

# Automated E-mail Reminders Linked to Electronic Health Records to Improve Medication Reconciliation on Admission

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## ABSTRACT

**Introduction:** Medication reconciliation can reduce medication discrepancies, errors, and patient harm. After a large academic hospital introduced a medication reconciliation software program, there was low compliance with electronic health record documentation of home medication reconciliation. This quality improvement project aimed to improve medication reconciliation on admission in 4 pediatric inpatient units by 50% over 3 months. **Methods:** We used Lean Sigma methodology to observe medication reconciliation processes; interview residents, nurses, pharmacists, and families; and perform swim lane process mapping and Ishikawa Cause and Effect analysis. The improvement plan included education and automated e-mails sent to admitting residents who had not completed medication reconciliation within 24 hours of admission. The daily percentage of patients without medication reconciliation within 24 hours of admission, indicated by the presence of old prescriptions in Sunrise Prescription Writer (RxWriter) (Allscripts Healthcare Solutions, Chicago, Ill.) from prior admissions, was assessed from March 2015-June 2016. We constructed statistical process control charts and identified special causes. **Results:** Key barriers included lack of knowledge about RxWriter and lack of accountability for completing medication reconciliation. The percentage of patients without medication reconciliation decreased from 32% at baseline to 22% with education ( $P < 0.001$ ), to 15% with the use of automated e-mail reminders ( $P < 0.001$ ). We sustained improvement over the following year. Statistical process control testing indicated shifts aligning with each stage of the study. **Conclusion:** Provider-tailored, automated e-mail reminders linked to electronic health record with educational training significantly improved resident compliance with use of an electronic tool for documentation of home medication reconciliation on hospital admission. (*Pediatr Qual Saf* 2018;3:e109; doi: 10.1097/pq9.000000000000109; Published online September 19, 2018.)

## INTRODUCTION

Medication errors are common, representing up to one-third of all hospital errors, and are responsible for an estimated 1 in 5 injuries or deaths among hospitalized patients.<sup>1-3</sup> Pediatric patients may be 3 times more likely than adults to suffer an adverse event due to medication errors.<sup>4-7</sup> More than 50% of inpatients have at least 1 unintended medication discrepancy at hospital admission, and 39% of these discrepancies have the potential to cause moderate or severe



harm.<sup>8</sup> Poorly communicated medical information at admission, intrahospital transfer, and discharge are estimated to be responsible for at least half of all medication errors in the inpatient setting.<sup>9</sup> Medication reconciliation, the process of comparing the medications a patient is actually and should be taking with the medications documented in a chart or prescribed, can reduce the number of unintended medication discrepancies with each patient visit or transfer of care during hospitalization.<sup>2,3,9-13</sup>

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To cite: Johnson K, Burkett GS, Nelson D, Chen AR, Matlin C, Garger C, McMahan S, Miller M, Kim JM. Using Automated E-mail Reminders linked to Electronic Health Records to Improve Medication Reconciliation on Hospital Admission at a Large Academic Children's Center. *Pediatr Qual Saf* 2018;3:e109.

Received for publication December 14, 2017; Accepted August 15, 2018.

Published online September 19, 2018

DOI: 10.1097/pq9.000000000000109

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Preliminary data were presented at the Pediatric Academic Societies Annual Meeting, May 1, 2016, Baltimore, Md.

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In 2005, the Joint Commission on Accreditation of Health-care Organizations identified medication reconciliation as a National Patient Safety Goal.<sup>14</sup> Health care organizations were subsequently tasked with implementing a medication reconciliation process that ensured an accurate list of home medications upon admission and all subsequent transitions of care.

In 2014, the Johns Hopkins Hospital adopted Sunrise Prescription Writer (RxWriter) (Allscripts Healthcare Solutions, Chicago, Ill.), a software program compatible with Allscripts Sunrise Clinical Manager electronic health record (EHR) system to facilitate EHR documentation of medication reconciliation on admission, transfer, and discharge.<sup>15</sup> The adoption of this new software program was driven by Centers for Medicare and Medicaid meaningful use incentives for EHR systems to capture a codified medication list to improve medication safety.<sup>16</sup> Postimplementation surveillance by a committee of physician faculty, residents, nurses, and pharmacists raised concerns that medication reconciliation documentation through RxWriter was not routinely and properly taking place, with potential risks for medication errors. A quality improvement team aimed to improve medication reconciliation on hospital admission for general pediatric patients cared for by pediatric residents.

## METHODS

Lean Sigma quality improvement methods were used to improve compliance with hospital-wide goals for medication reconciliation. With the RxWriter program, prescriptions from prior hospitalization discharges remain active in the software, unless they are properly reconciled by the admitting provider. We developed an automated measure to capture the daily percentage of patients with prescriptions from prior discharges remaining in RxWriter after 24 hours of admission. We defined this measure in our study as “medication reconciliation noncompliance.” Our intervention aimed to reduce this measure by 50%, from a baseline of 32 to 16%, over 3 months.

Ishikawa fishbone diagram and process mapping identified lack of knowledge and training about the RxWriter tool among resident physicians, and a lack of accountability for completing the medication reconciliation process, as major contributors to lack of medication reconciliation documentation upon inpatient admission. Thus, we targeted resident physicians with an educational intervention and implemented automated daily e-mail reminders to address the issue of accountability.

### *Setting and Context*

Johns Hopkins Children’s Center is an urban, academic pediatric medical center admitting approximately 9,000 pediatric patients per year. RxWriter was adopted as a transitional medication reconciliation tool during the period before implementing a new EHR system. Initial integration of the RxWriter software program into EHR raised

patient and medication safety concerns around the appropriate use of the system. There was institutional prioritization of medication reconciliation and the use of RxWriter. Pediatric residents received quality and safety training through didactics, by conducting quality improvement projects, and actively participating and facilitating morbidity and mortality conferences twice a month. In the months leading up to this project, the residents had experienced challenges with medication reconciliation and RxWriter, provided feedback, and were prepared to engage in the process of improvement. Patients included in this analysis were admitted to 1 of the 4 general medical pediatric units, specifically selected because they are staffed by pediatric residents working under the supervision of attending physicians. The Johns Hopkins Medicine Institutional Review Board determined that this quality improvement project did not constitute human subjects research.

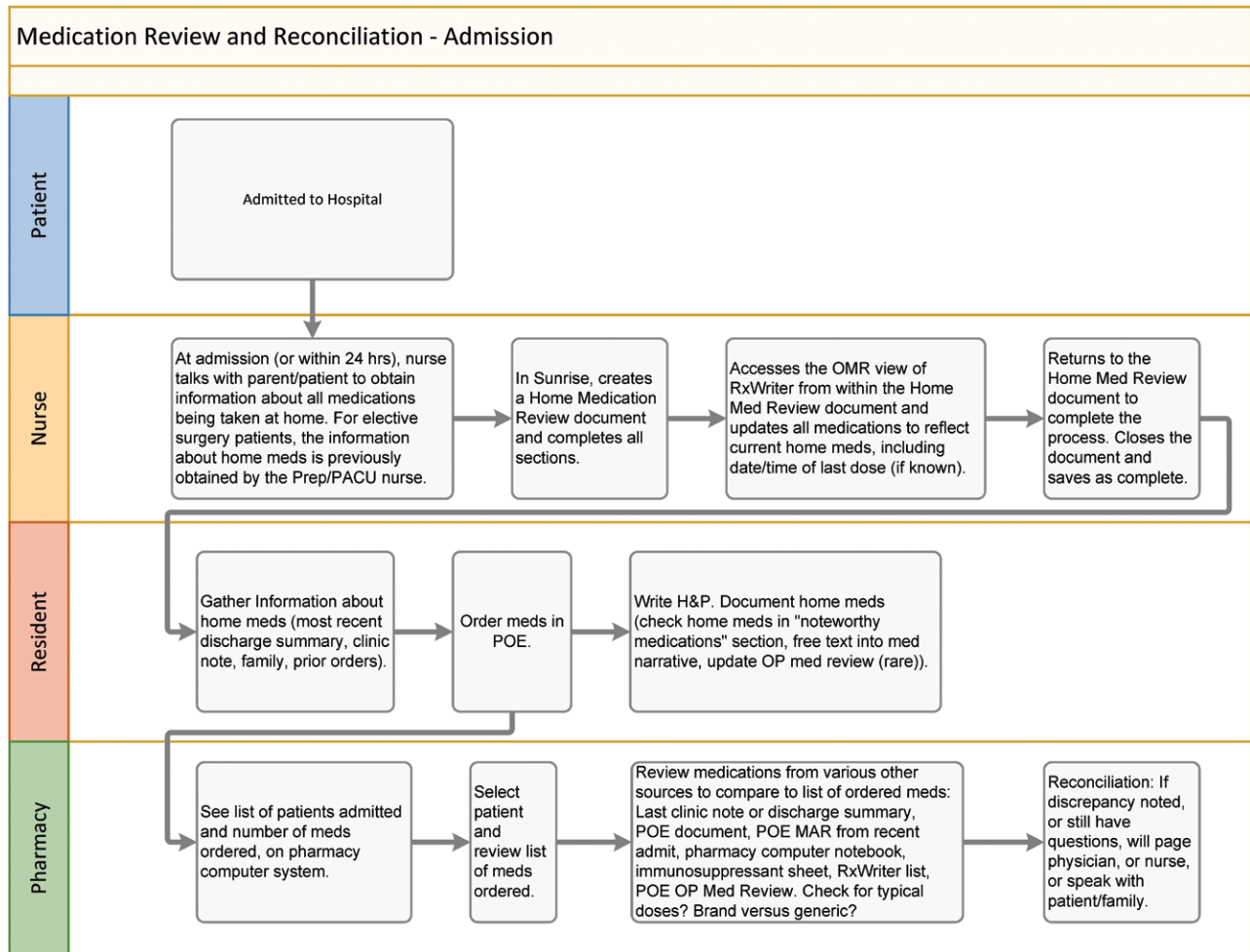
### *EHR*

RxWriter was intended to capture a unified medication list and facilitate medication review and reconciliation in the inpatient setting. This software program integrated with the EHR that was in use at the time of the project at the Johns Hopkins Hospital, Sunrise Clinical Manager (Allscripts Healthcare Solutions, Chicago, Ill.)<sup>15</sup>, which supported a variety of clinical information systems functions including the management of inpatient orders, documentation of administered medications, and interdisciplinary documentation of daily patient care.

### *Planning the Intervention*

An improvement team consisted of faculty members in Quality and Safety, current and future pediatric chief residents, nursing leadership in safety, informatics, and education, a senior pharmacist, and Lean Sigma Blackbelt consultants. Project champions included the Department Chair of Pediatrics and the Vice-Chair of Quality and Safety for the Johns Hopkins Children’s Center. The team conducted interviews with pediatric residents, nurses, pharmacists, and a parent from the Patient and Family Advisory Council about the patient experience with medication reconciliation on hospital admission. We surveyed pediatric residents and nurses about their knowledge and use of RxWriter. Process mapping and an Ishikawa Cause and Effect Analysis were performed to identify factors contributing to medication reconciliation noncompliance.

**Swim Lane Process Mapping.** Swim Lane Process Mapping defined the process of home medication reconciliation (Fig. 1). The admitting nurse talked with the patient and/or parent to obtain names and time of the last dose of all current prescription and over-the-counter medications and entered the drug names into a Home Medication Review document in the Sunrise EHR. In parallel, the admitting pediatric resident gathered information about all home medications by speaking with the patient and/or parent and by reviewing recent hospitalization



**Fig. 1.** Swim lane process map defining the process of home medication reconciliation and roles of patient, nurse, resident, and pharmacist. H&P, history and physical; MAR, medication administration record; OMR, outpatient medication review; OP, outpatient; PACU, postanesthesia care unit; POE, provider order entry.

orders, discharge summaries, and outpatient clinic notes. Residents ordered inpatient medications after reconciliation. Residents documented medication reconciliation in a variety of ways, including utilizing RxWriter or typing data into an admission note. The inpatient pharmacist reviewed the ordered medications to ensure consistency with recent clinic notes, recent admissions and discharges, and outpatient pharmacy data. In case of a discrepancy, the pharmacist contacted the pediatric resident to discuss.

**Ishikawa Cause and Effect Analysis.** The Ishikawa Cause and Effect analysis identified numerous factors contributing to medication reconciliation noncompliance (Fig. 2). A lack of knowledge and training about the RxWriter tool, and a lack of accountability for completing this process, were key contributors to the breakdown in the medication reconciliation process.

### Improvement Activities

**Educational Training.** We distributed a 1-page overview of the use of RxWriter to pediatric residents and nurses

along with a summary of hospital policy on medication reconciliation. Resident education on medication reconciliation through RxWriter was provided during resident conferences, with reminders through weekly chief resident e-mails. We implemented the educational intervention on April 7, 2015.

**Automated E-mail Reminders.** To provide a visual cue (“kanban”)<sup>17</sup> to pediatric residents when they did not complete medication reconciliation in the prescribed time frame, we sent automated e-mail reminders to the resident who had signed the admission orders and not documented medication reconciliation in RxWriter after 24 hours of admission (Fig. 3). The timeframe of 24 hours was selected to align with the institutional mandate that medication reconciliation occur as soon as possible within the first 24 hours of admission. Automated e-mails were signed by the Director of the Johns Hopkins Children’s Center, demonstrating leadership support for the safety initiative. The e-mail provided a list of patients requiring medication reconciliation and brief instructions for

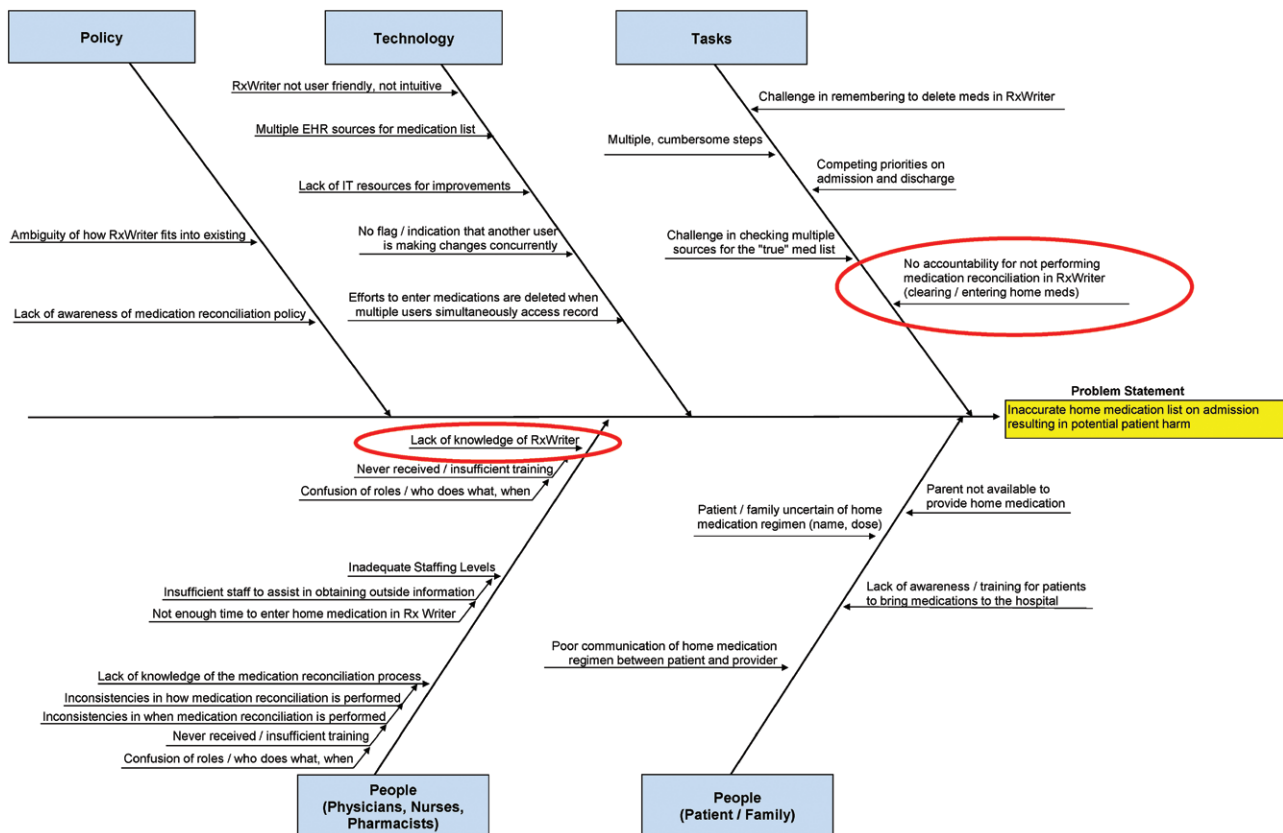


Fig. 2. Ishikawa cause and effect diagram for incomplete home medication reconciliation on hospital admission.

performing medication reconciliation through RxWriter. All e-mails were sent at 1:00 AM each day, to communicate with both night and day team admitting residents promptly. If reconciliation remained incomplete, we sent a new e-mail each day to the same resident. If the admitting resident went off service, they would continue to receive the e-mails. We implemented the automated e-mail reminders on April 27, 2015.

**Control Phase: Sustaining Improvement.** Periodic educational training of residents continued, and daily automated e-mail reminders were sent from July 1, 2015, through June 30, 2016. We provided training on medication reconciliation and the use of RxWriter during intern orientation in June 2015. The intervention ended after June 2016 as the hospital introduced a new EHR system with integrated processes for capturing a codified medication list to facilitate medication reconciliation.

### Planning the Study of the Intervention and Measure

The multi-step process of medication review and reconciliation on admission presented challenges in defining evaluation measures. Medication reconciliation has been previously defined as clinician-reported documentation of medication review as a proxy for reconciliation. This study similarly measured medication reconciliation as a

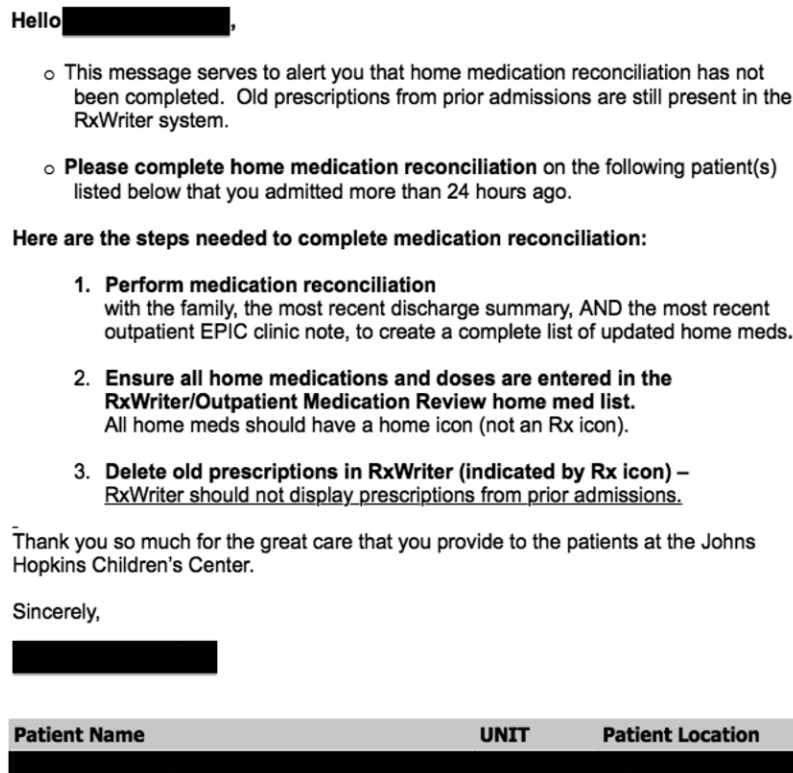
dichotomous variable; medication reconciliation was or was not performed within 24 hours of admission for each admitted patient.

An EHR-linked, automated, indirect measure was identified based on the presence or absence of old prescriptions (date of prescription compared with the date of admission) from prior hospitalizations that were remaining in RxWriter after 24 hours of a new admission without having been deleted or continued. Patients who continued on home medications while in the hospital needed to have old medications deleted from RxWriter and reordered in the computer system. Although this system created redundancies, it was necessary to prevent duplicate orders, especially on discharge.

At the time of discharge, RxWriter automatically generated a medication list based on prescriptions written for home use. At the time of subsequent hospital admission, these prior prescriptions were still present in the RxWriter medication list. The process of medication reconciliation in RxWriter on admission required that prescribers actively delete prescriptions for medications and then reenter the drugs as “home medications” if the patient continued on the medication.

We identified this crucial step at our institution as a safety concern, given the potential for errors of commission, if a medication from a prior discharge was unintentionally continued during a subsequent admission.





**Fig. 3.** Automated e-mail reminder message sent to admitting resident physician for patients without medication reconciliation > 24 hours after admission.

The presence of old prescriptions from prior discharges in RxWriter after 24 hours of admission indicated that the admitting resident had not performed medication reconciliation through RxWriter.

Medication reconciliation noncompliance was defined as the percentage of patients with prescriptions from prior discharges remaining in RxWriter after 24 hours of admission, among all patients admitted for > 24 hours on 4 general pediatric units. We determined this measure once daily. (Numerator: daily number of patients with old prescriptions from prior admissions remaining in RxWriter; denominator: daily number of patients admitted for > 24 hours on 4 pediatric units.) Patients admitted for more than 1 day on a general pediatrics unit were counted for each day that medication reconciliation was not performed in RxWriter.

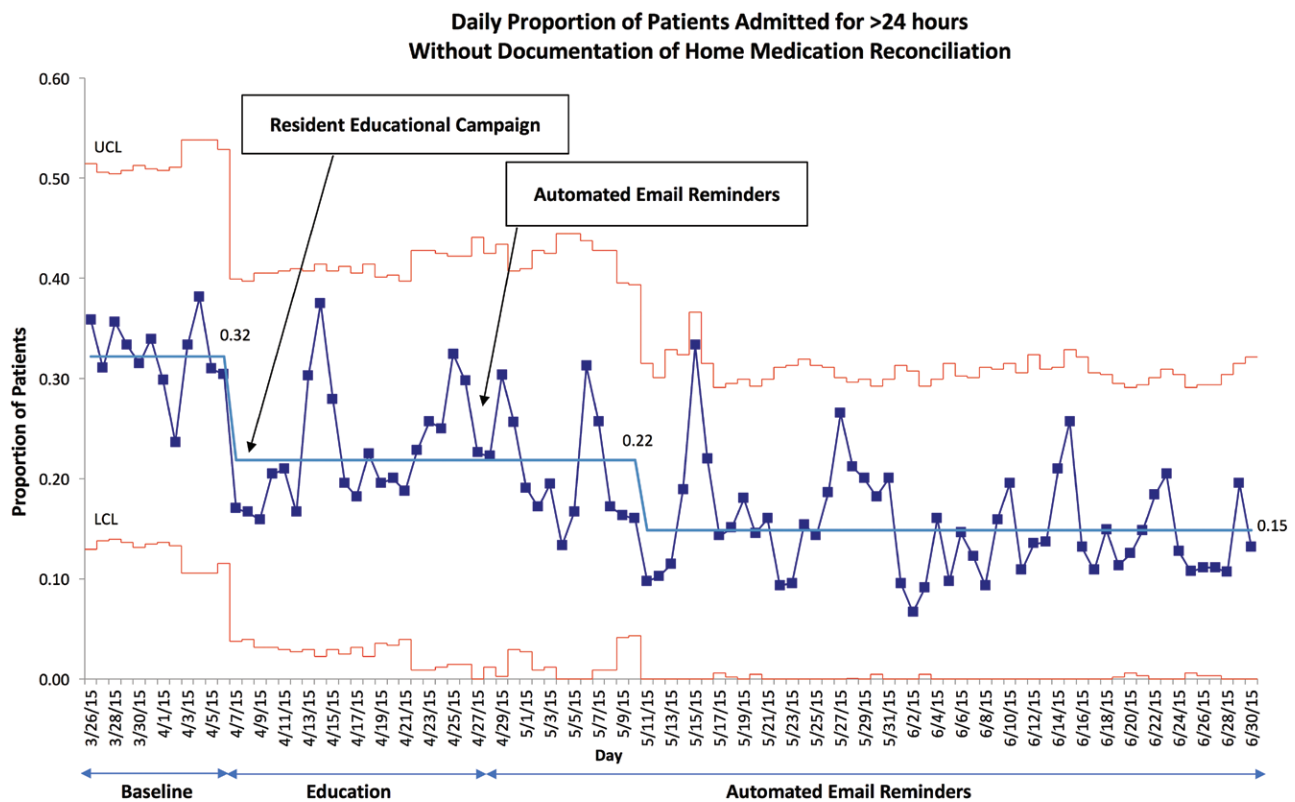
### Data Analysis

We calculated the proportion of medication reconciliation noncompliance (defect rate) for each stage of the project. Chi-square test was used to assess for differences in proportions between the stages. A one-way between-subjects analysis of variance was conducted to compare the effect of day of the week on medication reconciliation noncompliance. Statistical process control (SPC) charts with daily time intervals were constructed to assess intervention effects on medication reconciliation noncompliance. Control limits at 3 SDs from the mean were determined

by the data. SPC charts were constructed using QI Macros 2017 for Excel (KnowWare International Inc., Denver, Colo.). Healthcare-IHI tests were applied to identify special cause variation.

### RESULTS

During the timeframe of this study, from March 26, 2015 to June 29, 2016, there was a daily average of 44 patients admitted for longer than 24 hours to 4 general pediatrics units (median, 44; range, 23–59 patients). The baseline period had a higher daily mean of 52 patients admitted to the general pediatrics units (median, 55; range, 42–59 patients), compared with a daily average of 42 admitted patients during the educational campaign and 44 admitted patients during the automated e-mail reminder and control phases. The daily median (range) number of patients with old prescriptions in RxWriter was 17 (13–21) in the baseline period, 9 (7–15) after the educational campaign, 7 (3–13) after automated e-mail reminders, and 5 (1–15) in the control phase. After implementing educational training for residents, the proportion of patients with medication reconciliation noncompliance decreased from a baseline of 32 to 22% (Fig. 4). After implementing automated e-mail reminders, we achieved the target goal, as medication reconciliation noncompliance continued to decline to 15%. In the control phase, improvements continued with medication reconciliation noncompliance at



**Fig. 4.** SPC chart of the daily proportion of patients admitted to general pediatric units without documentation of home medication reconciliation in RxWriter after 24 hours of admission. LCL, lower control limit; UCL, upper control limit.

13%, sustained over the next 12 months (**Supplemental Digital Content, Figure 5: SPC chart demonstrating sustained improvement in the weekly proportion of pediatric patients without documentation of medication reconciliation, in the control phase over the following year.** UCL = upper control limit; LCL = lower control limit. Available at <http://links.lww.com/PQ9A42>). SPC testing identified multiple shifts in the data with each subsequent stage of the project, indicating special cause variation, equivalent to  $P < 0.01$  (Fig. 4). We also found statistically significant improvement with chi-square tests comparing medication reconciliation defect rates in the baseline, educational training, and automated e-mail plus education stages, and the control phase ( $P < 0.001$ ).

After we initiated automated e-mail reminders, there was a 9–14 day lag between the start of the intervention and a significant decrease in medication reconciliation noncompliance (Fig. 4). Although initial data points were consecutively decreasing, this slight delay may reflect a more gradual time course for implementing behavioral change. The intervention directly targeted accountability of the residents. E-mails provided specific patient information and brief instructions on how to complete medication reconciliation. Full instructional handouts that we distributed as part of the educational campaign were not attached to the e-mails. So there were multiple steps involved to complete reconciliation. These additional steps may have contributed to the lag.

Four special cause data points of unknown etiology were identified during the control phase. We excluded these points from the calculation of the mean and control limits (**Supplemental Digital Content, Figure 5, available at <http://links.lww.com/PQ9A42>**). Two of the special causes occurred during resident rotation switch weeks, and while this may have contributed to noncompliance, this did not occur on a monthly basis. Additionally, while it may be plausible that limited staffing on weekends and holidays may adversely affect medication reconciliation, there was no significant effect of the day of the week on medication reconciliation noncompliance at the  $P < 0.05$  level [ $F(6,450) = 0.22$ ;  $P = 0.97$ ].

## DISCUSSION

The use of automated EHR-linked e-mail reminders to admitting resident physicians is a novel approach to improving documentation of medication reconciliation on hospital admission. With automated e-mail reminders and educational training, we achieved the target goal over a 3-month period, with statistically significant improvement in medication reconciliation documentation in RxWriter with a decrease in noncompliance from 32% to 22% to 15%. Over the following year, this change was sustained at 13%. The use of electronic measures to assess daily compliance with medication reconciliation on admission with tailored performance feedback to

providers daily provided a sustainable means for tracking performance.

The 1999 Institute of Medicine report *To Err is Human* estimated that medical error leads to upwards of 98,000 deaths per year in the United States.<sup>18</sup> Medication errors in the hospital commonly occur on admission, transfer, and discharge, and more than 50% of inpatients have at least 1 discrepancy in their admission medication history.<sup>8,9,11,19,20</sup> Patients with discrepancies between their admission medication history and inpatient prescriptions have a continued risk for errors following discharge.<sup>8,9</sup> For these reasons, inaccurate or incomplete medication reconciliation is an important target for patient safety in the hospital setting.

The use of the EHR to perform medication reconciliation has been shown to decrease rates of medication errors.<sup>3,6,11,13,21,22</sup> Numerous institutions have attempted to integrate medication reconciliation interventions into their EHR, and such interventions are particularly effective at decreasing the rate of unintentional medication omissions.<sup>11</sup> The Medicare and Medicaid EHR Incentive Programs offered financial incentives for the “meaningful use” of certified EHR technology, and these programs required medication reconciliation at all transitions of care through the use of a “coded medication list.”<sup>16</sup> To comply with these mandates, the Johns Hopkins Hospital adopted Sunrise RxWriter, which integrated with the Sunrise clinical manager EHR at the time of the project. RxWriter assisted with capturing coded medication lists during this period before the hospital adopted a new EHR system.

Patient safety concerns were raised with the introduction of new medication reconciliation software, highlighting the challenges of integrating EHRs with other electronic systems and within clinical workflows. In response to these concerns, our team implemented improvement activities targeting the lack of knowledge about the use of RxWriter and lack of accountability for its use, with successful improvement and sustainability. Since this intervention initially only applied to patients on units covered by pediatric residents, our dissemination plan included educational materials and meetings with nurse practitioners admitting surgical and subsurgical patients, who were not covered by general pediatric teams. Although our intervention was specific to Sunrise RxWriter, similar functionalities of linking automated electronic messages exist in other EHR systems, which can be used as tools for medication reconciliation follow-up and accountability.

Strengths of the initiative include the use of an automated electronic measure to provide a daily indicator of medication reconciliation noncompliance for each admitted patient. We tailored the intervention to the admitting resident performing medication reconciliation on admission. Using automated EHR-linked e-mail reminders demonstrated significant improvement in medication reconciliation noncompliance and addressed issues of

accountability. Improvement was sustained in the control phase during the following 12 months.

There are several limitations to this study. The definition of medication reconciliation noncompliance was necessarily limited by the technology available to track use of RxWriter and was incapable of assessing all defects in medication reconciliation. In this intervention, we defined and measured medication reconciliation noncompliance by the presence of prescriptions from prior hospitalizations remaining in the tool after 24 hours of admission. This measure could not detect failures of medication reconciliation in patients without prior hospitalizations or prior prescriptions in EHR, although we still captured these patients in the denominator. Thus, the results underestimate medication reconciliation noncompliance on admission. Also, the automated electronic measure did not assess for medication discrepancies or accuracy of medication reconciliation. Additionally, only 2 weeks of true baseline data could be measured before starting the intervention, since the electronic data could not be captured retrospectively. Operational priorities favored implementing interventions without delay for additional baseline data collection, given the potential to improve patient safety. Although the baseline period had a higher average daily census, there was no difference in average daily census in subsequent phases of the study, yet we saw a continued decrease in the number and percentage of patients with old RxWriter prescriptions remaining in the system with each subsequent intervention in the educational campaign, automated e-mails, and control phases. This supports our argument for the impact of our intervention on the decreased daily number and percentage of old RxWriter prescriptions remaining in the system throughout the study.

## CONCLUSIONS

Pediatric patients are vulnerable to medication errors and adverse drug events, especially on inpatient admissions with increased illness acuity and multiple drug therapies.<sup>4</sup> Provider-tailored automated EHR-linked e-mail reminders, with educational training, significantly improved rates of compliance with the use of an electronic tool for documentation of home medication reconciliation on hospital admission. Automated EHR-linked e-mail reminders coupled with use of electronic measures may serve as additional tools for medication reconciliation and patient safety.

## ACKNOWLEDGMENTS

The authors are extremely grateful to Dr. George Dover for his tremendous support for quality and safety during his tenure as Chairman of the Department of Pediatrics, and to Bob Hody, Assistant Director of Lean Sigma Deployment at the Johns Hopkins Armstrong Institute, for his assistance with statistical analysis.

**DISCLOSURE:**

The authors have no financial interest to declare in relation to the content of this article.

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