Quality Improvement

Reducing Unnecessary Acid Suppression Use in Hospitalized Patients: A Description of Targeted Strategies Implemented Across a Large Health System

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Abstract

Background
Ensuring the appropriate use of proton pump inhibitors (PPIs) and histamine type 2-receptor antagonists (H2RAs) is an important hospital patient safety and quality initiative because therapy may be inappropriately continued during transitions of care. In this article, we aim to describe the impact of targeted quality improvement strategies to reduce unnecessary acid suppression use in hospitalized patients across a large health system.

Methods
Beginning January 1, 2018, focused quality improvement strategies to prevent unnecessary initiation and continuation of proton pump inhibitors (PPIs) and histamine type 2-receptor antagonists (H2RAs) were implemented throughout a large health system. Targeted strategies were initially tested as part of the PPI deprescribing Institute for Healthcare Improvement (IHI) International Innovators Network initiative and were expanded to include H2RAs for hospitalized patients. Strategies to decrease PPIs and H2RAs during hospitalization included standardization of stress ulcer prophylaxis care pathways, evidence-based order set modifications, technology-driven support, and clinical pharmacy metric performance to goal. PPI/H2RA days of therapy (DOT) per 1000 patient days were measured from the first quarter (1Q) of 2017 to the fourth quarter (4Q) of 2021 to determine if implemented strategies resulted in improvement.

Results
After quality improvement strategies were implemented, the number of PPI/H2RA DOT was reduced by 7.9 days per 1000 patient days each quarter over 4 years. The average PPI/H2RA DOT per 1000 patient days decreased from 592 (1Q 2017) to 439 (4Q 2021). In the fourth quarter of 2018, 45 hospitals (28%) achieved a 10% reduction in combined PPI/H2RA DOT per 1000 patient days, and 121 hospitals (97%) attained the goal of greater than 25% of eligible patients deprescribed PPI/H2RA for ICU patients in the fourth quarter of 2019. In the fourth quarter of 2020, 97 hospitals (87%) met the metric of 40% or more of eligible patients deprescribed from PPI/H2RA in or after an ICU stay, and 85 hospitals (87%) reached 50% or more of eligible patients deprescribed PPI/H2RA in or after an ICU stay in 4Q2021.

Conclusion
Targeted quality improvement strategies decreased unnecessary PPI and H2RA use for a large health system over 4 years. Continually evaluating measured results along with establishing a new clinical pharmacy metric goal each year to encourage further improvement contributed to deprescribing success.

Keywords
proton pump inhibitors; drug therapy; inappropriate prescribing; quality improvement; pharmacy; clinical decision support; metrics; acid suppressant therapy; histamine type 2-receptor antagonist

Introduction

Proton pump inhibitors (PPIs) and histamine type 2-receptor antagonists (H2RAs) are 2 classes of medications commonly used as acid suppressant therapy (AST). PPIs and H2RAs suppress gastric acid secretion through 2 different mechanisms of action. PPIs inhibit H+/K+-ATPase in the gastric parietal cell, while H2RAs inhibit gastric acid secretion through competitive inhibition of histamine H2 receptors of the gastric parietal cells. PPIs and H2RAs are used to treat a variety of gastric acid-related conditions such as dyspepsia, gastroesophageal reflux disease (GERD), and hypersecretory disorders (eg, Zollinger-Ellison syndrome). The duration of AST is short-term for most indications regardless of the treatment setting; however, over-the-counter availability, a wide variety of treatment indications, and the perception among patients and healthcare providers that AST does not cause harm, have led to overuse and misuse.[1]

Numerous studies have demonstrated an increased use of AST in patients in a variety of settings. Nardino and colleagues found that 55% of patients admitted to a general medicine floor over a 3-month time period received a PPI or an H2RA for stress ulcer prophylaxis, with only 65% of patients having an appropriate indication for use.[2] Other studies have shown that an estimated 32-64% of all inpatients or patients in long-term care facilities are on chronic PPI therapy; approximately 50-60% of these patients did not have an appropriate, evidence-based indication for PPI use.[3-8] Often, AST overutilization leads to patient discharge without an evidence-based indication for use with AST.[1,9] This is concerning because chronic PPI therapy is associated with adverse effects such as osteoporosis-related fractures, acute and chronic kidney disease, hypomagnesemia, and *Clostridioides difficile* infections.[10-15] While H2RAs are not associated with the same adverse effect profile as PPIs, data on their safety with long-term use is lacking.[16,17]

For these reasons, our health system assessed AST use, and based on findings, implemented targeted quality improvement strategies to reduce unnecessary AST for both PPIs and H2RAs. Measures used to successfully reduce AST use and promote deprescribing are described.

Methods

To understand PPI and H2RA utilization and opportunities for deprescribing, HCA Healthcare pharmacy leaders conducted an internal evaluation of inpatients admitted to 161 acute care hospitals between January 1, 2016, and December 31, 2017. It was anticipated that the number of hospitals would increase or decrease based on health system acquisitions and divestitures, as well as the number of hospitals meeting the minimum denominator for inclusion based on a newly created metric. The hospital was required to have a minimum of 10 deprescribing opportunities per month to be considered eligible for inclusion. The number of eligible hospitals varied based on the total number of hospitals that met the minimum threshold of deprescribing opportunities for inclusion, were divested or acquired.

Deprescribing was defined as the planned and supervised process of dose reduction or stopping of medication that might be causing harm or might no longer be providing benefit.[18] During the medication administration process, when the nurse scanned the patient's wristband and the medication to be administered, bar-coded medication administration data was collected, and these results were used to identify inpatients that received a dose of a PPI or an H2RA. Patients were considered eligible for deprescribing if they received a dose of a PPI or an H2RA per bar-coded medication administration. In 2016, 75 118 patients received a dose of a PPI or an H2RA compared to 73 390 patients in 2017. Deprescribing occurred in 16 096 (21.4%) and 16 464 (22.4%) eligible patients in 2016 and 2017, respectively.

Using principles from the Ottawa Deprescribing Initiative and Institute for Healthcare Improvement,[19,20] HCA Healthcare pharmacy leaders participated in the Institute for Healthcare Improvement (IHI) International Innovators Network as the primary innovation hospital from June 1, 2017, to December 21, 2018. The IHI International Innovators Network cohort focused on quality improvement processes to reduce inappropriate utilization of PPIs in the inpatient hospital setting. Under IHI leadership, the primary innovation hospital developed a comprehensive step-wise approach to decrease PPI use.

Pre-Implementation Proof of Concept

Before implementing this initiative at HCA Healthcare hospitals, a cohort quality improvement project proof of concept was conducted at a single 200-bed hospital to determine the impact of individual interventions on PPI deprescribing. This targeted PPI deprescribing cohort analysis was part of the IHI International Innovators Network. Between June 1, 2017, and May 31, 2018, HCA Healthcare stakeholders at the corporate, regional, and hospital levels collaborated to intensively review the impact of targeted deprescribing interventions for the single hospital's targeted inpatient unit. The unit was selected because it was a step-down unit for patients after discharge from the ICU with consistent pharmacist coverage during daily multidisciplinary team rounds for optimal intervention opportunities.

The primary outcome measure was the percent decrease of PPI days of therapy (DOT) per 1000 patient days for the targeted unit and all inpatient units. Secondary outcomes included the percent increase or decrease of H2RA DOT per 1000 patient days for the targeted unit and all inpatient units, and the number of successful pharmacist interventions. During the proof of concept, H2RA DOT per 1000 patient days was used as a balancing measure to determine whether 1 intervention was causing disruption to another part of the system (ie, whether providers were using a similar medication class as a substitute for the PPI medication, which was the targeted medication class).

After 6 months of successfully reducing PPI use at the 200-bed HCA Healthcare hospital, the project was expanded to other HCA Healthcare hospitals beginning January 1, 2018. The proof of concept continued at the 200-bed HCA Healthcare hospital for an additional 6 months to complete the IHI Innovators Network quality improvement work. Deprescribing H2RAs was included in the system-wide quality improvement project because the single-site HCA Healthcare hospital revealed an increase in H2RA prescriptions. After validation of the small test of change at the 200-bed hospital, the PPI/H2RA deprescribing measure was integrated into the larger clinical pharmacy program metric and evaluation strategy system-wide. To measure if changes resulted in improvement, PPI/H2RA DOT data were collected beginning in the first quarter (1Q) of 2017. Beginning in early 2018, "PPI/H2RA DOT per 1000 Patient Days" was added as a metric on the HCA Healthcare clinical pharmacy dashboard. The 2018 goal for hospitals was a 10% reduction in PPI/H2RA DOT per 1000 patient days compared to the fourth quarter (4Q) of 2017 baseline. The project was undertaken as a quality improvement project and as such did not need institutional review board (IRB) review.

As part of the quality improvement project, key drivers were identified to reduce unnecessary AST use including a standardized approach to stress ulcer prophylaxis delivery via evidence-based care pathways, technology-driven clinical decision support promoting appropriate use, evidence-based order set modifications, and medication reconciliation at each point-of-care transition. A toolkit was created and disseminated system-wide, along with the clinical pharmacy metric goal, current metric results, and how to assess the clinical pharmacy metric for improvement (**Table 1**). Additional intervention strategies to promote evidence-based use of AST included: 1) removal of PPI/H2RA medications from order sets, 2) clinical decision support in the electronic health record (EHR), and 3) technology-driven alerts to pharmacists for ongoing assessment of therapy.

Strategy 1: Removal of PPI/H2RA Medications From Order Sets

To reduce unnecessary AST and improve compliance with recommended evidence-based practices, order sets were reviewed for opportunities to remove PPIs/H2RAs. For example, admission order sets may have included medication options for AST. However, not all patients require or should receive PPIs/H2RAs while hospitalized. Hospitals were advised to conduct an interdisciplinary, team-based review of order sets, algorithms, protocols, and empiric guidelines for potential modifications to standardize care.

Strategy 2: Clinical Decision Support: Indication-for-Use Screens

Clinical decision support (CDS) screens were developed in the EHR to guide appropriate, evidence-based use of AST during order entry and verification. CDSs were provider- and pharmacist-facing. Upon entering a PPI or an H2RA

medication order, a provider received a required prompt to select an indication for use from a prepopulated list of options (**Appendices 1 and 2**). For example, initial indications to continue a PPI were accompanied by one of the following indications: bleeding diathesis history, erosive esophagitis, gastric outlet obstruction, gastrointestinal bleed, *Helicobacter pylori* infection, an H2RA was contraindicated due to hypersensitivity or drug-drug interaction, hypersecretory disorders (eg, Zollinger-Ellison syndrome), or stress ulcer prophylaxis and H2RA intolerance.

Table 1. Resources for Acid Suppressant Therapy (AST) Reduction in the Hospital

Clinical pharmacist and physician engagement
1. Identify patients receiving AST a. Identify population of interest b. Develop searchable fields for medication list in the electronic health record (EHR) or registry to identify potential patients c. Assess for proper indication
2. Use evidence-based algorithm to develop standardized deprescribing tools a. Develop single page algorithm for deprescribing each medication class with a single-page clinical guidance b. Create risk assessment for self-evaluation
3. Engage clinical champions to support deprescribing efforts a. Designate physician and clinical pharmacist as team leaders b. Use interdisciplinary team to develop initiative
Leadership directed by data
1. Create process improvement dashboards a. Conduct routine monitoring and assessment b. Facilitate frank discussions of what is going well and what needs improvement
2. Tell clinical stories a. Ask and reflect on how the process is going b. Understand what is progressing as planned c. Identify where and when results differ from what was anticipated d. Review learnings and surprises e. Evaluate constraints and barriers
3. Monitor data a. Monitor data routinely and report to leadership b. Adjust measures as new learnings emerge
AST deprescribing toolkit
1. Stopping AST therapy patient resource: One-page summary for patients and/or caregivers about discontinuing AST therapy while in the hospital and alternative strategies for symptom control
2. AST deprescribing provider tip sheet: Provider education about the importance of reducing unnecessary use of PPI/H2RAs and deprescribing considerations
3. Nursing huddle card AST deprescribing guide: Nurse education about the importance of reducing unnecessary use of PPIs and ASTs
4. AST deprescribing strategies pharmacist resource: Checklist of various strategies to consider for deprescribing PPI/H2RA therapy in appropriate candidates
5. AST deprescribing clinical decision support tools: Overview of PPI indication screens (EHR) and Clinical Pharmacist Workflow alerts related to assessing PPI/H2RA use
6. Medication use evaluation AST deprescribing template: Example of how pharmacists can use hospital data to identify opportunities to reduce unnecessary PPI/H2RA use, including data collection templates
7. Stress ulcer prophylaxis tip sheet: Outlines risk factors associated with stress-related mucosal disease, includes a tool to stratify risk of stress-related mucosal disease and provides a brief overview of acid-suppressive therapy agents and considerations for use

Table 1. Continued

AST clinical pharmacy metric performance improvement assessment	
Assessment task	**Task description**
Evaluate order sets for PPI/H2RA inclusion	• Can PPIs/H2RAs be removed from hospital order sets?
Evaluate hospital guidelines, care pathways, and supporting documentation	• Do these resources contain triggers that may result in unintentional utilization of PPI/H2RAs? • Can these triggers be removed?
Assess PPI and H2RA indication screens	• Have PPI and H2RA indication screens been implemented? • What are the indications being used? • Is targeted education or re-education needed?
Evaluate deprescribing interventions	• Is the PPI or H2RA being discontinued? • Is the PPI or H2RA being changed to PRN frequency? • Is the PPI being converted to an H2RA?
Analyze hospital data	• Are there factors that are barriers to appropriate, evidence-based utilization (eg, drug shortages, new service line, new provider)?
Evaluate provider trends	• Are specific providers ordering PPI/H2RAs? • What is the ordering provider specialty?
Assess PPI/H2RA order point of origin	• Where do new PPI/H2RA orders originate (eg, units such as emergency room, home medication, ICU, other)? • Do trends exist for units to conduct targeted education?
Evaluate transitions of care	• Are interventions occurring during transitions of care?

The CDS screen prompted providers during any attempt to order a PPI or an H2RA medication. The pharmacist-facing CDS screen displayed the indication for use selected by the provider during pharmacist order verification. The pharmacist contacted the provider for further discussion and clarification if there were questions about the appropriateness of the medication order if no indication for use was populated, or if the provider left the field blank. Pharmacists were prompted to clarify an indication for use before verifying the PPI/H2RA medication orders.

Optimization of PPI/H2RA indication-for-use CDS screens and data capture occurred over several years. Both technical and clinical adjustments were made over time. For example, the additional option of "other" was added to the list of evidence-based indications for use to capture specific outlier cases. A report was developed to gather and analyze CDS PPI/H2RA indication for use to measure the ongoing impact of the indication screen. This report allowed team members to identify opportunities and develop targeted solutions to improve evidence-based use of PPIs/H2RAs as a continuous, quality improvement initiative.

Strategy 3: Clinical Decision Support in the Clinical Pharmacist Workflow

The next system innovation centered on pharmacist intervention through direct interaction and collaboration with the patient care team. Pharmacists were alerted to potential AST deprescribing opportunities through a near real-time clinical surveillance system. This tool used predetermined clinical criteria rules and monitored patients during hospitalization from the initiation of therapy throughout all transitions of inpatient care (**Appendix 3**). Examples of alerts included: a) "Duplicate PPI Therapy", which alerted the pharmacist to a patient on 2 or more PPI medications, b) "Duplicate Therapy: PPI and H2RA", which alerted the pharmacist to a patient with an active order for both a PPI and an H2RA, and c) "PPI Active Order and Transferred from ICU to a Non-ICU Setting." Once alerted, the pharmacist reviewed the patient's chart to determine whether or not continued AST was clinically appropriate and warranted. If deprescribing was deemed clini-

cally appropriate, the pharmacist recommended discontinuation directly to the prescribers.

HCA Healthcare Clinical Pharmacy Metric Evolution

The PPI/H2RA deprescribing metric and targeted goal evolved over time since the original release of clinical pharmacy metrics in 2018 (**Table 2**). In 2018, the original metric aimed to monitor the PPI/H2RA DOT per 1000 patient days for all inpatients. However, the scope was too broad and an opportunity existed to streamline the metric. In 2019, the metric was revised to target deprescribing PPI/H2RA for ICU patients since transitions of care can lead to an unintended continuation of therapy. The metric included the percentage of patients on a PPI/H2RA that were transferred from the ICU to the floor with the PPI/H2RA discontinued; discontinued was defined as no administrations of PPI/H2RA for 24 to 96 hours after the transfer. The following exclusions were made: a) patients who may be candidates for long-term PPI/H2RA therapy, b) patients who were discharged within 24 hours of transfer from the ICU to a floor (to ensure enough time for deprescribing intervention), c) patients with ICD-10 codes for gastrointestinal bleed and Zollinger-Ellison syndrome, and d) patients receiving warfarin or a direct-acting oral anticoagulant.

In 2020, updates to the metric considered exclusions for the following additional patient populations as appropriate for the continuation of PPI/H2RA: a) patients admitted to a transplant unit at any time during the stay, b) patients with an ICD-10 code of transplant or burn during the current admission or a previous admission up to 30 days before the current admission date, and c) patients with a procedure code or ICD-PCS code for bariatric surgery during the admission or a previous admission up to 2 years prior to the discharge date. The name of the metric was revised for clarity; that is, if a patient was on a PPI/H2RA in the ICU and the medication was discontinued while the patient was in the ICU, this counted as deprescribed. The only change to the metric in 2021 was an additional exclusion for patients that received parenteral nutrition while admitted.

Results

From 1Q 2017 to 4Q 2021, the number of PPI DOT was reduced by 1.4 days per 1000 patient days each quarter, and the number of H2RA DOT was reduced by 6.5 days per 1000 patient days each quarter (**Figure 1**). The average PPI/H2RA DOT per 1000 patient days decreased from 592 (1Q 2017) to 555 (4Q 2017) to 530 (4Q 2018) to 493 (4Q 2019) to 470 (4Q 2020) to 439 (4Q 2021). For each year the AST deprescribing clinical pharmacy metric was measured, the number of eligible hospitals varied between 161 and 98 during the fourth quarter measurements (**Table 2**). This result occurred because only the hospitals that met the minimum

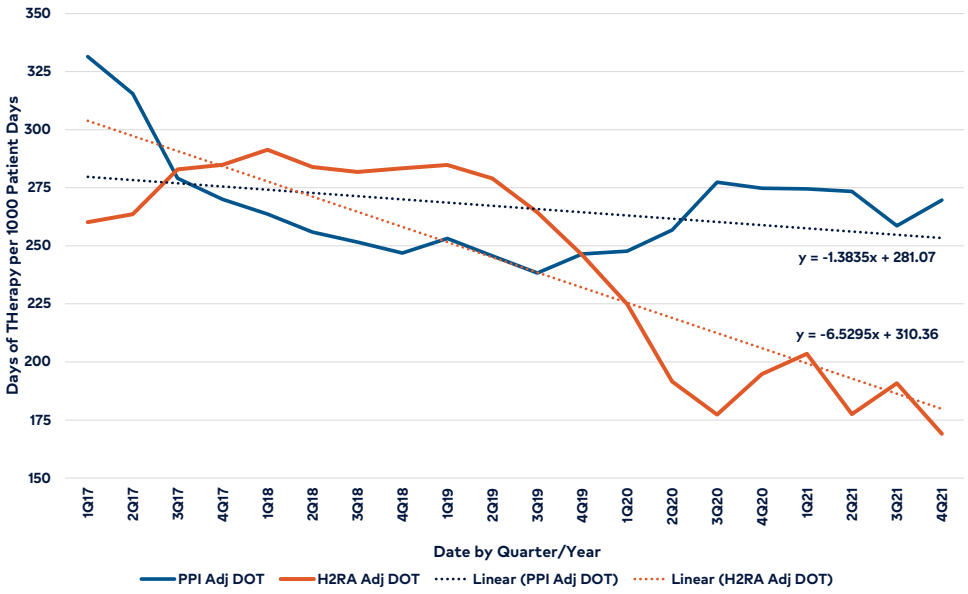

Figure 1. Health system PPI and H2RA adjusted (Adj) days of therapy (DOT) per 1000 patient days are shown by quarter.

Table 2. AST Deprescribing Quality Improvement Measures: Health System Performance

	2018				2019				2020				2021			
Metric	Total PPI and H2RA DOT per 1000 patient days				Deprescribing PPI/H2RA for ICU Patients				Deprescribing PPI/H2RA in or after ICU Stay				Deprescribing PPI/H2RA in or after ICU Stay			
Goal	10% reduction from baseline in 4Q18 (Baseline defined as 4Q17)				Deprescribing occurred in > 25% of eligible patients in 4Q19				Deprescribing occurred in ≥ 40% of eligible patients in 4Q20				Deprescribing occurred in ≥ 50% of eligible patients in 4Q21			
Minimum Threshold	N/A				Hospital must have a minimum of 10 deprescribing opportunities per month to be considered eligible for inclusion*											
Quarter Year	**1Q18**	**2Q18**	**3Q18**	**4Q18**	**1Q19**	**2Q19**	**3Q19**	**4Q19**	**1Q20**	**2Q20**	**3Q20**	**4Q20**	**1Q21**	**2Q21**	**3Q21**	**4Q21**
Health System Performance	-	-	-	-	26%	29%	37%	45%	53%	58%	57%	56%	56%	59%	56%	58%
# of eligible hospitals*	158	159	161	161	125	127	122	125	120	109	111	112	102	101	100	98
# (%) of eligible hospitals at goal	42 (27%)	48 (30%)	45 (28%)	45 (28%)	79 (63%)	74 (58%)	98 (80%)	121 (97%)	97 (81%)	96 (88%)	96 (86%)	97 (87%)	67 (66%)	78 (77%)	79 (79%)	85 (87%)

*Number of eligible hospitals varied based on total number of hospitals that met minimum threshold of deprescribing opportunities for inclusion, divestitures, and acquisitions.

threshold of deprescribing opportunities were included.

In 4Q 2018, 45 of 161 hospitals (28%) achieved the goal of a 10% reduction in PPI/H2RA DOT per 1000 patient days (**Table 2**). In 4Q 2019, 121 of 125 hospitals (97%) reached the goal of deprescribing PPI/H2RAs in greater than 25% of eligible ICU patients; performance in 2019 improved by 19% (1Q 2019 vs 4Q 2019). In 2020 and 2021, the metric changed to deprescribing PPI/H2RAs in or after the ICU stay. The goal of deprescribing 40% or more of eligible patients in 4Q 2020 was attained by 97 of 112 hospitals (87%), and in 4Q 2021, 85 of 98 hospitals (87%) achieved the goal of deprescribing 50% or more of eligible patients. As a whole, system-wide performance improved by 5% (1Q 2020 vs 4Q 2021).

Discussion

HCA Healthcare's PPI/H2RA reduction efforts targeted initiatives focused on 2 crucial opportunities for PPI/H2RA deprescribing: the initiation of AST during the ordering process and the continuation of AST during transitions of care. By developing a visible metric, using relevant tools, and engaging frontline staff in protocol and process development, the number of PPI/H2RA DOT was reduced by 7.9 days per 1000 patient days each quarter over 4 years.

Before implementing the PPI/H2RA deprescribing system-wide initiative, a small test of change was conducted at a 200-bed hospital with subsequent expansion of the interventions to other HCA Healthcare hospitals. Participation in the IHI International Innovators Network allowed us to share experiences and learn what barriers other health systems were facing to successful PPI deprescribing. Higher order strategies promoting deprescribing interventions included removal of PPI/H2RA medications from order sets, CDS indication-for-use screens for providers and pharmacists (**Appendices 1 and 2**) and CDS in the clinical pharmacist workflow. Employing more than 1 deprescribing intervention was essential to our success.

The PPI deprescribing initiative proof of concept monitored balanced measures designed to identify unintended increases in alternative AST, such as H2RA utilization. H2RA utilization use did increase during the proof of concept and revealed the need to provide prescriber-deprescribing education strategies. Provider education reinforced that while the innovation goal was to deprescribe PPIs, prescribers should avoid switching de-escalation to an H2RA if not warranted. This observation was used in the development of the HCA Healthcare combined PPI/H2RA-adjusted DOT metric.

HCA Healthcare developed an AST Deprescribing Toolkit for hospitals to use as part of the PPI/H2RA reduction initiative. For hospitals not achieving the pre-defined performance goal of a 10% reduction in PPI/H2RA adjusted DOT, an assessment was developed to serve as a guide to improve performance (**Table 1**), and barriers to successful AST deprescribing were tracked to improve patient care. Barriers included competing priorities, resource constraints, lack of prescriber engagement, and little opportunity for some hospitals that were early adopters of AST reduction initiatives. After learning more about the barriers to success, the clinical pharmacy metric was adjusted to focus on deprescribing AST in patients who were in the ICU and then transferred to a non-ICU unit. The intent was to create an opportunity for a more targeted approach to PPI/H2RA deprescribing that likely would result in completed interventions.

HCA Healthcare strategies used to decrease PPI and H2RAs during hospitalization included standardization of stress ulcer prophylaxis care pathways, evidence-based order set modifications, and technology-driven support. These interventions promoted evidence-based use of PPIs/H2RAs and strategically focused on evidence-based initiation of PPI/H2RA therapy and continual reassessment of need during inpatient hospitalization measured by performance to goal with an AST deprescribing metric. Further study is needed to replicate the results sustained by HCA Healthcare using an AST deprescribing metric. While ongoing evidence about the long-term consequences of PPIs remains controversial, streamlining patients' medication regimens and removing unnecessary medications is essential for patient safety and to be responsible stewards of healthcare resources. The opportunity to further define the optimal time to evaluate

patients routinely for the necessity of continued AST outside of the ICU should include the patient outcome (eg, AST discontinuation or continuation), time to investigate AST use by discipline, and return on investment.

Conclusion

Targeted quality improvement strategies decreased unnecessary PPI and H2RA use for a large health system over 4 years. Continually evaluating measured results along with establishing a new clinical pharmacy metric goal each year to encourage further improvement contributed to deprescribing success.

Acknowledgments

The authors wish to acknowledge the International Innovations Network Learning and Action Community, led by The Commonwealth Fund and the Institute for Healthcare Improvement (IHI) and Sarah Fraker, MS, CHDA for results consultation.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Dr Burgess is the Chief Operating Officer and Clinical Officer for VigiLanz, the clinical surveillance technology used by HCA Healthcare discussed in the manuscript.

Dr Kramer is a Clinical and Research Specialist for VigiLanz, the clinical surveillance technology used by HCA Healthcare discussed in the manuscript.

Drs Wiggins and Burgess are employees of HCA Healthcare Management Services and Dr Kramer is a retired employee of Clinical Sevices Group, HCA Healthcare, an organization affiliated with the journal's publisher.

This research was supported (in whole or in part) by HCA Healthcare and/or an HCA Healthcare-affiliated entity. The views expressed in this publication represent those of the author(s) and do not necessarily represent the official views of HCA Healthcare or any of its affiliated entities.

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Appendix 1. Electronic Health Record Clinical Decision Support Screens

H2RA order entry indication screen:					
	1	Bariatric surgery		6	Gastric ulcer
X	2	Bleeding prophylaxis		7	Gastroesophageal reflux disease (GERD)
	3	Duodenal ulcer		8	Hypersecretory disorders
	4	Dyspepsia		9	Stress ulcer prophylaxis
	5	Esophagitis		10	Other
H2RA use increases risk for *Clostridioides difficile* infection and hospital-acquired pneumonia. A reason for use is required. Select an approved indication or free text another reason. To cancel the order, enter no indication. Some indications may be preferred for the use of PPIs. These indications will present the option to replace the order with a PPI.					
Order:		Famotidine 20 mg PO BID			
Order indication:		Bleeding prophylaxis			
Order other indication:					

PPI order entry indication screen:					
	1	Bariatric surgery		6	Gastrointestinal (GI) bleed
X	2	Bleeding diathesis history		7	*Helicobacter pylori*
	3	Bleeding prophylaxis		8	Hypersecretory disorders
	4	Erosive esophagitis		9	Stress ulcer prophylaxis
	5	Gastric outlet obstruction		10	Other
PPI use increases risk for *Clostridioides difficile* infection and hospital-acquired pneumonia. A reason for use is required. Select an approved indication or free text another reason. To cancel the order, enter no indication. Some indications may be preferred for the use of H2RAs. These indications will present the option to replace the order with a H2RA.					
Order:		Pantoprazole 20 mg PO BID			
Order indication:		Bleeding diathesis history			
Order other indication:					

Appendix 2. Electronic Health Record Clinical Decision Support Indication Check Examples

Provider prompt H2RA indication check example
You are currently trying to order: Famotidine 20 mg IV BID
For the indication you have selected, it is recommended that **pantoprazole injection** is the preferred option.
Please replace with the recommended medication. Select cancel to end the ordering process. Select override to continue ordering the current medication.

Provider prompt PPI indication check example
You are currently trying to order: Pantoprazole 40 mg IV BID
For the indication you have selected, it is recommended that **famotidine injection** is the preferred option.
Please replace with the recommended medication. Select cancel to end the ordering process. Select override to continue ordering the current medication.

Appendix 3. Deprescribing a PPI/H2RA in or After an ICU Stay