clinic and pharmacy. The horizontal slopes in the post-CancelRx period indicate the sustained impact of this technological intervention.
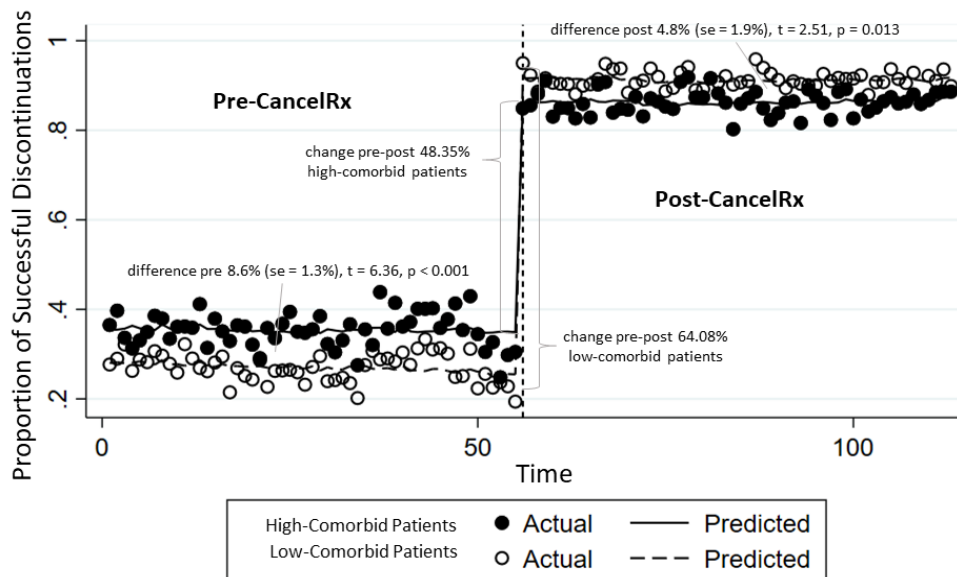

Figure 2 Successful Medication Discontinuations Pre- and Post-CancelRx Implementation by Patient Comorbidity

Clinic Type

Figure 3 illustrates the ITSA comparing the proportion of successful medication discontinuation based on the type of clinic that originated the discontinuation order. The two clinic types were primary care or specialty care. The ITSA found that there were significant differences between the proportion of successful medication discontinuations pre-CancelRx implementation. These two clinic subsets converged after the intervention launched –after CancelRx implementation, there was no significant difference in the proportion of successful discontinuations across the two clinic types.
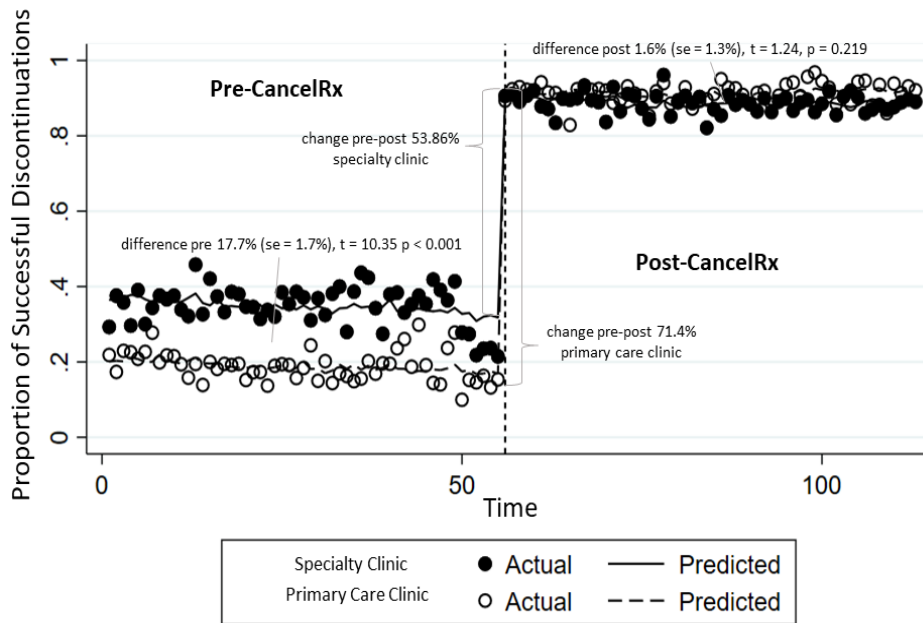
Figure 3 Successful Medication Discontinuations Pre- and Post-CancelRx Implementation by Clinic Type

Outcome 3: Time to Discontinuation Between Clinic System and Pharmacy Software Over Time

The final outcome of the study was to compare the average amount of time between discontinuation in the clinic system and pharmacy dispensing system pre- and post- CancelRx, this is represented in Figure 4.

It is important to note that while clinic EHR data contained the exact date and time of a medication discontinuation, the matched data in the pharmacy dispensing software contained only the day (no timestamp). Therefore, when matching the clinic and pharmacy data, prescriptions that were discontinued on the same day were coded as 0, prescriptions that were discontinued in the pharmacy on the following day were coded as a 1, etc. When these orders were aggregated and averaged over a week, they often represented values that represented the proportion of days (i.e. 0.5 days would be the result of averaging an order which took 1 day and order which took 0 days). To make the results easier to view and comprehend, these proportions of days were converted into hours (i.e. 0.5 days = 12 hours); however, these values are extrapolated and do not necessarily represent the specificity allowed in the data.

In the year prior to CancelRx implementation, the time required for a medication cancellation order to be discontinued in both the clinic EHR and pharmacy dispensing software varied (y-intercept 11.854, se = 0.639, t=18.55, p = 0.00, CI 10.587 – 13.216) — some prescriptions took several days while others were completed on the same day.

In comparison, after CancelRx implementation, medication discontinuations were all completed on the same day. This difference in pre- and post-CancelRx emphasizes that the instantaneous technology significantly reduced variation in the time to discontinuation (difference of 12.93 hours, p = 0.00).
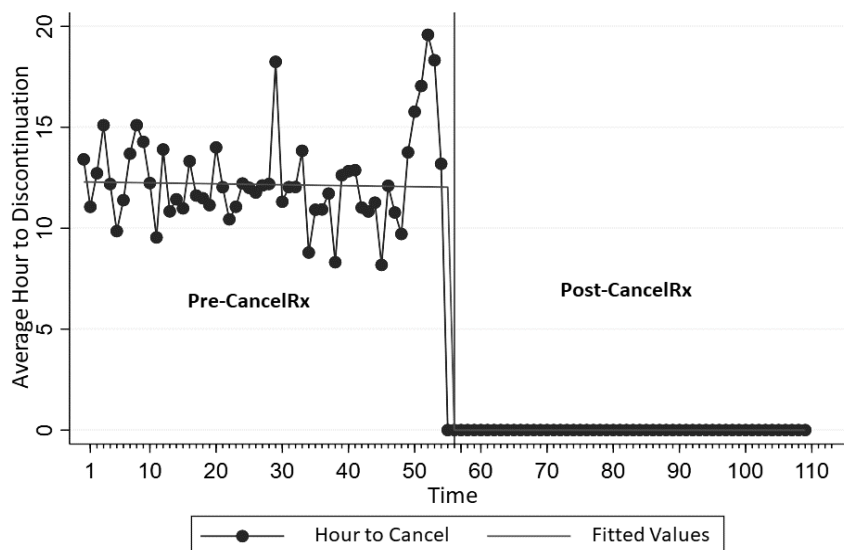
Figure 4 Average Time to Discontinuations Pre- and Post-CancelRx Implementation

Aim 2 Principal Findings and Outcomes

Clinic Work System Outcomes

<u>Prior to CancelRx</u>
There were numerous avenues in which a medication was discontinued or cancelled in the clinic electronic health record (EHR). First, when a patient appeared for their clinic visit, they were taken to their examination room and triaged by a medical assistant (MA). As part of this triage, the MA reviewed the patient's medication list (as found in the EHR) and asked the patient if they were currently taking the medication. If the patient replied that, "no" they were no longer taking the medication, the MA may simply mark the medication as "Not Taking" in the patient's record, leaving documentation for the prescriber/practitioner to review and discuss later, or they may choose to discontinue the medication altogether from the patient's record.

There was uncertainty by the MAs as to whether or not they felt responsible for discontinuing medications from a patient's profile. Some MAs stated that organizational policy prohibited them from removing medications from a patient's medication list without direct orders from a prescriber. Others stated that they were able to and felt comfortable removing medications from a patient's profile as long as they were "external" medications (ones that were not prescribed by the UW provider and simply reported by the patient), or those that were for over-the-counter (OTC) medications or for acute conditions (i.e. antibiotics for a mild infection). Additionally, there were some MAs who stated that they had established relationships and protocols with their physicians that allowed them to discontinue/remove medications from a patient's medication list (for situations other than those for OTC or acute medications). Overall, there seemed to be variability in the role and responsibilities of MAs with regards to the task of discontinuing or removing a medication from the patient's list in the EHR.

A final way in which a medication may be discontinued in the clinic EHR was when it was removed by a prescriber/practitioner. This could be the result of a clinical decision (such as a medication or dose change, completion of therapy), addressing an instance in which a patient reported that they were "not taking" a particular medication or as with the MAs, removing medications from external providers, OTCs, or acute treatments.

After a medication was discontinued or removed from a patient's medication list in the EHR (whether by a MA or a provider), the individual had the opportunity to select the "Reason for Discontinuation." Some of those reasons included the further directive to "send cancel msg to pharmacy." When a medication was discontinued, and the reason for discontinuation was left blank or included directions to "send a cancel msg to the pharmacy" a task/message was generated, instructing the MA or clinic staff to contact the patient's pharmacy. This message was conveyed to the clinic staff through "Inbox" messages, specifically in the "Medication Discontinuation" folder. Prior to CancelRx, there was variability as to whether or not MAs knew that this folder

(containing these messages) even existed. Throughout the pre-CancelRx interviews, some appeared to be very knowledgeable about the process, while others were only alerted to it via the study. Similarly, the interviews detailed that there was variability in whether or not the MAs completed these tasks, and "followed through" with actually calling the pharmacy. Some MAs insisted that they contacted the pharmacy for every patient seen by their designated provider, and some MAs called on every patient regardless of the provider seen in the clinic. MAs often stated they contacted the pharmacy for some medications but not others, using clinical judgement to determine if a pharmacy needed to be contacted. Medications which they stated warranted calls included medications for chronic conditions or with the potential for serious adverse drug events; medications that did not warrant calls included OTCs, or medications without refills (including acute therapies like antibiotics). Additionally, some MAs knew about the Inbox messages but said they did not have enough time or were not able to prioritize contacting the pharmacies regarding medication discontinuations.

Overall, there was a great deal of variability in the workflow/process surrounding medication discontinuation in the clinic prior to CancelRx and MAs stated that they received no formal training on the medication discontinuation process.

<u>Post CancelRx</u>
CancelRx was implemented as part of a system-wide EHR update in October 2017. Overall, the workflow and systems surrounding the identification and discontinuation of medications did not change—providers (or MAs) were still able to discontinue medications and select a reason for discontinuation that indicated the pharmacy should be notified. The main difference, however; was that instead of creating a task for the MAs to contact the pharmacy through an Inbox message, SureScripts (a third-party health information network used to communicate between clinics and pharmacies), attempted to generate a CancelRx transaction that would communicate the information electronically. In order for CancelRx to be sent, the functionality must be "turned on" at both the clinic (sender) and pharmacy (receiver). For the purposes of this study, UW Health Pharmacies were able to receive CancelRx messages. If, however, the pharmacy functionality was not supported the CancelRx would "fail" and the system would create an inbox message task for the MAs to complete exactly the same as in the pre-period. If the CancelRx was sent to the pharmacy and successfully discontinued the medication, no further action was needed on behalf of the clinic staff/MA/provider. If, however; the pharmacy was unable to cancel the medication as detailed in the CancelRx message [described further below] a "failure" message was returned to the clinic via SureScripts and an Inbox message was created notifying the staff.

Pharmacy Work System

<u>Prior to CancelRx</u>

Within the study community pharmacies, the workflow was organized into a series of queues: inbound communication queue/reception, data entry, pre-verification, product dispensing, verification, and release to patient/will call. The steps and tasks involved in each of these queues are described in Figure 5 below. When a new prescription arrived at the pharmacy (whether electronically, via paper, phone, or fax) the prescription flowed through the following queues until the designated medication/product was dispensed to the patient. Prior to CancelRx, information regarding a cancelled medication could be communicated in many ways:

- Patient (in person, phone)
- Clinic Personnel/Provider
    - As a note/comment on a new prescription or refill request
    - Call or voicemail
    - Fax
- Electronic Health Record
    - Pharmacists have access to the patient's EHR and can review notes/encounters

Pharmacists stated that they received cancellation messages infrequently, often approximating 3-5 each week. In theory, any pharmacy staff member (a technician, clerk, intern, or pharmacist) could receive these medication cancellation messages and discontinue them from the patient's record. When a medication discontinuation message was received, the pharmacy staff member navigated to the patient's medication profile, which lists all of the patient's active medications that they were in theory taking (this is different from the patient's transaction profile which is a comprehensive list of all the individual fills/refills for each medication, for example whereas the patient profile may list Lisinopril 20 mg once and the last fill date in September, the transaction profile may have Lisinopril 20 mg listed on 6 lines indicating refills in September, August, July, June, May, and April). Once in the patient's medication profile, the staff member selected/highlighted the medication and chose to discontinue/deactivate the item. This removed/canceled any future refills on the product. Additionally, a pop-up appeared, allowing the staff members to leave a comment or note as to why the medication was discontinued (i.e. replaced by new product, patient states not taking, allergic reaction, etc.).
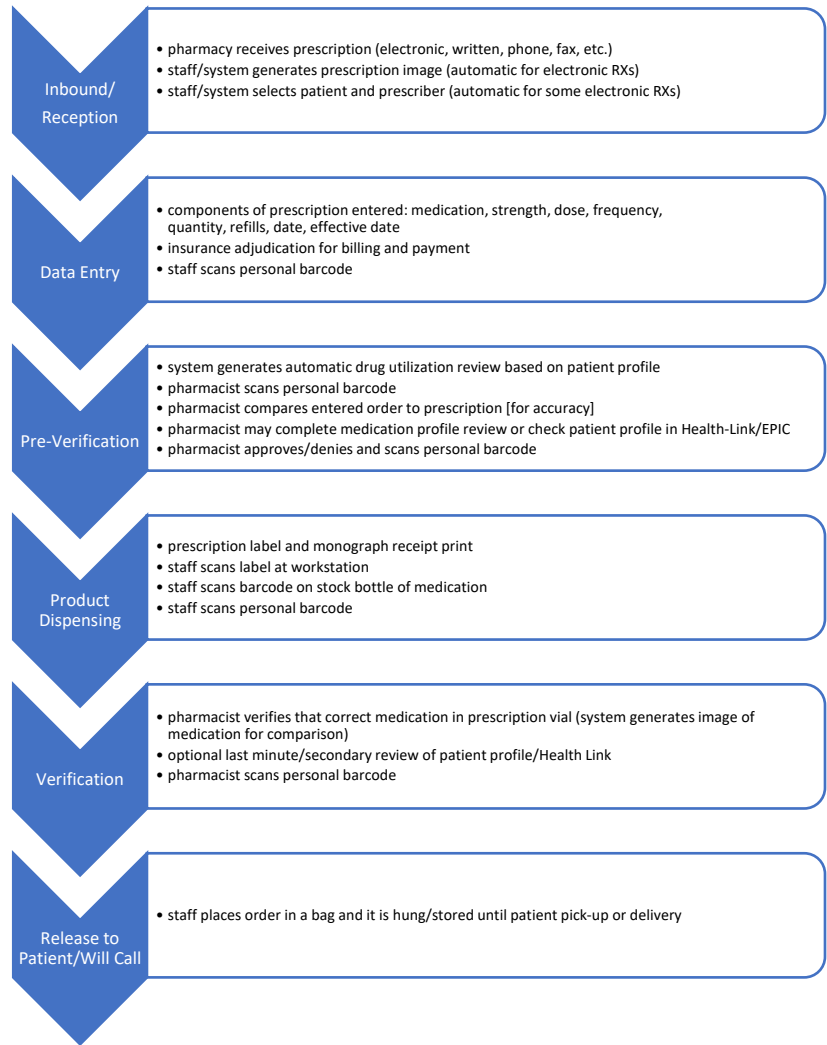
Inbound/Reception
- pharmacy receives prescription (electronic, written, phone, fax, etc.)
- staff/system generates prescription image (automatic for electronic RXs)
- staff/system selects patient and prescriber (automatic for some electronic RXs)

Data Entry
- components of prescription entered: medication, strength, dose, frequency, quantity, refills, date, effective date
- insurance adjudication for billing and payment
- staff scans personal barcode

Pre-Verification
- system generates automatic drug utilization review based on patient profile
- pharmacist scans personal barcode
- pharmacist compares entered order to prescription [for accuracy]
- pharmacist may complete medication profile review or check patient profile in Health-Link/EPIC
- pharmacist approves/denies and scans personal barcode

Product Dispensing
- prescription label and monograph receipt print
- staff scans label at workstation
- staff scans barcode on stock bottle of medication
- staff scans personal barcode

Verification
- pharmacist verifies that correct medication in prescription vial (system generates image of medication for comparison)
- optional last minute/secondary review of patient profile/Health Link
- pharmacist scans personal barcode

Release to Patient/Will Call
- staff places order in a bag and it is hung/stored until patient pick-up or delivery

Figure 5 Pharmacy Dispensing Process

In general, during the pre-CancelRx interviews pharmacists stated they rarely communicated back to the clinic/provider indicating that the medication had been successfully discontinued (unless there was a question). Also, they stated that they may communicate this information to the patient if instructed to do so by the cancellation message, but many had assumed that the patient was aware of the changes and informed by the provider/clinic. When discussing the medication cancellation process with pharmacists, many interviewees stated they were unsure if technicians felt comfortable discontinuing a medication in the patient's profile and may defer/communicate these messages to the pharmacist to utilize clinical judgement. In discussing the possibility of the CancelRx functionality, some pharmacists were concerned that CancelRx would create *more* work, communicating messages for prescriptions that were already discontinued (such as antibiotics) or had no refills (such as controlled substances). Overall, however; many recognized the patient safety concerns and vulnerabilities associated with medication list discrepancies between clinics and pharmacies and were able to cite examples.

Post CancelRx
After CancelRx implementation, the overall workflow for processing an electronic prescription did not change. There was, however; a change in the way the majority of medication discontinuation messages were communicated. Post implementation of CancelRx, most medication cancellations messages were arriving to the pharmacy via CancelRx. Interviewees stated that they received cancellation messages much more frequently than prior to CancelRx, approximately 20-50 per week on average.

CancelRx messages were received at the pharmacy in the Inbound/Reception communications queue (the same location as new e-prescriptions). These messages were indicated by a small icon that stated "PPI Cancel" [PPI = Pharmacy Prescriber Interface, aka SureScripts] and order information that stated either "CancelRx Matched" or "CancelRx Not Matched." According to UW Health Pharmacy policy, these messages were only to be addressed and acknowledged by the pharmacist (not technicians or other pharmacy staff members). When a pharmacist clicked on a CancelRx message, a pop-up screen appeared, depicted by Figure 6 below. The CancelRx message contained information pertaining to the patient, the written and dispensed product, the prescriber, and whether or not the medication was currently being processed.

PPI CancelRx Message	PATIENT	WRITTEN PRODUCT	PRESCRIBER	PPI MESSAGE DETAILS
	Patient Name Address	Drug Refills (last fill date) SIG	Prescriber Name Address	
Matched Details	PATIENT	WRITTEN PRODUCT	PRESCRIBER	MATCH INFO
	Patient Name Address	Drug Refills SIG	Prescriber Name Address	
No Item in Workflow				
RX# / Store #	Workflow Status	Dispensed Product	Fill Date	Prescriber

Figure 6 CancelRx Message Example

When the CancelRx was "matched," both the first and second sections were complete; the pharmacist then reviewed the message as they saw fit. In the 3-months post intervention implementation observations, most pharmacists investigated the message in some fashion. Either by navigating to the patient medication profile and transaction profile, or by logging in to the clinic EHR to read the most recent patient encounter/note regarding the medication discontinuation. Many pharmacists commented on how they wished that the CancelRx message included the reason for discontinuation. After potentially investigating the message, the pharmacist would return to the CancelRx message and select "Remove from ICQ" [inbound communication queue]. Pharmacist participants said that it was unclear at first, but they learned through experience (and going to the patient profiles) that the CancelRx/SureScripts connection had already discontinued/deactivated the medication—there was no "undoing" the process. Their act of clicking the "Remove from ICQ" button was simply to attest that they had seen and acknowledged the medication was discontinued. This was also evident because after medication was cancelled via CancelRx it was locked and unable to sold or released to a patient.

When the CancelRx was "not matched" the second section appeared blank. A button appeared at the bottom of the screen indicating that the pharmacist could "manually" match the prescription and when clicked, the patient's Rx Profile popped up. The pharmacist could then scroll through the patient's profile, identify the matching Rx, and complete the CancelRx. However, if the pharmacist was unable to match the prescription to any records in their pharmacy (perhaps in the instance of an old/outdated prescription more than several years old or if the prescription has been transferred out of the pharmacy), the pharmacist could indicate "No Match Found," which removed the message from the inbound queue and sent a response to the originating clinic/doctor's office. In talking with pharmacists, most of the instances in which a match was not found occurred when they received a CancelRx for a prescription more than 5-7 years old [prescriptions are only good for 1 year and records are only required to be maintained or the local server for a limited amount of time].

At first, many pharmacists were frustrated by the sheer number of CancelRx messages they were receiving. They stated that most of the messages were meaningless in that they were for acute therapies (such as antibiotics) or for medications that had no refills (such as controlled substances). One pharmacist indicated that she received at least 15 CancelRx messages a day and would be happy if one of them was "real" or provided "meaningful" information. In discussing this frustration with the UW Health Pharmacy Administrators that were interviewed 9 months post-CancelRx, they agreed that they received so many negative comments from the

front-line pharmacists initially that they considered turning the functionality off all-together. They said that they didn't, however; because they hoped that the number of CancelRxs would decrease over time (as clinics "cleaned" up patient records and removed superfluous/old medications) and because they could see the value for patient safety in alerting pharmacists of changes to the patient medication record.

Additionally, pharmacists/pharmacies also voiced frustration over the fact that once a CancelRx was received and a medication was cancelled using that method, there was no way to reverse the cancellation. This hard-stop safety functionality provided barriers when a pharmacy needed to re-bill for product after it was dispensed, or when the CancelRx was sent prematurely or unintentionally (often in the case of hospital discharges in which a patient was sent one prescription to the Outpatient pharmacy for immediate use and a second prescription to the patient's usual community pharmacy for chronic use).

By 9-months post CancelRx, many pharmacists did not investigate or navigate to the patient pharmacy or EHR profile. If the prescription matched, they simply clicked "Remove from ICQ," taking approximately 5-10 seconds per encounter.

UW Health Pharmacy administrators made several CancelRx implementation choices that were unique compared to other pharmacy organizations who have implemented CancelRx. 1) Pharmacists/Pharmacy Staff Members must view and acknowledge the CancelRx messages. Anecdotally, the research team learned that other organizations such as Walgreens do not require any intervention on behalf of the pharmacy staff and that CancelRx simply runs in the background. 2) Only Pharmacists and not Technicians are able to handle CancelRx messages. This was done because administrators believed in the clinical judgement that would be required to process CancelRx messages (in the event to therapeutic interchange or adverse reactions). Although in theory true, from the interviews it appears these types of messages are not as often as originally anticipated. At the time of the 9-month interviews, UW Health Pharmacy Administrators had no intention of removing the pharmacist acknowledgement for CancelRx messages or expanding that responsibility to technicians.

Identification of Vulnerabilities in the Clinic and Pharmacy Work Systems

A proactive risk assessment was also conducted in order to identify vulnerabilities and consequences associated with each step of the CancelRx process. Using the process map generated from the interviews and observations as a guide, 35 vulnerabilities that encompassed the clinic and pharmacy work systems were identified and organized into vulnerability themes.

Clinic Sociotechnical Vulnerability Themes   - error in information acquisition during rooming regarding whether a patient is taking or not taking a medication   - error in documenting whether a patient is taking or not taking a medication   - EHR is complex and duplicative with many areas to note whether patient is taking/not taking a medication   - error in discontinuing a medication or not in EHR   - error in selecting discontinuation reason in the EHR, and ambiguity regarding which tasks clinic staff should and should not be completing.
Pharmacy Sociotechnical Vulnerability Themes   - error in clinic staff contacting the pharmacy regarding discontinued medications   - error in pharmacy identifying, matching, and discontinuing the correct medication for the correct patient   - medication unable to be discontinued in pharmacy system because it was already dispensed or because there was not an active prescription on file.
Transfer of Information Between Clinic and Pharmacy Systems   technical errors/glitches in the system

Consequences for these vulnerabilities included clinic medication lists not being up to date, patient continuing to take a medication they should no longer be taking, inconsistent clinic work, medication discontinuation messages not communicated to pharmacy or unnecessarily communicated to pharmacy, important information not passed from the EHR system to pharmacy system, pharmacy medication list is not up to date, and increased workload for pharmacy.

The majority of themes involved multiple actors. For instance, an accurate clinic medication list was dependent upon the patient sharing information about which medications they were currently taking, clinic staff correctly documenting that information in the EHR, and proper interpretation of the medication list by the prescriber. Failure in any one of these steps could lead to the consequence of the medication list not being up to date or the patient continuing to take a medication that they should not be taking. Figure 7 below illustrates a revised process map that identifies where vulnerabilities may be located across the clinic, during handoff/communication, and in the pharmacy.
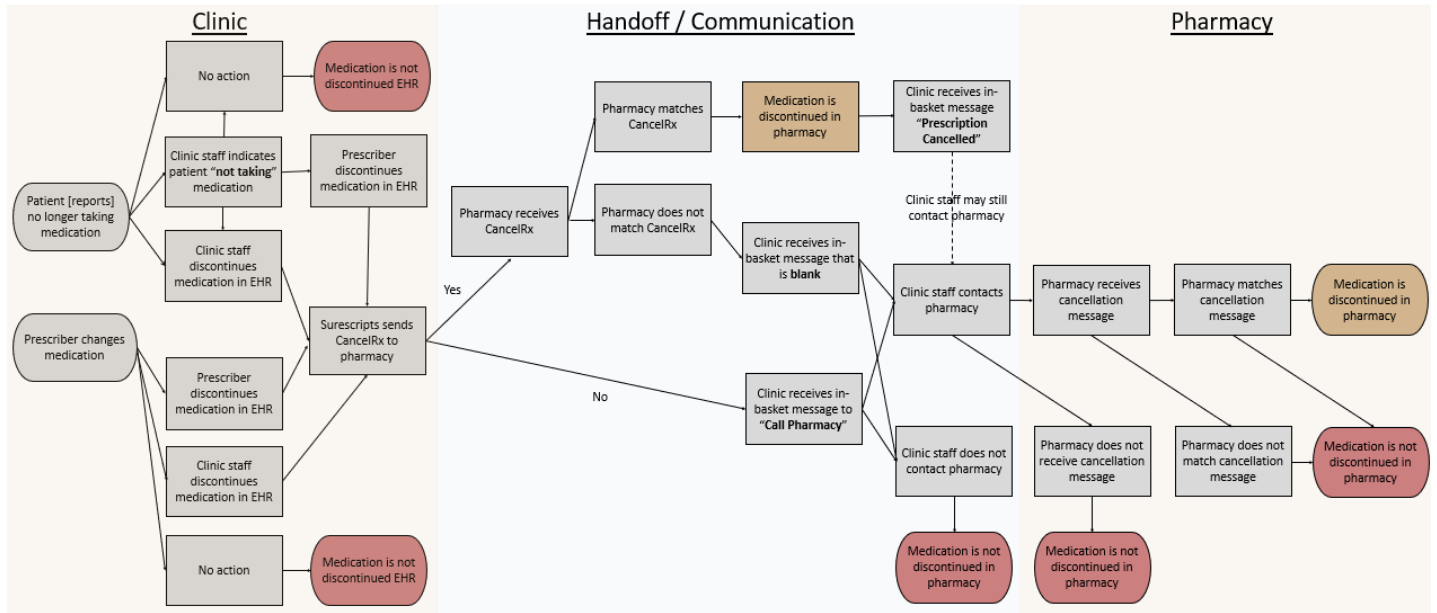

Figure 7 Medication Discontinuation Process Map

Discussion/Conclusions

CancelRx had a swift and immediate impact on the proportion of successful discontinuations between the clinic and pharmacy systems, a 58.5% increase to approximately 93% successful discontinuations on average. Additionally, the trends in the year following CancelRx implementation illustrate the sustained impact of this intervention over time. Although this significant and abrupt change may seem surprising, considering the technological nature of this intervention, the results are not as surprising as initially thought. The CancelRx functionality is intended to run "behind the scenes" and in this case, the intervention was truly the act of "flipping a switch" and intended to work behind the scenes.

Even post CancelRx, however, the percentage of successful discontinuations was not 100%. Approximately 7% of medications that should have been discontinued were potentially able to be dispensed. One may anticipate a 100% success rate following CancelRx implementation given that this is a heavily automated process, however, there are several instances in which the system may not be able to function as designed. Examples of these situations may be: a prescription is too old and therefore already inactivated by the pharmacy dispensing software, the prescription was transferred out of the pharmacy's system to another pharmacy, or the medication was prescribed or changed verbally. Secondly, CancelRx requires that both the clinic system and the pharmacy system have the functionality turned on through the third-party vendor, SureScripts, to be able to communicate and automate the process. Although this study only looked at

communication between the clinics and outpatient pharmacies in the same health system, this is important to consider in comparison of CancelRx "as designed" and "as used" when considering implementation choices by the health system– there may be instances in which this functionality simply cannot work.

The significant increase in the proportion of medications successfully discontinued in both the clinic and pharmacy demonstrates the drastic reduction in patient safety vulnerabilities. With more successful discontinuations, there are fewer opportunities for medication list discrepancies or inappropriate dispensing of medications that should have been discontinued but never communicated to the pharmacy.

Patient Comorbidity

A priori, the research team hypothesized that those individuals with a high comorbidity status would have a higher percentage of successful medications discontinued than those with a low comorbidity status in the pre- and post-CancelRx period. The assumption was that prescribers and pharmacists are more cautious and diligent about the accuracy of medication lists in these patients with complex diseases, numerous pharmaceutical therapies, riskier therapies, or even multiple pharmacies. Indeed, the pre-CancelRx results showed the proportion of successful discontinuations was higher in the high-comorbidity patients than in the low-comorbidity patients. This supports the assumption that in the absence of technological support (pre-CancelRx), increased patient comorbidity is associated with an increased level of attention and prioritization by clinic and pharmacy teams.

However, the results were not consistent with the hypothesis in the post-CancelRx period. Low-comorbidity patients had higher percentages of successful medication discontinuations than high-comorbidity patients. In the presence of technological support (post-CancelRx), the two subsets appear to have "flipped". A possible explanation is that discontinuing medications for low comorbidity patients is easier and faces fewer barriers than for high-comorbidity patients. Examples of these reduced barriers include: less time and human resources needed to communicate medication cancellation messages, and less complex medication lists in low-comorbidity patients (both fewer medications, and fewer high-risk medications). By making discontinuations easy regardless of priority, the technological support may have enabled additional improvement for low-comorbidity patients.

Clinic Type

Pre-CancelRx, specialty clinics had a higher percentage of successful discontinuations than primary care clinics. After CancelRx implementation, however, the specialty and primary care groups converged. These findings demonstrate the automated functionality of CancelRx – compensating for patients, specialized operations, structures, and resources of the specialty clinics and making the medication discontinuation process more accessible and easier for primary care clinics to attain in their broader and generalized practice.

Overall, CancelRx equalized these two subsets, with a greater impact on the primary care group. In this sense, it is important to consider the implications of relatively low-cost technology on various practice models— recognizing that the functionality may support practices differently and to anticipate these changes in preparing for implementation.

Time to Discontinuation Between Clinic System and Pharmacy Software Over Time

The study results show the statistically significant impact of CancelRx on time to discontinuation. These findings are crucial in that the longer the time between clinic and pharmacy discontinuations, the more vulnerable the patients are to inappropriate medication dispensing and adverse drug events related to taking a medication that should have been stopped.

Impact on Clinic and Pharmacy Work systems

Overall, CancelRx appeared to reduce the workload of the clinic staff/MAs when contacting community pharmacies about medication discontinuations. CancelRx reduced the number of "Inbox Messages" directed towards MAs. Many of the messages that previously instructed them to contact a patient's pharmacy when medications were discontinued were now automated by this novel health IT. However, during the post-

interviews, some MAs stated they were still unclear about their role in communicating medication discontinuations to pharmacies, their responsibilities for addressing some or all of the Inbox messages, lack of time to prioritize calling pharmacies, or even that the folder existed. Many stated that they still received minimal to no training on the process.

In comparison, CancelRx appeared to somewhat increase the workload of the pharmacists for receiving and processing medication communications. The sheer number of cancellation messages increased, but the pharmacists often indicated that they were of little value or significance (i.e. medications that were outdated, expired, or did not have refills). However, pharmacist and pharmacy administrators recognized the importance of this functionality for patient safety and decided to persevere (even amidst discussions of "shutting it off."). The administrative decisions discussed above influenced how CancelRx was integrated and used at the pharmacy. This emphasizes the importance of thoughtful consideration when implementing novel health IT, it is not merely an act of flipping a switch, but anticipating the consequences (both to patient outcomes and work systems).

Initial assumptions by the health system implementation team were that because the cancelation messages would follow the same route as sending new medications to pharmacies, that CancelRx "go-live" would essentially be invisible to users and have minimal impact on clinic and pharmacy workflow. As a result, CancelRx was implemented in all departments at the same time and minimal training for staff was conducted. Consequences following implementation included inaccurate medication lists, ambiguity regarding whether or not messages were actually sent, and increased pharmacy workload. The fact that these consequences were not identified and addressed prior to CancelRx implementation may be due in part to the lack of transparency of the vulnerabilities across the clinic and pharmacy systems as well as a lack of diverse front-line users on the implementation team. While individual actors may understand the vulnerabilities that exist in their own sociotechnical system (i.e. in the clinic), they may not understand the vulnerabilities in other systems (i.e. the pharmacy) and the impact of their actions on one another.

Significance & Implications

This study provides valuable insight into the impact of CancelRx on reducing medication list discrepancies between clinician EHR and pharmacy dispensing software. These findings illustrate the potential for health IT in mitigating risks for the dispensing of previously discontinued medications and decreasing the time in which these discontinuations are communicated. Additionally, the results demonstrated how CancelRx had varied impact based on the patient's comorbidity status as well as the resources the originating clinic had access to (such as personnel). The study emphasized the importance of considering the environment in which new technological interventions are implemented—anticipating differences in resources and capabilities that impact implementation and adoption.

Although CancelRx has the potential to reduce medication discrepancies between clinics and pharmacies, it is clear that additional adjustments to both the IT functionality itself (e.g. closed loop communication) as well as additional training and organizational policies for clinic and pharmacy staff that elucidates the roles of clinic staff, prescribers, and pharmacists in the medication discontinuation process will lead to improved medication safety outcomes for patients.

This study has several implications for practice: 1) the feasibility of novel health IT at communicating medication discontinuations between clinics and pharmacies and ensuring accurate medication lists in both systems; and 2) the variability of health IT impact based on patient and clinic subsets, emphasizing the need to consider implementation science principles when considering new interventions.

LIST OF PUBLICATIONS AND PRODUCTS

Submitted

Watterson TL, Stone JA, Brown R, Xiong KZ, Schiefelbein A, Ramly E, Semanik M, Kleinschmidt P, Craddock L, Pitts S, Woodroof, T, Chui MA. CancelRx: A Health IT Tool to Reduce Medication Discrepancies in the Outpatient Setting. Submitted to JAMIA, September 2020.

Watterson TL, Stone JA, Brown R, Xiong KZ, Schiefelbein A, Ramly E, Semanik M, Kleinschmidt P, Craddock L, Pitts S, Woodroof, T, Chui MA. CancelRx: Reducing Medication List Discrepancies in the Outpatient Setting. Submitted to American Pharmacists Association Annual Meeting & Exposition, October 2020.

Published Manuscripts and Presentations

Watterson TL, Stone JA, Brown R, Ramly E, Kleinschmidt P, Semanik M, Schiefelbein A, Xiong KZ, Craddock L, Chui MA. CancelRx: Implementation and sustainability of a health IT tool to reduce medication list discrepancies. Academy Health Conference on the Science of Dissemination and Implementation. 2020 December; Virtual Conference.

Pitts S, Chui MA, Oltman C, Akinwale T. Implementation of electronic prescription cancellation: A Tale of two health systems, a retail pharmacy, and the evolution of the CancelRx standard. AMIA 2020 Virtual Annual Symposium; Nov 14-18, 2020.

Kleinschmidt P, Watterson T, Xiong KZ, et al. CancelRx: An interoperability standard to reduce medication discrepancies between clinics and community pharmacies [session cancelled]. AMIA 2020 Clinical Informatics Conference; May 19-21, 2020; Seattle, WA.

Stone JA, Watterson T, Xiong KZ, et al. Identifying vulnerabilities in HealthIT: A case study of CancelRx implementation in clinic and pharmacy sociotechnical systems. Paper presented at: 2020 International Symposium on Human Factors and Ergonomics in Health Care March 8-11, 2020; Toronto, Canada

Watterson T, Xiong KZ, Stone JA, Ramly E, Chui MA. CancelRx: Comparing Front-Line and Leadership Perceptions of Health IT Implementation Using Quantitative Ethnography. American Pharmacists Association 2020 Annual Meeting and Exposition; March 20-23, 2020; National Harbor, MD.

Xiong KZ, Watterson T, Stone JA, Chui MA. Unintended Consequences of CancelRx. 12th Annual Conference on the Science of Dissemination and Implementation; Dec 4-6, 2019; Arlington, Virginia

Watterson T, Xiong KZ, Stone JA, et al. Front-Line vs. Leadership Perceptions of Health IT Implementation. International Conference for Quantitative Ethnography; Oct 19-22, 2019; Madison, Wisconsin.

Watterson T, Xiong KZ, Stone JA, et al. Implementing CancelRx: Describing adoption barriers using a process map framework. 11th Annual Conference on the Science of Dissemination and Implementation; December 3-5, 2018; Washington, D.C.

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