

Grant Final Report

Grant ID: R03 HS18250

Electronic Medication Management

Inclusive project dates: 09/30/09 - 09/29/11

Principal Investigator:

David K. Vawdrey, PhD

Team members:

Nancy Chang, MD (Co-Investigator)

Audrey Compton, MD, MPH (Co-Investigator)

George Hripcsak, MD, MS (Co-Investigator)

Michael Owen, MD

Performing Organization:

Columbia University

Federal Project Officer:

Vera Rosenthal

Submitted to:

The Agency for Healthcare Research and Quality (AHRQ)

U.S. Department of Health and Human Services

540 Gaither Road

Rockville, MD 20850

www.ahrq.gov

Abstract

Purpose: To assess the challenges and benefits of an electronic medication reconciliation process on clinician workflow, medication list completeness, and the potential severity of unintentional medication discrepancies across inpatient and ambulatory care encounters.

Scope: The study was conducted using data obtained from inpatient and ambulatory care encounters in an urban, minority, medically-underserved community.

Methods: Data were obtained retrospectively from six community-based primary care clinics and two inpatient facilities that adopted an electronic process for medication reconciliation at hospital admission using a longitudinal medication list called the “Outpatient Medication Profile” (OMP). We examined medication lists in free-text clinical documents to determine the harm potential for missing information about the dosage, route, or frequency of a medication.

Results: Before the electronic medication reconciliation process was adopted, the average number of medications contained in the OMP for a patient at hospital admission was <2. One year after adoption, the average number had increased to 4.7. Of 253 medications lists reviewed, 181 lists (72%) had at least one medication missing a dose, route, or frequency. Missing information was judged to be potentially harmful in 47 of the lists (19% of 253).

Key Words: medication reconciliation; electronic health record; medication management; care transitions

The authors of this report are responsible for its content. Statements in the report should not be construed as endorsement by the Agency for Healthcare Research and Quality or the U.S. Department of Health and Human Services of a particular drug, device, test, treatment, or other clinical service.

Final Report

Purpose

The purpose of the study was to assess the challenges and benefits of an electronic medication reconciliation process on clinician workflow, medication list completeness, and the potential severity of unintentional medication discrepancies across inpatient and ambulatory care encounters.

Scope

As patients transfer between ambulatory and hospital care settings, there are numerous opportunities for medication errors¹⁻⁵. Evidence suggests that poor communication of medical information at care transition points is responsible for 50% of medication errors and 20% of adverse drug events in hospitals^{6, 7}. The Institute of Medicine reported that inaccurate medication lists in ambulatory clinics caused a larger number of fatal adverse drug events than in a hospital setting⁸.

Following numerous published studies on medication errors^{8, 9}, policy makers, such as the Joint Commission, have focused on improving the quality of medication list documentation and communication through the process of medication reconciliation.

Medication reconciliation employs a systematic approach to comprehensively review all of a patient's medications at each transition of care. This process helps ensure that an accurate list is maintained as clinicians add, change, or discontinue medications. Medication reconciliation may be viewed as a three-step process^{10, 11}:

1. Verification: Collect an accurate medication history, including dose, route, and frequency for each medication.
2. Clarification: Confirm that each medication and dose is appropriate for the patient.
3. Reconciliation: Document any changes to the medication list.

Most previous research on medication reconciliation has focused on the third step of the medication reconciliation process by looking for unintentional discrepancies between the medication list generated by clinicians and a "gold-standard" medication list. The percentage of patients with at least one discrepancy has ranged from 48-87% in the emergency department^{12, 13} and 22-54% on hospital admission^{3, 14, 15}. At hospital discharge, one study found that 41% of patients had at least one actual unintentional discrepancy¹⁶. In the outpatient setting the discrepancy rate has ranged from 22-82%¹⁷⁻²⁰.

Some studies have attempted to estimate the clinical significance of discrepancies by having clinical experts rate the degree of potential harm posed by the discrepancy. Two studies have

reported a rate of Potential Adverse Drug Events (PADEs) caused by medication discrepancies ranging from 1.05 to 1.44 PADEs/patient^{21, 22}. Other investigators have reported a percentage of discrepancies that were judged to be potentially harmful, with this percentage ranging from 12-39%^{3, 14-16}.

A study by Nassaralla and colleagues¹⁹ is one of the few to focus on the first step of medication reconciliation, collecting a complete medication list, including medication name, dose, route, and frequency. The authors drew a distinction between medication list “completeness” and medication list “correctness.” In this context, “completeness” referred to whether each listed medication included the name, dose, route, and frequency. On the other hand, “correctness” measured the consistency between lists and a lack of discrepancies with what the patient was truly taking. In their study of 230 outpatient encounters, Nassaralla found that even after the introduction of electronic documentation and a process improvement campaign, only 19% of medications lists were complete. Most of the incomplete medications were due to missing route and frequency information. The study by Nassaralla did not evaluate the clinical significance or harm potential of the missing information.

In 2008, New York-Presbyterian (NYP) instituted an interdisciplinary, electronic process for reconciling patients’ medications as they transitioned from ambulatory-to-hospital and hospital-to-ambulatory care settings. The process improved the rate of documenting medication reconciliation attestation at hospital admission from less than 40% to over 95%. Before the adoption of the medication reconciliation process, pre-admission medications and discharge medications were stored as free-text in the electronic health record (EHR). After the adoption, an electronic structured medication list was shared across NYP’s ambulatory EHR and inpatient EHR.

Many hospitals have experienced challenges with accomplishing the Joint Commission’s National Patient Safety Goal for medication reconciliation. Our institution implemented a fully electronic process for performing and documenting medication reconciliation at hospital admission. The process used a commercial EHR and relied on a longitudinal medication list called the “Outpatient Medication Profile” (OMP). Clinician compliance with documenting medication reconciliation was difficult to achieve, but approached 100% after a “hard-stop” reminder was implemented. We evaluated the impact of the process at a large urban academic medical center. Before the new process was adopted, the average number of medications contained in the OMP for a patient upon admission was <2. One year after adoption, the average number had increased to 4.7, and there were regular updates made to the list. Updating the OMP was predominantly done by physicians, NPs, and PAs (94%), followed by nurses (5%) and pharmacists (1%).

Clinical documents frequently contain a list of a patient’s medications. Missing information about the dosage, route, or frequency of a medication impairs clinical communication and may harm patients. We examined 253 medication lists. There were 181 lists (72%) with at least one medication missing a dose, route, or frequency. The potential for patient harm due to the missing information was rated by three physicians ($\kappa = 0.69$). Missing information was judged to be potentially harmful in 47 of the lists (19% of 253). We also observed that many lists contained additional information included as annotations, prompting a secondary thematic analysis of the annotations. Fifty-five of the 253 lists (22%) contained one or more annotations. The most frequent types of annotations were comments about the patient’s medical history, the clinician’s treatment plan changes, and the patient’s adherence to a medication. Future development of

electronic medication reconciliation tools to improve medication list completeness should also support annotating the medication list in a flexible manner.

Methods

The setting for this investigation was Columbia University Medical Center (CUMC), an urban hospital delivering care to a medically underserved population in New York City. CUMC was one of two academic medical centers that were part of New York-Presbyterian Hospital. CUMC used a commercial EHR (Eclipsys Sunrise, Eclipsys Corp., Atlanta, GA) which has been deployed since 2004 and was used for computerized provider order entry (CPOE), recording medication administration events, and clinical documentation.

In April 2007, clinical and information technology leadership at the hospital began developing a strategy to improve the existing medication reconciliation process. At that time, medication reconciliation at hospital admission used paper forms and was unreliable. The decision of the group was to use the EHR to maintain a coded, longitudinal medication list known as the “Outpatient Medication Profile” (OMP).

In July 2007, the OMP was made available in the EHR for use by physicians, physician assistants, and nurse practitioners. As the OMP was refined over the course of several months, pharmacists and nurses were given the ability to enter historical outpatient medications. Medications were entered as coded data elements, and included optional fields such as form, dose, route, frequency, and start and end times. Entering a medication was accomplished by selecting the drug name from a formulary database, from a personal “favorites” list, or entering it as free-text.

In addition to its use in the medical center, the OMP was used in several community-based clinics to enter prescriptions and historical medications. The OMP was longitudinal in scope, meaning that medications were visible to providers during subsequent inpatient encounters and clinic visits. When a patient was admitted to the hospital, a member of the care team was expected to update the OMP by verifying existing entries and adding new medications that the patient was taking. A medication reconciliation view was created within the EHR that displayed two columns: 1) the list of the current inpatient medication orders and 2) the list of outpatient medications from the OMP. From this screen, a provider could identify discrepancies between the two lists and update the inpatient orders accordingly. Once finished, the provider attested that medication reconciliation was complete by clicking a checkbox and entering his or her password.

By February 2008, the OMP was integrated into all admission notes, and the medication reconciliation view was linked to admission order sets. The electronic process became the approved method for reconciling medications throughout the institution. Adoption of the process was slow. To improve adoption, clinical leadership of the hospital consulted with the house staff and IT personnel to create a medication reconciliation reminder in the inpatient EHR. Six hours after admission to the hospital (as recorded by the institution’s electronic admission/discharge/transfer system), a reminder dialog was displayed when placing orders in the CPOE system if attestation of medication reconciliation had not been completed. If the attestation had not been completed by eighteen hours after admission to the hospital, a “hard-stop” dialog was displayed and no orders could be placed until attestation was documented. Attestation of

admission medication reconciliation required the OMP to be non-empty (i.e., one or more outpatient medications were listed, or the absence of home medications was documented).

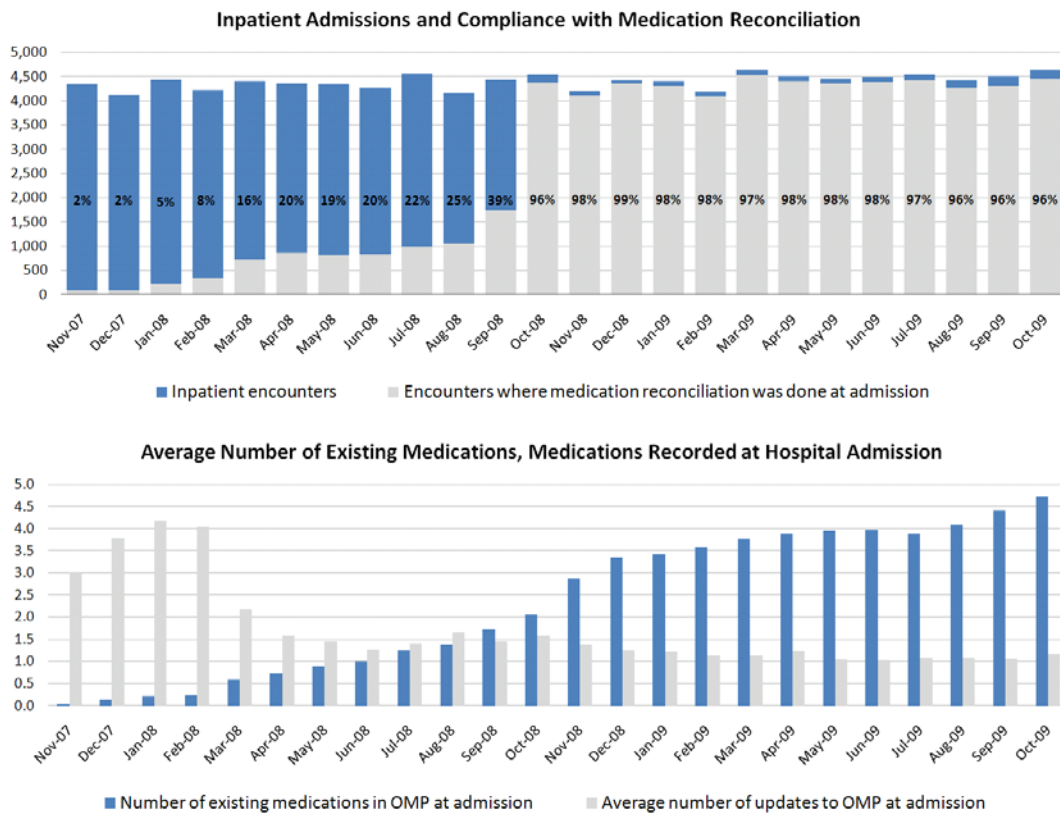
The “hard-stop” reminder for medication reconciliation was implemented in October 2008. To evaluate how the new process affected the ways by which clinicians collected and reconciled medications, we answered the following questions:

- When a patient was admitted to the hospital, how many active medications already existed in the Outpatient Medication Profile? How many were added or modified at the time of admission? What types of medications were added?
- What was the delay between hospital admission and the attestation of medication reconciliation? Did the delay decrease in the weeks following the implementation of the “hard-stop” reminder?
- How often did various types of care providers (e.g., physician/provider, nurse, and pharmacist) enter medications into the Outpatient Medication Profile?

Another purpose of the study was to measure the completeness of medication lists in terms of medication name, dose, route, and frequency. For medication lists that were incomplete, we evaluated the harm potential associated with the missing information. Electronic notes authored over a two year period were collected for a random sample of 100 patients who had the following sequence of consecutive clinical encounters: an outpatient visit, an inpatient admission, an inpatient discharge, and a second outpatient visit. Each encounter was expected to generate a note, for a total of four notes per patient.

Each clinical note was reviewed to identify a medication list within the note. Any note that lacked a medication list or contained only a reference to see another note for the medication list was excluded from further analysis. Following the definition provided by Nassaralla et al., each medication list was categorized as “complete” or “incomplete” (19). A list was considered to be complete if it included a dose, route, and frequency for each medication (Figure 1, Panel A).

Figure 1. Compliance with medication reconciliation, number of medications in patients' Outpatient Medication Profile (OMP) at hospital admission, and number of updates during medication reconciliation process



Medication lists deemed incomplete were independently reviewed and categorized as “potentially harmful” or “low harm potential” (Figure 1, Panels B and C) by three experienced physicians, who specialized in hospital medicine, ambulatory medicine, and critical care medicine, respectively. The physician reviewers were instructed to classify each incomplete medication list as “potentially harmful” if, in the opinion of the reviewer, the information missing from the list could lead to a prescribing error. If the missing information could likely be inferred by a practitioner with a similar background, then the medication list was classified as “low harm potential.” Inter-rater agreement was calculated using the Cohen’s kappa coefficient. If the three reviewers were not unanimous in their classifications, the classification chosen by a majority of the reviewers was used.

During the compilation of the medication lists for the study, it was observed that many lists contained comments or annotations separate from the dose, route, and frequency information. This observation prompted a secondary qualitative analysis of the medication lists based on a grounded theory approach. Thematic analysis was used to identify patterns in the content and meaning of the medication list annotations. Four candidate themes were proposed based on the initial review of the medication lists. The initial themes were “Source,” “Adherence,” “Reconciliation,” and “Certainty.” As each annotation was reviewed and categorized, the additional themes of “Historical Information” and “Pharmaceutical Information” were added.

Results

Figure 2 shows the monthly trend of medication reconciliation attestation compliance, the number of medications listed in patients' outpatient medication profiles at hospital admission, and number of updates during medication reconciliation process. Before the implementation of the reminder, usage of the electronic medication reconciliation process was low (<40% usage). The "hard-stop" intervention improved the rate of medication reconciliation documentation to above 96% within one month. Before the intervention, the average number of medications contained in the OMP for a patient upon admission was less than 2. One year later, the average number had increased to 4.7 medications. The average number of modifications made to the list during the medication reconciliation process decreased over time, from more than 3 modifications in October 2007 to approximately 1 in October 2009. The decline in the number of modifications on admission demonstrates the benefit of a longitudinal medication list that spans encounters.

Before the reminder intervention, the mean duration between hospital admission and attestation of medication reconciliation was 84.5 hours (median= 9.1 hours). After the reminder intervention, the mean duration between hospital admission and attestation of medication reconciliation was 9.2 hours (median= 5.3 hours).

Figure 2. Examples of complete and incomplete medication lists (abbreviations are defined in brackets)

<ul style="list-style-type: none"> • Coumadin 2mg PO [by mouth] daily • Synthroid 50mcg PO [by mouth] daily • Nexium 40mg PO [by mouth] daily • FeSO4 325mg PO [by mouth] q8h [every 8 hours] • Lasix 120mg PO [by mouth] BID [twice daily] • Sildenafil 12.5mg PO [by mouth] q8h [every 8 hours] • Iloprost 5mcg inh [inhaled] q6h [every 6 hours] • Neurontin 200mg PO [by mouth] q8h [every 8 hours] 	<ul style="list-style-type: none"> • Leflunomide 40 mg PO [by mouth] Daily • Levaquin 500mg po [by mouth] every day • Lamivudine HBV Oral +R+ 100 MG PO [by mouth] Daily • Tacrolimus Oral 2 MG PO [by mouth] q12h [every 12 hours] (pt unsure of dose, but as per previous notes) • Isosorbide Mononitrate ER 	<ul style="list-style-type: none"> • Tacrolimus 3 mg bid [twice daily] • Myfortic 720 mg bid [twice daily] • Valcyte 450 mg daily • Bactrim SS daily • Nystatin qid [four times daily] • Coreg 37.5 mg bid [twice daily]] • Lipitor 10 mg daily • ASA 81 mg daily • Epivir 100 mg daily • Zantac 150 mg daily • Lantus 45 units
---	---	--

A. A complete medication list. Each medication has a medication name, dose, route, and frequency.

B. An incomplete medication list that is potentially harmful. The last medication “Isosorbide Mononitrate ER” includes neither a dose, a route, nor a frequency. The lack of a dose in particular, could lead to patient harm.

C. An incomplete medication list that has low harm potential. “Nystatin” is missing a dose. “Lantus” is missing a frequency. All medications are missing routes. The missing information could be inferred by a clinician based on clinical experience and the context.

Table 1 shows the frequency of additions to the OMP. The most common medications added to the list were central nervous system agents (including pain medications) (17%), cardiovascular agents (16%), and gastrointestinal agents (9%). The medications in the “Other” class included immunologic agents, antineoplastics, genitourinary tract agents, and items entered as free-text that were not classifiable.

Table 2 shows the number of additions to the OMP by clinician role. The medications in the OMP were most commonly updated by resident physicians (39%) and nurse practitioners/physician assistants (36%), followed by attending physicians (19%). Nurses occasionally edited information in the OMP (5%); pharmacists performed this task rarely (1%).

Table 1. Medications added to OMP by drug class

Drug Class	#	%
Central nervous system agents	47,386	17
Cardiovascular agents	45,221	16
Gastrointestinal agents	24,572	9
Nutritional products	21,100	8
Metabolic agents	20,906	8
Coagulation modifiers	20,395	7
Anti-infectives	14,068	5
Respiratory agents	8,751	3
Hormones/hormone modifiers	8,327	3
Psychotherapeutic agents	8,270	3
Topical agents	5,499	2
Other	51,687	18
TOTAL	276,182	100

Table 2. Additions to OMP by clinician role

Role	#	%
Resident Physician	108,423	39
Nurse Practitioner/Physician Assistant	99,751	36
Attending Physician	51,475	19
Nurse	14,339	5
Pharmacist	2,194	1
TOTAL	276,182	100

To assess completeness and potential for harm due to missing information, we searched for pertinent notes for 100 patients and retrieved a total of 306 clinical notes that were available in electronic form. The notes that were not available were presumably documented using a paper medical record that was still in use at some locations during the study period. The notes contained 253 medication lists. Some notes did not include a medication list because the patient was taking no medications, the clinician referenced a separate medication list in another document, or the clinician commented on the patient's medications in the plan section of the note without documenting a separate medication list. Of the 253 medication lists, 98 (38.7%) were from outpatient notes, 83 (32.8%) were from admission notes, and 72 (28.4%) were from discharge summaries. Of all notes with medication lists, 234 (92.5%) were entered as free-text documentation, and 19 (7.5%) were completed using structured documentation.

Of the 253 medication lists, 72 (28.5%) were complete, meaning all the medications on the list included a medication name, dose, route and frequency. There were 181 (71.5%) medication lists that were not complete.

All of the 181 medication lists that were not complete were examined by all three physician experts in order to evaluate whether the incomplete lists had the potential to cause harm. There was moderate agreement between the raters ($kappa = 0.69$) for the initial rating. After the review process, 134 (74.0%) of the incomplete lists had low harm potential, while 47 (26.0%) lists had

the potential to cause harm (Table 3). A total of 206 (81.4%) medication lists were either complete, or incomplete with low harm potential.

Table 3. All notes categorized by visit type (outpatient note, admission note, and discharge note) and completion type (complete, incomplete—low harm potential, and incomplete—potentially harmful)

Note Type	Complete	Incomplete: Low Harm Potential	Incomplete: Potentially Harmful	Total
Outpatient	21 (21.4%)	52 (53.1%)	25 (25.5%)	98
Admission	19 (22.9%)	51 (61.4%)	13 (15.7%)	83
Discharge	32 (44.4%)	31 (43.1%)	9 (12.5%)	72
TOTAL	72 (28.5%)	134 (53.0%)	47 (18.6%)	253

A total of 160 annotations were identified in 86 medication lists for 55 patients (Table 4). Annotations were categorized as relating to:

1. Historical Information: the indication for a particular medication, previous treatments tried, the name of the clinician who prescribed a medication, start and stop date, etc.
2. Reconciliation Information: instructions on medication changes such as “start,” “stop,” “hold,” etc.
3. Adherence Information: differences between how a medication was ordered or prescribed and how the patient was actually taking it or not taking it.
4. Pharmaceutical Information: the medication’s drug class, generic or trade name, etc.
5. Medication List Source: who supplied the information for the medication list, such as the patient, family member, pharmacy, previous note, etc.
6. Level of Certainty: how sure the clinician documenting the medication list was that the list was accurate.

Table 4. The six annotations types that were observed, including the number of each type observed and the percent of all annotations (Examples are taken from actual medication lists. Latin abbreviations are defined in brackets)

Annotation Type, Number Observed (%)	Definition	Examples		
Historical, 44 (28%)	Indication, previous treatments, prescriber, start and stop dates	fluconazole 100 mg daily (for thrush, beginning mid September - thrush went away within 1.5 weeks)	Wellbutrin (started 2 days ago)	neurontin 300mg tid [three times daily] (by Pain clinic)
Reconciliation, 35 (22%)	Instructions regarding medication changes	Glucotrol 5mg PO [by mouth] daily (NEW)	Lasix 40mg Po [by mouth] daily (increased)	- HOLD Metformin 850 mg PO daily
Adherence, 28 (18%)	Differences between prescription and how the patient takes the medication	Glipizide 20 mg bid [twice daily] (pt reports only taking 10 mg daily)	fibercon 625 bid [twice daily] (pt does not take every day, states minimal effectiveness)	-lasix 40 daily (pt taking lasix 80 mg bid [twice daily])
Medication Information, 24 (15%)	Drug class or generic name	Sitagliptin 50mg (Januvia) po [by mouth] daily	Anama (some OTC herbal med)	Prograf (Tacrolimus) 2mg at 10am and 10pm
Source, 16 (10%)	Where did the medication list come from	pt brought pill bottles 8/31	(patient does not know her medications, lists provided below per d/c summary)	(pt brought in list from PMD)
Certainty, 13 (8%)	How certain is the clinician that the medication list is accurate	Hydroxyzine 25 mg po [by mouth] ? Frequency	(pt does not know doses, family to bring meds in am)	Norvasc 5 mg po daily (may be 10 patient unsure.)

In examining the completeness and safety of medication lists recorded in outpatient notes, admission notes, and discharge summaries, we found that 28.5% of notes were complete, including a medication name, dose, route, and frequency. Of the incomplete notes, 74.0% were judged to be safe by two clinical experts, and 26.0% were judged to be potentially harmful. We also examined the notes for annotations that supplied information in addition to the medication name, dose, route, and frequency. The annotations were categorized according to the type of information they contained.

The completeness rate in our sample of 28.5% was higher than that found by Nassaralla and colleagues (19). In that study, the authors found that 7.7% of medication lists were complete before an intervention that included process improvement and the use of an electronic medication documentation tool. After the intervention, the percentage of notes that were complete increased to 18.5%. While the work by Nassaralla only examined outpatient notes, we examined both outpatient and inpatient notes, which may account for some of the difference in the rate of completeness between our findings and those from the previous study. In our study sample, the outpatient notes had a completeness rate of 21.4%, which is closer to the post-

intervention findings of Nassaralla. Discharge summaries had the highest rate of completeness (44.4%), which is probably due to the amount of time and resources that are applied to obtaining a complete medication list during the course of a hospitalization. Admission notes had a lower rate of completeness (22.9%) than discharge summaries, which may reflect the lack of information available in many cases at the time of admission. For example, complete medication information may not be available if a patient presents to the emergency room unexpectedly and does not remember the details of his or her medications.

We extended the work of Nassaralla, et al. by evaluating the clinical significance of incomplete medication lists. Of the incomplete medication lists, 74.0% were judged to be safe and only 26.0% were judged to be potentially harmful. There was moderate agreement between raters on the initial rating of whether an incomplete medication list was safe or potentially harmful, indicating that this determination is somewhat subjective. The raters believe that their particular clinical experience and backgrounds impacted their individual ratings of incomplete lists. For example, a clinician who is very familiar with a particular medication through his or her daily practice may feel more comfortable inferring missing information for that medication (such as the dose, route, or frequency) than another clinician who does not routinely prescribe that medication. This issue is especially relevant for medications that are only, or at least very commonly, given in one dose, formulation, or frequency. For example, in our sample of medication lists, many patients were taking cardiovascular medications such as simvastatin. Simvastatin is routinely administered at bedtime and always by mouth. Thus, a clinician familiar with simvastatin would probably not find a medication list that omitted the route or frequency for simvastatin to be harmful because she could infer that the route would be oral and the frequency would be daily at bedtime. On the other hand, a clinician who is not familiar with simvastatin might perceive such as list as potentially harmful. Therefore, the risk of patient harm may be lower than what we measured when the medication list is used for transitions of care between clinicians with similar levels of clinical experience and backgrounds, such as a transplant team or other specialized care team.

We observed annotations within the medication list regarding historical information, reconciliation of medication changes, patient adherence, pharmaceutical information, medication list source, and medication list certainty. We are unaware of any other study that has reported the presence and type of annotations in medication lists. Over half of the patients in our sample had at least one medication list with one annotation. We did not separately rate the clinical significance of the annotations, but they are likely to be important for patient care. The clinicians who documented the medication lists purposefully added extra information in the form of these annotations because they are likely to have thought that the extra information was important. It is possible that the information in the annotations also existed in other sections of the medical record; however, the clinicians who recorded the annotations may have thought that the information within the annotations would be most helpful to future users of the documented medication list if the annotation was directly linked with the medication list. For example, the annotations "HOLD Metformin 850 mg PO daily" may contain information that is also present in the assessment and plan section of the note or in a separate medication reconciliation document. Still, the clinician who duplicated this information in the medication list may have done so to alert any future reader who might only look at the medication list and not carefully read the entire document. Thus, the absence of these annotations (for example, as institutions convert from free-text to structured medication documentation) could lead to potential patient harm.

Future medication reconciliation tools should be designed to easily accommodate documentation of the annotation types that we observed.

Conclusion

This retrospective study of the medication reconciliation process at NYP can serve as a benchmark for future IT implementations addressing medication reconciliation. The medication reconciliation process was innovative because 1) it did not require paper forms; 2) it used a commonly-deployed commercial EHR; and 3) it used a medication list based on discrete, coded elements that bridged ambulatory and inpatient care settings. This study assessed how the electronic medication reconciliation process at NYP affected provider workflow, medication list completeness, and the potential severity of unintentional medication discrepancies.

References

1. Rozich JD. Medication safety: one organization's approach to the challenge. *J Clin Outcomes Manage.* 2001;8(10):27-34.
2. Rozich JD, Howard RJ, Justeson JM, Macken PD, Lindsay ME, Resar RK. Standardization as a mechanism to improve safety in health care. *Jt Comm J Qual Saf.* 2004 Jan;30(1):5-14.
3. Gleason KM, Groszek JM, Sullivan C, Rooney D, Barnard C, Noskin GA. Reconciliation of discrepancies in medication histories and admission orders of newly hospitalized patients. *Am J Health Syst Pharm.* 2004 Aug 15;61(16):1689-95.
4. Lau HS, Florax C, Porsius AJ, A DB. The completeness of medication histories in hospital medical records of patients admitted to general internal medicine wards. *British journal of clinical pharmacology.* 2000;49(6):597-603.
5. Sullivan C, Gleason KM, Rooney D, Groszek JM, Barnard C. Medication reconciliation in the acute care setting: opportunity and challenge for nursing. *J Nurs Care Qual.* 2005 Apr-Jun;20(2):95-8.
6. Barnsteiner JH. Medication reconciliation: transfer of medication information across settings-keeping it free from error. *J Infus Nurs* 2005;28(2 Suppl):31-6.
7. Rozich JD. Medication safety: one organization's approach to the challenge. *Journal of Clinical Outcomes Management.* 2001;8(10):27-34.
8. Kohn LT, Corrigan J, Donaldson MS. *To err is human: building a safer health system.* Washington, D.C.: National Academy Press; 2000.
9. Bates DW, Cullen DJ, Laird N, et al. Incidence of adverse drug events and potential adverse drug events. Implications for prevention. ADE Prevention Study Group. *JAMA.* 1995 Jul 5;274(1):29-34.
10. Greenwald JL, Halasyamani LK, Greene J, et al. Making inpatient medication reconciliation patient centered, clinically relevant, and implementable: a consensus statement on key principles and necessary first steps. *Jt Comm J Qual Patient Saf.* 2010 Nov;36(11):504-13, 481.
11. Rogers G, Alper E, Brunelle D, et al. Reconciling medications at admission: safe practice recommendations and implementation strategies. *Jt Comm J Qual Patient Saf.* 2006 Jan;32(1):37-50.
12. Caglar S, Henneman PL, Blank FS, Smithline HA, Henneman EA. Emergency Department Medication Lists Are Not Accurate. *J Emerg Med.* 2008 Sep 29.
13. Shepherd G, Schwartz RB. Frequency of incomplete medication histories obtained at triage. *Am J Health Syst Pharm.* 2009 Jan 1;66(1):65-9.
14. Coffey M. Medication reconciliation: Coming to a hospital near you. *Paediatr Child Health.* 2009 Feb;14(2):76-7.

15. Cornish PL, Knowles SR, Marchesano R, et al. Unintended medication discrepancies at the time of hospital admission. *Arch Intern Med*. 2005 Feb 28;165(4):424-9.
16. Wong JD, Bajcar JM, Wong GG, et al. Medication reconciliation at hospital discharge: evaluating discrepancies. *Ann Pharmacother*. 2008 Oct;42(10):1373-9.
17. Bedell SE, Jabbour S, Goldberg R, et al. Discrepancies in the use of medications: their extent and predictors in an outpatient practice. *Arch Intern Med*. 2000 Jul 24;160(14):2129-34.
18. Ernst ME, Brown GL, Klepser TB, Kelly MW. Medication discrepancies in an outpatient electronic medical record. *Am J Health Syst Pharm*. 2001 Nov 1;58(21):2072-5.
19. Nassaralla CL, Naessens JM, Chaudhry R, Hansen MA, Scheitel SM. Implementation of a medication reconciliation process in an ambulatory internal medicine clinic. *Qual Saf Health Care*. 2007 Apr;16(2):90-4.
20. Wagner MM, Hogan WR. The accuracy of medication data in an outpatient electronic medical record. *J Am Med Inform Assoc*. 1996 May-Jun;3(3):234-44.
21. Pippins JR, Gandhi TK, Hamann C, et al. Classifying and predicting errors of inpatient medication reconciliation. *J Gen Intern Med*. 2008 Sep;23(9):1414-22.
22. Schnipper JL, Kirwin JL, Cotugno MC, et al. Role of pharmacist counseling in preventing adverse drug events after hospitalization. *Arch Intern Med*. 2006 Mar 13;166(5):565-71.

List of Publications and Products

Owen MC, Chang NM, Chong DH, Vawdrey DK. Evaluation of medication list completeness, safety, and annotations. *AMIA Annu Symp Proc*. 2011;2011:1055-61. Epub 2011 Oct 22. PMID: 22195166

Vawdrey DK, Chang N, Compton A, Tiase V, Hripcsak G. Impact of electronic medication reconciliation at hospital admission on clinician workflow. *AMIA Annu Symp Proc*. 2010 Nov 13;2010:822-6. PMID: 21347093 (Distinguished Paper Award Recipient)

Hripcsak G, Vawdrey DK, Fred MR, Bostwick SB. Use of electronic clinical documentation: time spent and team interactions. *J Am Med Inform Assoc*. 2011 Mar-Apr;18(2):112-7. Epub 2011 Feb 2. PMID: 21292706

Vawdrey DK, Owen MC, Chang NM, Hripcsak G. Discrepancies among medication lists across transitions of care. In preparation.