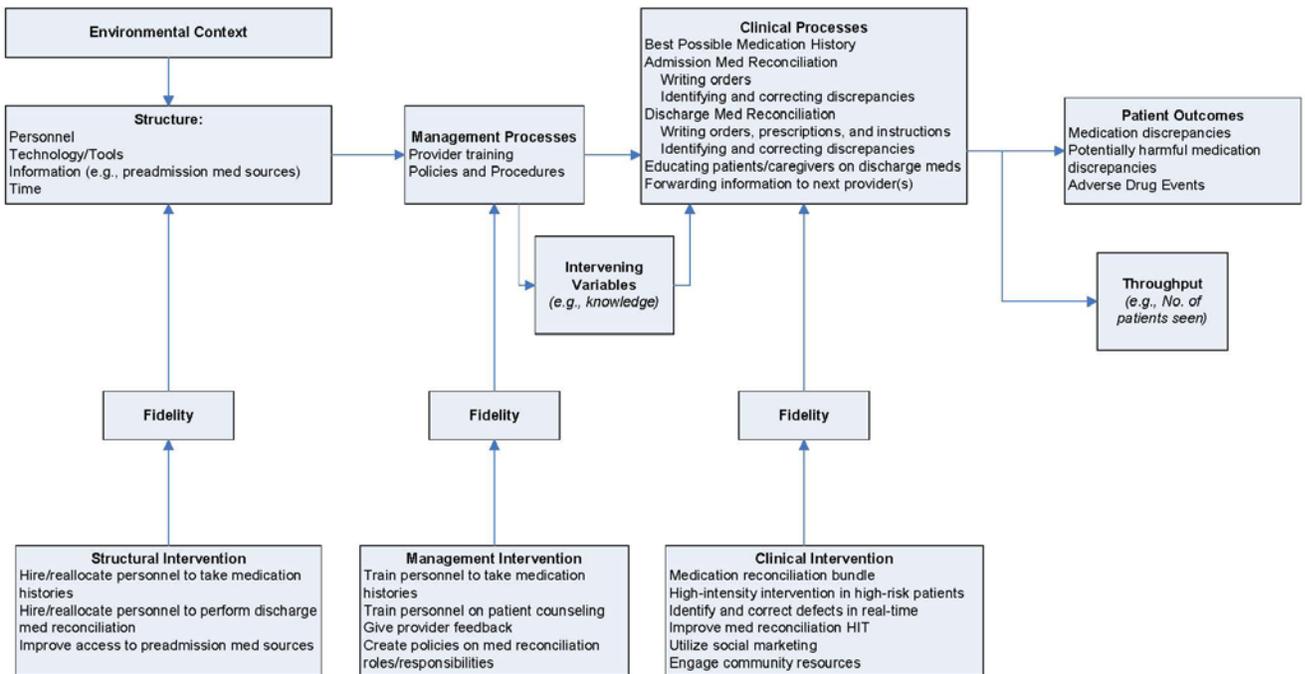


## Online Appendix



**Appendix Figure 1.** Modified Structure/Process/Outcome theoretical framework for medication reconciliation. The interventions at the bottom of the figure comprise the different components of the MARQUIS intervention toolkit. The efficacy of any interventions in reducing medication discrepancies and downstream patient harm is dependent on upstream context and the fidelity with which interventions are implemented. Adapted from Brown C, Lifford R. *BMJ* 2008;337:a2764

**Appendix Table 1. Site Characteristics and Medication Reconciliation Processes at Baseline**

Site	1	2	3	4	5
Mentor	A	B	C	C	A
Hospital Type	AMC	AMC / Community	Community	Community	VAMC
Region	West Coast	Northeast	Southeast	Southeast	Midwest
Setting	Urban	Urban	Suburban	Suburban	Rural
Number of Beds	450	653	535	110	45
Teaching Status	Teaching	Teaching	Non- teaching	Teaching	Teaching
Inpatient EHR <sup>3</sup>	Implemented during study	Yes	No	Implemented during study	Yes
Medication Reconciliation Software	Paper → As part of EHR during implementation	As part of EHR	Yes	Paper → As part of EHR during implementation	Yes, not fully integrated
% patients for whom site has electronic access to ambulatory medication history	50%	50%	<10%	0%	95%

Clinicians primarily responsible for taking medication histories	Physicians	Jointly shared by physicians and nurses	Pharmacists and nurses	Nurses first, then physicians	Residents and PAs
Process of medication reconciliation at discharge <sup>1</sup>	Physicians write orders, pharmacists available by request to reconcile medications	Physicians use electronic tool to reconcile medications	Physicians reconcile medications using paper form	Nurses fill out a reconciliation form, physicians reconcile medications	Physicians or pharmacists, depending on time of day

1. Comparing discharge medication orders with pre-admission medication list and inpatient orders to identify and resolve discrepancies.

AMC: Academic medical center; VAMC: Veterans Affairs Medical Center; EHR: Electronic Health Record;

PAs: Physician assistants

**Appendix Table 2. Time Series Analysis: Number of Potentially Harmful Discrepancies Per Patient**

<b>Parameter</b>	<b>Unadjusted Incidence Rate Ratio (95% CI)</b>	<b>P Value</b>	<b>Adjusted Incidence Rate Ratio (95% CI)*</b>	<b>P Value</b>
<b>Time Series Covariates</b>				
1. Month (Baseline temporal trend in control units)	<b>0.94 (0.91 to 0.97)</b>	<b>&lt;0.001</b>	<b>0.96 (0.94 to 0.98)</b>	<b>0.0009</b>
2. Post-implementation time period (sudden change in control units at start of implementation period)	1.17 (0.77 to 1.76)	0.46	1.18 (0.66 to 2.09)	0.57
3. Month-After-Implementation (change in temporal trend in control units after implementation period started)	<b>1.09 (1.06 to 1.14)</b>	<b>&lt;0.001</b>	<b>1.05 (1.03 to 1.07)</b>	<b>&lt;0.001</b>
4. Intervention Unit (Baseline difference between intervention and control units)	0.86 (0.50 to 1.47)	0.57	0.90 (0.42 to 1.93)	0.78
5. Month* Intervention Unit (Difference in baseline temporal trend between control and intervention units)	1.10 (1.00 to 1.22)	0.06	1.05 (0.93 to 1.17)	0.46
<b>Primary Predictors</b>				
6. Post* Intervention Unit (Difference in sudden change between control and intervention units at start of implementation period)	1.24 (0.69 to 2.23)	0.48	0.84 (0.49 to 1.44)	0.52

<p>7. Month-After-Implementation*</p> <p>Intervention Unit (Difference in temporal trend in intervention units over baseline and over control units after implementation period started)</p>	<p><b>0.89 (0.80 to 0.98)</b></p>	<p><b>0.02</b></p>	<p>0.97 (0.86 to 1.08)</p>	<p>0.53</p>
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Odd-numbered variables refer to differences in temporal trends in discrepancy rates over time (i.e., differences in slope), while even-numbered variables refer to differences in y-intercept at the start of the study or at the start of the implementation period.

\* Adjusted for patient age, service, insurance, marital status, number of prior admissions, number of high-risk medications, Elixhauser comorbidity score, DRG weight, season, and median income by zip code; clustered by site, with number of medications as a model offset

**Appendix Table 3. Time Series Analysis: Total Number of Discrepancies per Patient**

Parameter	Unadjusted Incidence Rate Ratio (95% CI)	P value	Adjusted Incidence Rate Ratio (95% CI)*	P Value
<b>Time Series Covariates</b>				
1. Month (Baseline temporal trend in control units)	<b>0.98 (0.97 to 1.00)</b>	<b>0.03</b>	<b>0.99 (0.99 to 0.99)</b>	<b>&lt;0.001</b>
2. Post-implementation time period (sudden change in control units at start of implementation period)	1.09 (0.90 to 1.31)	0.39	1.07 (0.77 to 1.51)	0.68
3. Month-After-Implementation (change in temporal trend in control units after implementation period started)	<b>1.02 (1.005 to 1.04)</b>	<b>0.01</b>	1.01 (0.99 to 1.03)	0.41
4. Intervention Unit (Baseline difference between intervention and control units)	<b>1.64 (1.36 to 1.99)</b>	<b>&lt;0.001</b>	<b>1.54 (1.29 to 1.85)</b>	<b>&lt;0.001</b>
5. Month* Intervention Unit (Difference in baseline temporal trend between control and intervention units)	<b>1.09 (1.05 to 1.13)</b>	<b>&lt;0.001</b>	<b>1.08 (1.02 to 1.14)</b>	<b>0.01</b>
<b>Primary Predictors</b>				
6. Post* Intervention Unit (Difference in sudden change between control and intervention)	0.85 (0.67 to 1.07)	0.16	0.84 (0.54 to 1.28)	0.41

units at start of implementation period)				
7. Month-After-Implementation* Intervention Unit (Difference in temporal trend in intervention units over baseline and over control units after implementation period started)	<b>0.90 (0.87 to 0.93)</b>	<b>&lt;0.001</b>	<b>0.92 (0.87 to 0.97)</b>	<b>0.002</b>

Odd-numbered variables refer to differences in temporal trends in discrepancy rates over time (i.e., differences in slope), while even-numbered variables refer to differences in y-intercept at the start of the study or at the start of the implementation period.

\* Adjusted for patient age, service, insurance, marital status, number of prior admissions, number of high-risk medications, Elixhauser comorbidity score, DRG weight, season, and median income by zip code; clustered by site, with number of medications as a model offset.

**Appendix Table 4. Implementation of Intervention Components by Site<sup>1</sup>**

Intervention Component	Site				
	1	2	3	4	5
Clearly defined roles and responsibilities and communicated this with clinical staff				Hospitalist messaging; policy document; mandatory session for new hires	
Improved access to pre-admission medication sources		Ambulatory CPOE implemented, med rec mandated at outpt visits		Developed list of outpatient and SNF providers and pharmacies	
Trained existing staff to take preadmission medication histories		Formal education of ward nurses (70% reached)	Refresher training for pharm techs; formal education and pocket cards for hospitalists	Formal education, refresher training, and pocket cards for ICU staff, ward nurses	Formal education of medical residents, inpt and outpt pharmacists
Hired additional staff to take preadmission medication histories		Two ED pharmacists and one pharm tech hired to take BPMH; pilot of unit-based pharmacists	Additional pharm techs hired to cover weekends; admit/DC nurse added to take BPMH in pts who didn't get it in ED	One pharm tech hired to take BPMH in high-risk patients	
Trained existing staff to perform discharge medication reconciliation and patient counseling			Formal training of pharmacists on dc counseling; educational video placed on intranet	Formal education of medical/ surgical nurses on counseling and teach-back	Education of medical residents on new dc med rec and documentation process
Hired additional staff to perform discharge medication reconciliation and patient counseling			Admit/DC nurse hired to do discharge med rec		Hired pharmacist (backfill of open position)
Performed high-intensity interventions on high-risk patients				High risk patients receive BPMH and later DC counseling by trained pharm tech, nurse, or pharmacy resident	
Improvements to existing medication reconciliation health information technology		New DC med rec module deployed in EHR; pharmacists given ability to edit meds from outpt med list			New med rec HIT module deployed

1. Sites 1 and 4 implemented a new electronic medical record, but this is not considered a component of the MARQUIS intervention.

CPOE: computer provider order entry; med rec: medication reconciliation; outpt: outpatient; SNF: skilled nursing facility; ICU: intensive care unit; inpt: inpatient; ED: emergency department; pharm tech: pharmacy technician; BPMH: best possible medication history; DC: discharge; pt: patient; EHR: electronic health record; HIT: health information technology

**Appendix Table 5. Aggregated Medication Discrepancies Per Patient by Type, Excluding Site 4<sup>1</sup>**

Outcome	Control floors		Intervention floors	
	Mean (SD)		Mean (SD)	
	Pre- implementation N=309 Mean (SD)	Post- implementation N=244 Mean (SD)	Pre- implementation N=304 Mean (SD)	Post- implementation N=791 Mean (SD)
<b>Total discrepancies</b>	2.77 (3.01)	3.51 (3.70)	3.66 (4.07)	3.37 (3.58)
<b>Potentially harmful discrepancies</b>	0.63 (1.38)	0.83 (1.39)	0.34 (0.88)	0.29 (0.69)
<b>Discrepancies on Admission</b>	1.33 (1.69)	1.80 (2.13)	1.89 (2.17)	1.63 (1.98)
<b>Discrepancies at discharge</b>	1.45 (1.93)	1.69 (2.10)	1.77 (2.34)	1.74 (1.92)
<b>Discrepancies due to history errors</b>	0.99 (1.67)	1.72 (2.65)	2.46 (3.40)	2.59 (3.14)
<b>Discrepancies due to reconciliation errors</b>	1.78 (2.50)	1.79 (2.46)	1.21 (2.24)	0.78 1.39)

1. Site 4 was excluded given the large negative impact of EHR implementation on discrepancy rates at this site.

Intention-to-treat analysis