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Hospital-based Medication Reconciliation Practices: A Systematic Review

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Abstract

Background—Medication discrepancies at care transitions are common and lead to patient harm. Medication reconciliation is a strategy to reduce this risk.

Objectives—To summarize available evidence on medication reconciliation interventions in the hospital setting and identify the most effective practices.

Data Sources—Medline (1966 through **February 2012**) and hand search of article bibliographies.

Study Selection—26 controlled studies.

Data Extraction—Data were extracted on study design, setting, participants, inclusion/exclusion criteria, intervention components, timing, comparison group, outcomes, and results.

Data Synthesis—Studies were grouped by type of medication reconciliation intervention: pharmacist-related, information technology (IT), or other, **and assigned quality ratings utilizing U.S. Preventative Services Task Force criteria.**

Results—15 of 26 studies reported on pharmacist-related interventions, 6 evaluated IT interventions, and 5 studied other interventions. **6 studies were classified as good quality**. The comparison group for all studies was usual care, with no direct comparisons of different types of interventions. Studies consistently demonstrated a reduction in medication discrepancies (17/17 studies), potential adverse drug events (5/6 studies), and adverse drug events (2/3 studies), but showed inconsistent reduction in post-discharge healthcare utilization (improvement in 2/8

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studies). Key aspects of successful interventions included intensive pharmacy staff involvement and targeting the intervention to a 'high-risk' patient population.

Conclusions—There is a paucity of rigorously designed studies comparing different inpatient medication reconciliation practices and their effects on clinical outcomes. Available evidence supports medication reconciliation interventions that heavily utilize pharmacy staff and focus on patients at high-risk for adverse events. Higher quality studies are needed to determine the most effective approaches to inpatient medication reconciliation.

Introduction

Adverse drug events (ADEs), defined as patient injuries related to a drug,[1] are an epidemic patient safety issue, occurring in 5–40% of hospitalized patients and in 12–17% of patients post-discharge.[2–3] Transitions of care, such as hospital admission and discharge, contribute to ADEs in part due to medication discrepancies, or unexplained differences in documented medication regimens across different sites of care.[4–5] Medication discrepancies are common, occurring in up to 70% of patients at admission or discharge,[6–10] with nearly one-third of these having potential to cause patient harm (i.e., potential adverse drug events, or PADEs).[10] ADEs associated with medication discrepancies can prolong hospital stays and, in the post-discharge period, may lead to emergency room visits, hospital readmissions, and utilization of other healthcare resources.[11–12]

Medication reconciliation is a strategy to reduce the occurrence of medication discrepancies that may lead to ADEs or PADEs. Medication reconciliation is the "process of identifying the most accurate list of all medications a patient is taking…and using this list to provide correct medications for patients anywhere within the health care system."[13] Recognizing the potential impact of properly reconciling medications during care transitions, in 2005 The Joint Commission added medication reconciliation to its list of National Patient Safety Goals.[14]

During the past decade, various medication reconciliation interventions have been described, but the specific elements important to successful efforts have not been fully appreciated. We performed a systematic review of the literature to summarize the available evidence on medication reconciliation in the hospital setting and to identify the most effective practices.

Methods

Data Sources and Searches

We performed a systematic search of English language articles published from 1966 through February 2012 on medication reconciliation during patient hospitalization. Using Medline, we searched a combination of Medical Subject Headings (MeSH) and keywords including "medication reconciliation," "medication errors/prevention and control," "patient discharge," "medication systems, hospital," "medical records systems, computerized," "medication list," and "medication record." We performed a second electronic search adding the keyword "patient admission" in combination with the above list to update the search and to incorporate interventions that took place on admission and not just at discharge. We hand-searched the reference lists of relevant articles.

Study Selection

Controlled intervention studies that met the following criteria were eligible for inclusion: English language, medication reconciliation was the primary focus of the intervention, the comparison group was defined, the intervention was clearly described, the intervention took place in the hospital setting during the period of hospitalization and/or transition into or out

of the hospital, and quantitative results were provided. One reviewer (SM or KS) performed initial independent assessments of titles for relevance and subsequent examination of abstracts and articles for inclusion, which was then verified by a second reviewer (SM or KS). Discrepancies were resolved by a third reviewer (JS or SK).

Data Extraction

One reviewer (SM) extracted relevant data from included articles, which was then verified by 2 other reviewers (KS and JS). Information was obtained regarding study design, setting, number of participants, components of the intervention, timing of the intervention related to hospital course, comparison group, outcome measures, type of outcome, and results (data extraction tool shown in Appendix A).

Data Synthesis and Analysis

Studies were first grouped into the following 3 categories, based on the primary component of the intervention: (1) pharmacist-related, (2) information technology (IT), or (3) other type. Two authors (SM and JS) then collectively determined 4 common types of reported outcomes, including: (1) medication discrepancies, defined as unexplained differences in documented medication regimens across different sites of care, (2) potential adverse drug events (PADEs), defined as medication discrepancies with potential to cause patient harm, (3) adverse drug events (ADEs), defined as patient injuries related to a drug, and (4) healthcare utilization, defined as post-discharge emergency room visits, hospital readmissions, and/or utilization of other healthcare resources. Meta-analysis was not feasible due to heterogeneity in methods, interventions, and reported outcomes.

Studies were also rated on quality and categorized as “good”, “fair”, or “poor”, utilizing the U.S. Preventive Services Task Force (USPSTF) standardized criteria for assessing internal validity of individual studies,[15] adapting the criteria for pre-post studies where needed. Two authors (SM and SK) graded each study individually and then resolved any differences by consensus.

Observational (Non-Controlled) Studies

Observational studies that met the same inclusion criteria as described were examined and data extracted in the same manner as reported above. Although not included in this manuscript, information on these studies can be found in the e-appendix.

Results

Of the 1632 articles initially identified via electronic search, 173 abstracts were reviewed. A second electronic search and hand search of references yielded an additional 57 abstracts. Of the 230 abstracts reviewed, 80 publications warranted full review. Of these, 17 articles met criteria for inclusion. An updated search identified 9 additional articles meeting criteria for inclusion, resulting in 26 total included articles, including 10 randomized controlled trials, 3 non-randomized trial with a concurrent control group, and 13 pre-post studies (Figure 1). Of the 26 included studies, 14 were conducted in countries other than the United States including Canada,[16–17] Australia,[18–19] New Zealand,[20] Northern Ireland,[21] United Kingdom,[22] Belgium,[23] Denmark,[24] Netherlands,[25] and Sweden.[26–29]

Fifteen studies reported on pharmacist-related interventions,[16–19, 21–22, 24–26, 28–33] 6 studies reported on IT-focused interventions,[34–39] and 5 studies reported on other types of interventions including educating staff about medication reconciliation[20, 40] and use of a standardized medication reconciliation tool.[23, 27, 41] The majority of studies were classified as poor quality (15 of 26)[18–23, 27, 29–30, 34–35, 37–38, 40–41] with 6 studies classified as good

quality,[24–25, 28, 31, 36, 39] and the remaining 5 studies classified as fair quality.[16–17, 26, 32–33] A summary of the timing and components of the interventions and quality ratings of the studies is shown in Table 1, and results of the studies are summarized in Table 2. Comparison groups for all included studies was "usual care," as defined in Table 1.

The 15 studies involving pharmacist-related interventions included diverse roles of the pharmacy staff in the medication reconciliation process, as well as varied timing of pharmacy staff involvement during the patient's hospitalization. Four of the 15 studies were rated as good quality[24–25, 28, 31] (Table 1). The majority of these studies involved licensed pharmacists, although pharmacy residents[32] and pharmacy technicians[30] were also utilized. These interventions reduced medication discrepancies (10/10 studies)[16–19, 21–22, 25–26, 30, 33] and potential adverse drug events (improvement in 2 of 3 studies),[16, 18, 25] but showed mixed effects on preventable adverse drug events (improvement in 1 of 2 studies)[24, 31] and healthcare utilization (improvement in 2 of 7 studies)[21, 24, 28–29, 31–33] (Table 2). In the larger of these last 2 studies, Gillespie et al. utilized a pharmacist to perform medication histories and reconciliation on admission and discharge, patient and provider medication counseling during hospitalization, communication with the primary care physician on discharge, and communication with the patient 2 months after discharge. This intervention reduced the odds of all hospital visits by 16% (OR 0.84, 95% CI 0.72–0.99), including a 47% reduction in emergency department (ED) visits and an 80% reduction in drug-related readmissions in the 12 months following hospital discharge. No difference was seen in all-cause hospital readmission or overall mortality.[28] Koehler et al. reported on a similar intensive intervention, but utilized pharmacy residents instead of licensed pharmacists. This intervention decreased 30-day ED visits/readmissions (10% in the intervention group versus 38.1% in the control group, p=0.04).[32] Common themes of these 2 successful studies included (1) limiting the intervention to elderly patients (age ≥ 80 and ≥ 70 years, respectively); (2) intensive pharmacy staff involvement including medication history-taking on admission and medication reconciliation on admission, during hospitalization, and at hospital discharge; (3) communication with the primary care physician via direct communication or use of a template; and (4) telephone follow-up after discharge. The 5 studies that demonstrated no effect on healthcare utilization had more limited roles for the intervention pharmacist[21, 29, 31] or utilized them for a more limited time during hospitalization (e.g., admission or discharge only).[24, 31, 33]

The 6 studies that reported IT-focused medication reconciliation interventions all improved access to electronically available sources of preadmission medication information such as ambulatory electronic medical records.[34–39] These interventions leveraged data to create a preadmission medication list and facilitated comparison of this list with admission and/or discharge orders to help with the medication reconciliation process. Two of the 6 studies were rated as good quality.[36, 39] IT-related interventions reduced medication discrepancies (3/3 studies),[34–35, 37] potential adverse drug events (1/1 study),[36] and adverse drug events (1/1 study),[38] but demonstrated no improvement/slightly increased healthcare utilization (within 1 study).[39] Through implementation of an electronic medication reconciliation tool and process redesign, Schnipper et al. decreased the incidence of potential adverse drug events, with an average of 1.05 PADEs per patient in the intervention arm versus 1.44 in the control arm (RR 0.72, 95% CI 0.52–0.99).[36] However, Showalter et al. demonstrated that implementation of an automated medication reconciliation tool on discharge, that also included autopopulation of other discharge instructions, resulted in no difference in composite 30-day healthcare utilization, and was associated with an increase in 30-day hospital readmission (11% post-intervention versus 10.2% pre-intervention, p=0.02). The authors hypothesized that improving the discharge instructions to inform patients of worrisome symptoms may have led to higher rates of subsequent (appropriate) readmissions.[39]

Among the 5 studies that described other types of interventions, 2 provided education/feedback for the staff about medication reconciliation,[20, 40] and 3 used a standardized medication reconciliation tool. The standardized tools included a discharge report that provided a brief hospital summary detailing all medication changes that occurred during hospitalization,[27] a six-step standardized nursing approach to medication history taking and reconciliation on admission,[41] and a standard questionnaire used by emergency room physicians on admission.[23] None of these studies were rated as good quality. These studies demonstrated improvement in medication discrepancies (4/4 studies)[20, 23, 40–41] and in potential adverse drug events (2/2 studies).[20, 27] For example, Midlov et al. described use of a physician-generated medication report for post-discharge providers that included a brief summary of hospitalization, medications on discharge, and detailed medication changes made during hospitalization and reasons for those changes, which resulted in decreased PADE from 8.9% pre-intervention to 4.4% post-intervention (p=0.049).[27] The intervention was limited to elderly patients admitted from/returning to a nursing home.

Of all 26 studies, 13 focused the intervention on a “high risk” sub-group of patients. This “high risk” category was most commonly defined as older patients, with age threshold from 55 to 80 years.[18, 20–21, 24, 26–29, 32, 37] Other definitions of “high risk” included polypharmacy with thresholds ranging from greater than 4 to 13 medications[18, 20–21, 25, 32–33, 36] and having greater than 3 co-morbid conditions.[18, 32] Several studies included a combination of these criteria to define the intervention cohort.[18, 20–21, 32]

Observational studies described similar types of interventions as the comparative studies, with pharmacist-led interventions again the most commonly reported (see e-Appendix).

Discussion

This systematic review of hospital-based medication reconciliation practices found that various interventions including those involving pharmacy staff, IT, and other types of interventions successfully decreased medication discrepancies and potential adverse drug events, but demonstrated inconsistent benefit on adverse drug events and healthcare utilization, compared to usual care.

Most studies reported on pharmacist-related interventions (15/26 studies), which included a number of articles that evaluated clinical outcomes such as preventable adverse drug events[24, 31] and healthcare utilization,[21, 24, 28–29, 31–33] rather than solely examining process measures such as medication discrepancies. Further, this category of intervention had the greatest number studies rated as good quality, with 4 of 15 studies rated in this category.[24–25, 28, 31] In the two studies that demonstrated improvement in healthcare utilization,[28, 32] the pharmacy staff was heavily involved, performing a comprehensive medication history at admission, medication reconciliation at admission and discharge, patient counseling, discharge communication with outpatient providers, and post-discharge communication with the patient.

Notably, the majority of reported pharmacist-related interventions also included an the taking of an accurate medication history at time of admission, as noted in Table 1. Errors in obtaining an accurate preadmission medication history have great potential for harm, as they can propagate throughout a patient’s hospitalization and after discharge. They are also the most common reason for PADEs caused by medication discrepancies.[8] Although it is difficult to distinguish the impact of an accurate medication history from the impact of successful medication reconciliation when both are included in the intervention, in reality these two process steps are both necessary components of the overall medication

reconciliation process. It is therefore unrealistic to consider a successful medication reconciliation program that does not also include an initial accurate medication list from which to begin the reconciliation process.

Other common elements of the successful pharmacist-related medication reconciliation efforts included communication with post-discharge providers regarding the discharge medication regimen, including how and why the regimen differed from prior to admission,[17, 21, 28, 32–33] and patient education and follow-up.[17, 21, 26, 28, 31–33]

It is worth noting that the pharmacist-related interventions were comprised of studies that utilized licensed pharmacists as well as studies that used less resource intensive pharmacy staff, such as pharmacy residents[32] and pharmacist technicians,[30] demonstrating the viability of using other personnel in this role.

Despite these demonstrations of successful implementation of pharmacist-related interventions, the comparison group in all of these studies was “usual care,” and therefore the evidence does not definitively support pharmacist-led medication reconciliation as superior to other reported interventions.

In review of all pharmacist and non-pharmacist-related interventions, common elements of successful interventions was the targeting of a “high risk” sub-group,[18, 26–28, 32, 36–37] evidence of institutional support,[28, 36] and performing the intervention in a defined population, e.g. patients to/from a nursing home[27] or in the setting of an elective surgical admission.[19]

Despite these reports of successful medication reconciliation interventions, this review highlights the paucity of rigorously designed studies on inpatient medication reconciliation. Only 26 studies met inclusion criteria for our review, and of these, only 10 are randomized controlled trials,[16–17, 19, 21, 24–25, 28, 31–32, 36] only 1 of which was conducted at more than 1 site.[36] On quality review, only 6 of 26 studies met criteria to be classified as good quality.[24–25, 28, 31, 36, 39] Further, comparison groups in all studies were “usual care,” rather than alternative interventions. This is understandable given the state of medication reconciliation efforts prior to 2005, but it limits our ability to draw conclusions on the most effective practices of medication reconciliation. Also, “usual care” relating to medication reconciliation efforts has likely improved since it was first mandated by The Joint Commission, making it difficult to compare the efficacy of certain interventions in older versus newer studies. Additionally, most studies investigated process measures alone, such as presence of medication discrepancies with potential for harm, rather than clinical outcomes, which were reported in only 9 of the 26 studies.[21, 24, 28–29, 31–33, 38–39] While process measures are easily studied, pertinent to the issue of medication safety, and responsive to change, it is important to distinguish between these and actual patient outcomes.

There are many reasons why it has been difficult to rigorously examine medication reconciliation efforts despite its recognized importance to patient safety. As noted in the Society of Hospital Medicine’s 2010 Consensus Statement,[42] medication reconciliation efforts are often resource-intensive (e.g., HIT, pharmacists) and need to overcome several challenges, including the disjointed nature of the American healthcare system, the need to maintain up-to-date and accurate medication lists across different venues of patient care, and difficulty with identifying and maintaining role responsibility in the process. Further, electronic medication reconciliation solutions are often part of larger electronic medical record systems, making it difficult to study them in isolation. Therefore, studies comparing two different interventions are logistically difficult, and it may be more feasible to expect

comparisons of one intervention currently in use to that intervention plus the addition of another one.

There are several limitations of this review. Along with the lack of rigorous study design in most included studies, as discussed above, it is possible (and in fact likely) that other medication reconciliation interventions have been implemented and studied, found to be unsuccessful, and never published. Second, there were a large number of included studies from outside the United States, which potentially limits generalizability in U.S. healthcare settings. Differences in patient safety culture and/or better access to medication information (e.g., through nationalized health records) may make implementation efforts more successful in other countries than in the United States. Third, this review is intentionally limited to medication reconciliation practices within, or in transition to/from the hospital setting, and therefore does not include the broader scope of all medical settings, including primary care or other clinic venues.

Conclusions

In summary, there are limited data on most effective practices of inpatient medication reconciliation, and a lack of rigorously designed controlled studies comparing different approaches to medication reconciliation to each other.

In the context of these limitations, existing evidence supports pharmacist-related interventions compared to usual care in producing the best patient outcomes, with high degree of pharmacist or pharmacy staff involvement in all medication reconciliation-related processes producing the best patient outcomes. Targeting interventions to a subset of patients considered at greatest risk of an adverse drug event, such as elderly patients, patients taking many medications, and/or patients with many co-morbid conditions, may be of highest yield. This evidence also suggests that taking an accurate medication history and communicating with post-discharge providers are important steps, especially for achieving reduction in post-discharge healthcare utilization.

Future research should include randomized controlled trials when possible (and interrupted time series or ‘stepped wedge’ designs when not possible), utilizing rigorous outcome assessment that includes clinical as well as process outcomes. Studies should also compare interventions to each other or evaluate the incremental benefits of adding a second intervention to one already in use, ensuring standardized and consistent measurement methods and detailed descriptions of usual care. Additionally, the SHM consensus statement on medication reconciliation recommends a set of key action items for addressing identified barriers to implementation and reporting;[42] these should also be utilized in future research and quality improvement efforts. Despite the aforementioned difficulties in performing these types of rigorous studies, it should be emphasized that it is because of the resources required for successful medication reconciliation efforts that precise estimates of impact, based on rigorously conducted studies, are required.

This review should help inform the development of future interventions, both for research and for institutions wishing to improve medication safety during transitions in care.

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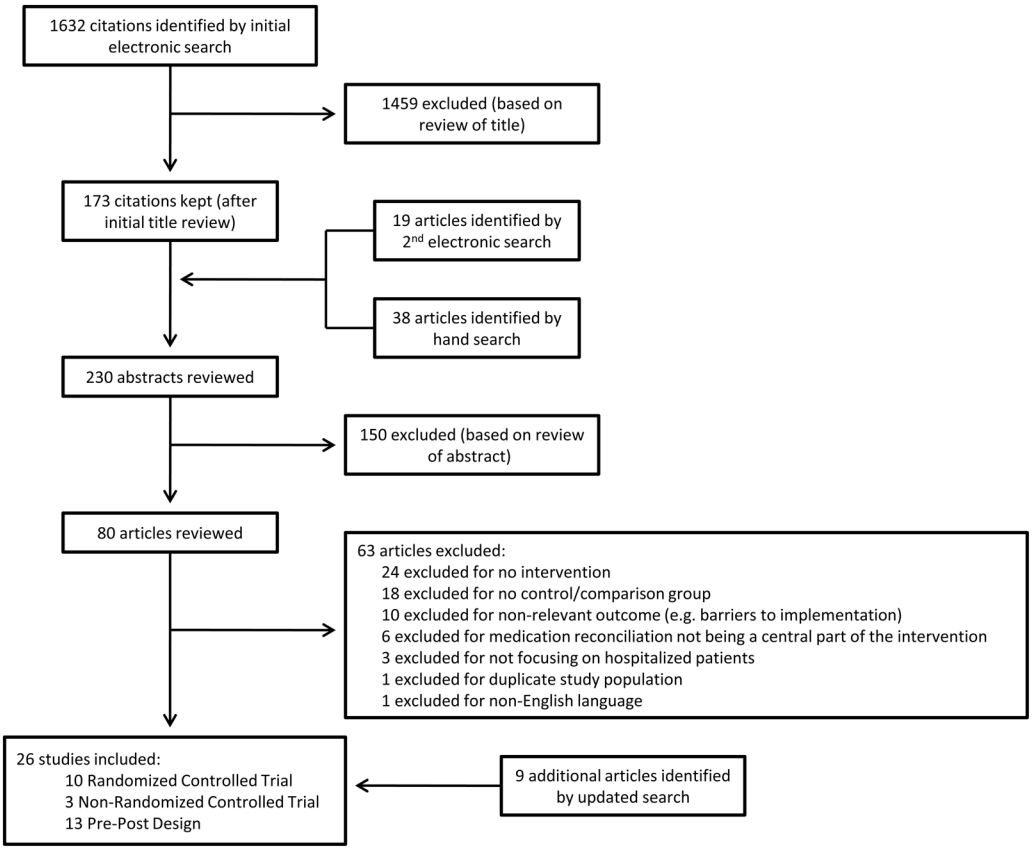

Figure 1.

Table 1

Timing and Components of Interventions

First Author, Yr (Study Design)	N	Timing of Intervention					Components of Intervention						Control Group	[1] USPSTF Quality Rating
		Pre-Admission	Admission	During Hospitalization	Discharge	Post-Discharge	Medication History Taking	Medication Reconciliation	Patient Counseling	Communication with Outpatient Providers	Review Appropriateness of Medications	Post-discharge Communication with Patient		
PHARMACIST-RELATED INTERVENTIONS														
Michels, 2003 (Pre-Post)	NR	√	√				√	√					Usual care prior to intervention (nurse or physician recorded home medication list which was used for admission orders)	POOR
Bolas, 2004 (RCT)	162		√	√	√		√	√	√	√			Usual care (standard clinical pharmacy service which did not routinely perform discharge counseling)	POOR
Nickerson, 2005 (RCT)	253				√			√	√	√	√		Usual care (nurse performed discharge counseling and transcribed discharge note from medical record)	FAIR
Schnipper, 2006 (RCT)	176				√			√	√	√		√	Usual care (ward-based pharmacist performed routine review of medication orders, nurse performed discharge counseling)	GOOD
Kwan, 2007 (RCT)	464		√				√	√					Usual care (nurse conducted medication history and surgeon generated post-operative	FAIR

First Author, Yr (Study Design)	N	Timing of Intervention					Components of Intervention						Control Group	[1] USPSTF Quality Rating
		Pre-Admission	Admission	During Hospitalization	Discharge	Post-Discharge	Medication History Taking	Medication Reconciliation	Patient Counseling	Communication with Outpatient Providers	Review Appropriateness of Medications	Post-discharge Communication with Patient		
													medication orders)	
Bergkvist, 2009 (Pre-Post)	115		√	√	√			√	√		√		Usual care prior to intervention (standard care without pharmacist involvement in reconciliation or review of medications on admission or discharge)	FAIR
Gillespie, 2009 (RCT)	400		√	√	√	√	√	√	√	√		√	Usual care (standard care without direct involvement of pharmacists at the ward level)	GOOD
Koehler, 2009 (RCT)	41		√	√	√	√	√	√	√	√	√	√	Usual care (floor nursing staff performed medication reconciliation and medication education)	FAIR
Vasileff, 2009 ([2] Non-RCT)	74		√				√	√					Usual care (physician obtained medication history from patient and generated orders)	POOR
Walker, 2009 ([2] Non-RCT)	724				√	√		√	√	√	√	√	Usual care (nurses provided patients with printed list of medications and instructions at discharge; Medicare beneficiaries received phone call 72 hours post-discharge)	FAIR
Eggink, 2010 (RCT)	85				√			√	√	√			Usual care (nurses provided verbal and written instructions at discharge, physician	GOOD

First Author, Yr (Study Design)	N	Timing of Intervention					Components of Intervention						Control Group	[1] USPSTF Quality Rating
		Pre-Admission	Admission	During Hospitalization	Discharge	Post-Discharge	Medication History Taking	Medication Reconciliation	Patient Counseling	Communication with Outpatient Providers	Review Appropriateness of Medications	Post-discharge Communication with Patient		
													provided patient with medication list to give to their primary care physician)	
Lisby, 2010 (RCT)	99		√				√	√			√		Usual care (medication review by junior physician on admission, and by senior physician within 24 hours of admission)	GOOD
Mills, 2010 (Pre-Post)	100	√	√				√	√					Usual care (Admitting junior physician obtained medication history and reconciled medications when patient arrived on ward from the ER)	POOR
Hellstrom, 2011 (Pre-Post)	210		√	√			√	√			√		Usual care (standard care without pharmacist involvement in medication reconciliation on admission or during hospitalization, standard physician performed medication reconciliation on discharge)	POOR
[3] Marotti, 2011 (RCT)	357	√	√				√	√					Usual care (medication history taking and prescribing performed by physician on admission)	POOR
IT INTERVENTIONS							**Components**							
Poole, 2006 (Pre-Post)	100				√		Formation of a medication list from pre-existing electronic sources Reconciliation of discharge medications with this list						Usual care prior to intervention	POOR

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First Author, Yr (Study Design)	N	Timing of Intervention					Components of Intervention						Control Group	[1] USPSTF Quality Rating
		Pre-Admission	Admission	During Hospitalization	Discharge	Post-Discharge	Medication History Taking	Medication Reconciliation	Patient Counseling	Communication with Outpatient Providers	Review Appropriateness of Medications	Post-discharge Communication with Patient		
													(patients discharged without use of a discharge medication worksheet)	
Agrawal, 2009 (Pre-Post)	NR		√				Formation of a medication list from pre-existing electronic sources Reconciliation of admission orders with this list						[3] Usual care during pilot phase (standard care without use of electronic medication reconciliation system)	POOR
Murphy, 2009 (Pre-Post)	NR		√		√		Pharmacist performed medication history and reconciliation on admission Formation of a medication list from pre-existing electronic sources Reconciliation of discharge medications with this list						Usual care prior to intervention (standard care without direct involvement of pharmacist on ward level and without electronic reconciliation)	POOR
Schnipper, 2009 (RCT)	322		√		√		Formation of a medication list from pre-existing electronic sources Reconciliation of admission orders and discharge medications with this list Pharmacist confirmation of reconciliation at admission						Usual care (ward-based pharmacist performed routine review of medication orders, nurse performed discharge counseling)	GOOD
Boockvar, 2011 ([2] Non-RCT)	795		√				Formation of a medication list from pre-existing electronic sources Reconciliation of admission orders with this list						Usual care (no computerized availability of recent VA outpatient medication use)	POOR
Showalter, 2011 (Pre-Post)	34088				√		Formation of a medication list from pre-existing electronic sources Reconciliation of discharge medications with this list						Usual care prior to intervention (manual completion of a printed medication reconciliation document)	GOOD
OTHER INTERVENTIONS							**Components**							
Varkey, 2007 (Pre-Post)	102		√	√	√		Multidisciplinary medication reconciliation with use of reconciliation form on admission and discharge Education of staff on medication reconciliation including real-time feedback on detected medication discrepancies						Usual care during “Phase	POOR

First Author, Yr (Study Design)	N	Timing of Intervention					Components of Intervention						Control Group	[1] USPSTF Quality Rating
		Pre-Admission	Admission	During Hospitalization	Discharge	Post-Discharge	Medication History Taking	Medication Reconciliation	Patient Counseling	Communication with Outpatient Providers	Review Appropriateness of Medications	Post-discharge Communication with Patient		
													I" (nurses, pharmacists and physicians used a medication reconciliation form to collect and reconcile medications at admission and discharge, but no feedback was given)	
Midlov, 2008 (Pre-Post)	427				√		Use of a physician generated medication report to next provider of care at time of discharge that includes details of medication changes made during hospital course						Usual care prior to intervention (no structured way that medication changes were communicated to outpatient providers)	POOR
Chan, 2010 (Pre-Post)	407		√				Multidisciplinary medication history and reconciliation on admission Education of health care providers on importance of medication reconciliation via lectures, posters around hospital, and reminder notes in patient charts						Usual care prior to intervention (pharmacist performed medication history on small number of patients; this did not change during the study)	POOR
Tessier, 2010 (Pre-Post)	100		√				Nursing performed medication reconciliation with use of a 6-step instructional pamphlet						Usual care prior to intervention (not described)	POOR
De Winter, 2011 (Pre-Post)	260	√					ED physician performed medication history taking and reconciliation with use of a standardized "limited questions list" questionnaire						Usual care (admitting physician performed medication history taking and reconciliation without use of a standardized tool)	POOR

Abbreviations: IT = Information Technology; RCT = Randomized Controlled Trial; Non-RCT = Non-Randomized Controlled Trial; NR = Not Reported

[1] USPSTF = U.S. Preventive Services Task Force, utilizing set criteria for assessing internal validity of individual studies. Please email corresponding author for further details on how quality ratings were assigned.

[2] Non-RCT had a concurrent control group, but the sample was a convenience sample as opposed to a randomized sample

[3]Given poor compliance during pilot phase, comparison group was reflective of usual care prior to intervention

Table 2

Study Outcomes

First Author, Yr (Study Design)	* Outcomes Examined				Results	P value or OR [95% CI]
	Medication Discrepancies	Potential Adverse Drug Events (PADEs)	Adverse Drug Events (ADEs)	Healthcare Utilization		
PHARMACIST-RELATED INTERVENTIONS						
Michels, 2003 (Pre-Post)	+				• Number of defects decreased from 1.45 per order form to 0.76 in first 16 weeks of implementation	<0.001
					• Mean number of defects per individual drug order decreased from 0.25 to 0.12	<0.001
Bolas, 2004 (RCT)	+			~	• Decrease in drug name mismatch at 10–14 days post-discharge	0.005
					Decrease in drug frequency mismatch at 10–14 days post-discharge	0.004
					• No difference in emergency readmission rates within 3 months or LOS on readmission	>0.05
Nickerson, 2005 (RCT)	+				• Medication discrepancies at time of discharge were noted in 56.3% of control patients versus 3.6% of intervention patients	NR
Schnipper, 2006 (RCT)			+	~	• Preventable ADEs 11% in control group versus 1% in intervention group at 30 days post-discharge	0.01
					• No difference in healthcare utiliza tion	>0.05
Kwan, 2007 (RCT)	+	+			• 40.2% of control patients had a post-op medication discrepancy versus 20.3% in intervention group	<0.001
					• 29.9% of control patients had a post-op medication discrepancy with potential for harm versus 12.9% in intervention group	<0.001

First Author, Yr (Study Design)	* Outcomes Examined				Results	P value or OR [95% CI]
	Medication Discrepancies	Potential Adverse Drug Events (PADEs)	Adverse Drug Events (ADEs)	Healthcare Utilization		
Bergkvist, 2009 (Pre-Post)	+				• 63.5% of control patients had at least one medication error versus 26.9% of intervention patients	0.012
Gillespie, 2009 (RCT)				+	• Intervention group had 16% reduction in all hospital visits (quotient of 2.24 in control group versus 1.88 in intervention group) at 12 months follow up	0.84 [0.72–0.99]
					• Intervention group had a 47% reduction in ED visits (quotient of 0.66 in control group versus 0.35 in intervention group) at 12 months follow up	0.53 [0.37–0.75]
					• Intervention group had 80% reduction in drug-related readmissions at 12 months follow up	0.2 [0.1–0.41]
					• No difference in all-cause readmissions, no difference in overall survival at 12 months follow up	>0.05
Koehler, 2009 (RCT)				+	• 38.1% of control group had readmission/ED visit at 30 days versus 10% in intervention group	0.04
					• Readmission/ED visit at 60 days was same in 2 groups	>0.05
					• Time to readmission/ED visit was 15.7 days in control group versus 36.2 days in intervention group	0.05
Vasileff, 2009 (Non-RCT)	+	+			• 75.6% of usual care patients had ≥ 1 unintentional discrepancy versus 3.3% of intervention patients	<0.05
					• Of the unintentional discrepancies, 2% were felt to have potential for no harm, 40% had potential for minor impact, 52% had potential	IRR < 0.8, except for one possible pairing (not specified)

First Author, Yr (Study Design)	* Outcomes Examined				Results	P value or OR [95% CI]
	Medication Discrepancies	Potential Adverse Drug Events (PADEs)	Adverse Drug Events (ADEs)	Healthcare Utilization		
					for significant impact, and 6% had potential for very significant impact	
Walker, 2009 (Non-RCT)	+			~	• Medication discrepancies at discharge were noted in 59.6% of control patients versus 33.5% of intervention patients	<0.001
					• No difference in 14-day or 30-day readmission rate, no difference in ED visits within 72 hours	>0.05
Eggink, 2010 (RCT)	+	~			• Medication discrepancies at discharge were noted in 68% of control patients versus 39% of intervention patients	0.57 [0.37, 0.88]
					• Of the medication discrepancies, 29% were felt to have potential for serious harm in the control group versus 32% in the intervention group	NR (stated in text "non-significant)
Lisby, 2010 (RCT)			~	~	• No difference in length of stay, time to readmission, 3-month readmission, ED visits, visits to general practitioners, mortality	>0.05
Mills, 2010 (Pre-Post)	+				• Medication errors decreased from 3.3 errors/ patient pre-intervention to 0.04 errors/patient post-intervention	>0.05
Hellstrom, 2011 (Pre-Post)				~	• No difference in drug-related healthcare utilization 3 months post-discharge	0.138
Marotti, 2011 (RCT)	+				• Mean number of missed medication doses during hospitalization was 3.21 in control group versus 1.07 in intervention group	<0.001
IT INTERVENTIONS						
Poole, 2006 (Pre-Post)	+				• Resolution of medication discrepancies increased by 65%	<0.001

First Author, Yr (Study Design)	* Outcomes Examined				Results	P value or OR [95% CI]
	Medication Discrepancies	Potential Adverse Drug Events (PADEs)	Adverse Drug Events (ADEs)	Healthcare Utilization		
Agrawal, 2009 (Pre-Post)	+				• Unintended discrepancy rate decreased from 20% per-intervention to 1.4% post-intervention	NR
Murphy, 2009 (Pre-Post)	+				• Unintended medication discrepancies decreased from 90% to 47% on surgical floors, and from 57% to 33% on medical floors	0.001
Schnipper, 2009 (RCT)		+			• Average number of PADEs per patient was 1.44 in the control group versus 1.05 in the intervention group	0.72 [0.52–0.99]
Boockvar, 2011 (Non-RCT)			+		• Intervention group experienced 43% reduction in adverse drug events caused by admission prescribing changes classified as errors	0.57 [0.33, 0.98]
					• No difference in adverse drug events caused by all admission prescribing changes	1.04 [0.68, 1.61]
Showalter, 2011 (Pre-Post)				~/−	• No difference in composite outcome of 30-day readmission or ED visit from pre-intervention to post-intervention	0.17
					• 30-day readmission rate was 10.2% pre-intervention compared to 11% post-intervention	0.02
OTHER INTERVENTIONS						
Varkey, 2007 (Pre-Post)	+				• Mean number of medication discrepancies per patient at time of admission decreased from 0.5 pre-intervention to 0 post-intervention	0.018
					• Mean number of medication discrepancies per patient at time of discharge decreased from 3.3 pre-intervention to 1.8 post-intervention	0.003
Midlov, 2008 (Pre-Post)		+			• 8.9% of control group had potential adverse drug events that would lead to required medical care (readmission to hospital or visit	0.049

First Author, Yr (Study Design)	* Outcomes Examined				Results	P value or OR [95% CI]
	Medication Discrepancies	Potential Adverse Drug Events (PADEs)	Adverse Drug Events (ADEs)	Healthcare Utilization		
					to PCP) compared with 4.4% of intervention group	
Chan, 2010 (Pre-Post)	+	+			• Unintentional medication discrepancy rate per admission decreased from 2.6 pre-intervention to 1.0 post-intervention	<0.001
					• The proportion of admissions with one or more clinically significant unintentional medication discrepancies decreased from 46% pre-intervention to 24% post-intervention	0.023
Tessier, 2010 (Pre-Post)	+				• Medication discrepancies were present in 42% of patients pre-intervention versus 20% of post-intervention patients	0.03
De Winter, 2011 (Pre-Post)	+				• Mean number of medication discrepancies per patient was 1.1 in control group versus 0.6 in intervention group	<0.001

Abbreviations: LOS = length of stay; IRR = Inter-rater reliability; IT = information technology; ED = Emergency Department; PCP = Primary Care Physician; RCT = randomized controlled trial

*Outcomes examined intervention versus “usual care” as the comparison group (detailed in Table 1) for all studies

+indicates statistically significant improvement with intervention versus control in at least one outcome in this category

~indicates no statistically significant difference between intervention and control in at least one outcome in this category

–indicates statistically significant worsening with intervention versus control in at least one outcome in this category