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Reducing overuse of antibiotics at discharge home: A single-center mixed methods pilot study

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Author contributions: VMV conceived the idea. DLG and VMV obtained study funding. DLG, AB, DM, and VMV designed the study protocol. DLG and VMV drafted the initial manuscript. LB created computer dashboard to track study protocol results. DR completed the quantitative statistical analysis. JKH and VMV conducted rapid debriefs and qualitative data analysis. SK provided mixed methods expertise and critical input on study design, reviewed the study protocol, methods and the manuscript. All of the authors discussed the findings of this study and contributed to the final manuscript.

SUPPLEMENTARY MATERIALS

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Abstract

Background: Antibiotic overuse at hospital discharge is common and harmful; however, methods to improve prescribing during care transitions have been understudied. We aimed to pilot a pharmacist-facilitated antibiotic timeout prior to discharge.

Methods: From May 2019 to October 2019, we conducted a single-center, controlled pilot study of a pharmacist-facilitated antibiotic timeout prior to discharge. The timeout addressed key elements of stewardship (eg, duration) and was designed and implemented using iterative cycles with rapid feedback. We evaluated implementation outcomes related to feasibility, including usability, adherence, and acceptability, using mixed methods. Pre versus postintervention antibiotic use at discharge in intervention versus control groups was assessed using logistic regression models controlling for patient characteristics.

Results: Pharmacists conducted 288 antibiotic timeouts. Timeouts were feasible (mean 2.5 minutes per time-out) and acceptable (85% [40/48] of hospitalists believed timeouts improved prescribing). Pharmacists recommended an antibiotic change in 25% (73/288) of timeouts with 70% (51/73) of recommended changes accepted by hospitalists. Barriers to adherence included unanticipated and weekend discharges. Compared to control services, there were no differences in antibiotic use after discharge during the intervention.

Conclusions: A pharmacist-facilitated antibiotic timeout at discharge was feasible and holds promise as a method to improve antibiotic use at discharge.

Keywords

Antimicrobial stewardship; Quality improvement; Implementation science; Health transition; Mixed methods research

INTRODUCTION

Antibiotic overuse is common and contributes to side effects, resistant infections, and unnecessary costs.[1,2] Antibiotics prescribed at hospital discharge account for over half of antibiotic exposure related to hospitalization for common infections[3] and are major contributors to excessive antibiotic duration and potentially inappropriate use.[4–6] In 2019, the Centers for Disease Control and Prevention (CDC) recognized the importance of optimizing antibiotic therapy at discharge in their Core Elements of Hospital Antibiotic Stewardship Programs; however, methods to improve antibiotic use at discharge are not well developed.[7]

Antibiotic timeouts, or structured pauses to evaluate the need for ongoing antibiotic therapy, have been recommended by both the CDC and The Joint Commission to optimize antibiotic use.[7,8] By discharge, there are often additional clinical and diagnostic data available to inform antibiotic necessity, selection, and duration, making discharge an opportune time to pause and reconsider antibiotic necessity and appropriateness. An antibiotic timeout at discharge may allow the provider to generate a final antibiotic treatment plan after systematically reviewing the patient's hospitalization. Pharmacists would be in a unique position to perform such an intervention given their frequent involvement in antibiotic

stewardship and medication reconciliation at discharge. Thus, we conducted a 6-month, controlled pilot study to determine feasibility of a pharmacist-facilitated antibiotic timeout prior to discharge.

METHODS

Study setting and participants

We conducted a single-center, controlled pilot study of adult medical patients anticipated to be discharged on oral antibiotics from a large, academic, quaternary referral hospital. The Standards for Quality Improvement Reporting Excellence 2.0 guidelines were followed in preparing this manuscript.[9] The intervention group included patients on the hospital medicine service (in the United States, hospitalists are general medicine physicians who care mostly [or exclusively] for hospitalized patients) which consists of 10 single-hospitalist teams that each care for up to 11 patients. The control group included patients on the general medicine service, a teaching service including one attending physician (hospitalist, general medicine physician, or internal medicine subspecialty physician) plus a house officer (ie, medical trainee) team. Clinical pharmacists are assigned daily to multiple inpatient services that consist of general medicine, hospital medicine, and other teams. Pharmacists typically round with the general medicine teams in the morning, and then briefly (~10 minutes) round with hospitalist teams in the afternoon to review patient lists. Prior to the pilot, there was no standardized workflow for discussing antibiotics during rounds. Discussions on the antibiotic plan, including discharge plans, occurred at the discretion of the individual pharmacist and hospitalist.

Study design

We used an iterative approach to inform the design, development, and implementation of an intervention to improve prescribing at discharge (Fig 1). This process, adapted from engineering frameworks, has been successfully used to implement infection control interventions.[10,11] The key strength of an iterative implementation strategy is that the intervention can be adjusted in near real-time based on formative evaluations (ie, feedback) conducted during early stages of the intervention. Using repeated cycles of design-test-revise, we were able to quickly adapt to unforeseen barriers to optimize intervention feasibility. At the conclusion of the study, a summative evaluation was conducted to evaluate feasibility and the intervention's effect on antibiotic use and outcomes.

Intervention

The intervention occurred between May 1, 2019 and October 31, 2019 and was developed in accordance with published data on using timeouts to improve antibiotic use (see eFig 1 for timeline).[7,8,12,13] Timeouts are structured pauses that remind clinicians to reconsider whether the diagnosis has changed and whether antibiotic therapy is still appropriate. The timeouts were led by clinical pharmacists via structured conversations with hospitalists including four questions targeting common ways to improve antibiotic use at discharge: (1) stopping unnecessary therapy (ie, antibiotics prescribed for a noninfectious or nonbacterial syndrome), (2) reducing excessive duration, (3) improving appropriate selection, and (4) documenting the antibiotic plan in the discharge summary (Fig 2).[7,13] Our timeout was

designed—and iteratively tested—in collaboration with the hospitalist, clinical pharmacist, and antibiotic stewardship teams.

The timeout was initially designed to occur in-person during afternoon pharmacy rounds. After feedback from pharmacists, we also designed a process where a page was sent out automatically from the electronic medical system to the covering pharmacist when any of their patients had a discharge antibiotic order signed. This page served as a backstop alerting the pharmacist of potential timeouts if the team failed to alert them of a discharge. Because timeouts only occurred Monday through Friday, pharmacists were instructed to ask hospitalists about potential weekend discharges during Friday rounds.

Initially, pharmacists were instructed not to perform timeouts on patients with an infectious disease (ID) consult or complicated infection (eg, bacteremia). However, during formative evaluations pharmacists suggested that discussing complicated patients would not only improve antibiotic use (eg, hospitalists misinterpreting ID consult notes) but would improve feasibility by reducing work required to identify eligible patients. Thus, we expanded our inclusion criteria on June 17, 2019 to include all patients anticipated to be discharged on oral antibiotics for any acute indication.

Two clinical pharmacists (Pharm1, Pharm2) and 2 hospitalists (Author1, Author2) served as local champions to promote and educate their respective teams on the intervention. Prior to the intervention's rollout, champions conducted teaching sessions to introduce the intervention, seek input, and gain support. To provide guidance on appropriate antibiotic therapy, we distributed a 2-sided pocket card listing the four timeout questions on one side, as well as recommended discharge antibiotics for common infections on the other (Fig 2).

Data collection and outcome measures

Primary feasibility outcomes focusing on usability, accessibility, awareness, adherence, and acceptability were measured through a combination of direct observation, hospitalist and pharmacist interviews, pre- and postimplementation hospitalist surveys, and prospective timeout and antibiotic data collected by the pharmacists. In addition, the summative evaluation included antibiotic use data collected for a subset of patients via the electronic medical record.

Approximately every 2 weeks throughout the intervention, research personnel directly observed (without deliberate interference) antibiotic timeouts (observation guides in appendix). After each observation, the research team conducted "rapid debrief" interviews with the participating pharmacists and hospitalists (separately) to ascertain acceptability, usability, facilitators, and barriers to the timeout that just occurred and to the intervention overall. Debrief interviews used a structured interview guide (appendix) with additional questions added based on the timeout witnessed. Observations and interviews were conducted by 2 team members (Author2, Author3), audio-recorded, and transcribed verbatim.

Hospitalists who were on the hospital medicine service during the intervention were surveyed immediately after the study (November 2019) to assess the intervention's

feasibility, which included usability, awareness, adherence, and acceptability. All survey questions were derived from prior literature on care transitions and antibiotic stewardship, tested with local stakeholders, survey design experts, and non-study clinicians, and administered online using Qualtrics XM.

During the intervention phase, pharmacists prospectively documented antibiotic timeout data in the electronic medical record including when the timeout occurred, indication for antibiotic therapy, which antibiotic was prescribed with dose/frequency, antibiotic duration, time spent on the intervention, and whether antibiotic changes were suggested and accepted.

To assess the interventions effect on antibiotic use, we evaluated antibiotic use on general medicine (control) versus hospital medicine (intervention) services during the intervention versus 1 year prior (May 1, 2018 – April 30, 2019), focusing on a subset of patients typically prescribed antibiotics at discharge, including those with pneumonia, skin and soft tissue infection (SSTI), or intra-abdominal infections (ICD-10 codes in appendix). To identify patients with urinary tract infection (UTI), we included patients with any urine culture during hospitalization that was flagged as positive. We excluded patients discharged on IV antibiotics, antibiotic duration after discharge of >14 days (to exclude chronic therapy), patients with severe immune suppression, those with osteomyelitis, and those with ≥1 blood culture positive for a bacterial pathogen. Demographic, clinical data, antibiotic use, and outcome data were collected from our institutional enterprise health data warehouse. In addition, for patients with timeout data, a team member (DG) reviewed each patient's discharge summary to evaluate for appropriate antibiotic documentation.

Statistical analysis

Descriptive statistics were used to summarize survey responses, patient and hospitalist characteristics, and timeout data. For surveys, percent positive response was defined as either a "yes" answer, strongly agree/agree, or usually/always.

All observation field notes and interview transcripts were coded individually by 2 reviewers using a mix of deductive (derived from the Tailored Implementation in Chronic Disease [TICD])[14] and inductive coding. Using NVivo 12, we created code reports that were reviewed by the study team to develop themes based on TICD factors. Specifically, we focused on TICD determinants related to our primary outcomes including guideline factors (eg, usability, accessibility) and health professional factors (eg, awareness). Representative quotes or observations are reported from interview transcripts and observation field notes.

Antibiotic use at discharge was measured as percentage of patients discharged on antibiotics and median duration of antibiotics prescribed at discharge. Segmented logistic regression models were used, allowing us to evaluate slope/level change pre- and post-intervention in antibiotic use at discharge. We ran separate models looking first for differences pre- and post-intervention in the treatment group and secondly, to compare the treatment and control groups over time. All logistic regression models were controlled for patient age, sex, race, Charlson Comorbidity Index, qSOFA (sequential organ failure assessment score) at 24 hours, diagnosis, presence of ID consultation, steroid use, length of stay, and source of admission (eg, home vs nursing facility) to produce adjusted odds ratios.

Patient and public involvement

No patients involved.

RESULTS

During the intervention, we observed 6% (18/288) of timeouts and conducted 13 interviews with 6 hospitalists and 5 pharmacists (2 pharmacists were interviewed twice). Of those invited to participate, 1 pharmacist and 1 hospitalist declined to be observed. Among 102 hospitalists surveyed, the response rate for postintervention surveys was 70% (71/102 Characteristics of survey respondents are shown in eTable 1. Of the 71 hospitalists who responded to the postintervention survey, 48 (67%) had worked a hospital medicine day shift during the intervention period and were asked about usability, adherence, and acceptability.

Pharmacist-collected timeout data

Pharmacists conducted 288 timeouts: 52% (151/288) occurred during afternoon rounds, 45% (130/288) occurred over the telephone after pharmacists were alerted of a discharge through the alert page, and timing could not be classified in 2% (7/288). Pharmacists recommended an antibiotic change during 25% (73/288) of timeouts; hospitalists accepted 70% (51/73) of recommendations. Changes included decreasing duration (45%, 23/51), narrowing spectrum (41%, 21/51), and discontinuing therapy (14%, 7/51). Based on review of discharge summaries, documentation of indication (98%, 281/288), antibiotic name (92%, 266/288), and total intended duration (78%, 224/288) was common.

Interview and observation data

Generally, interviews and observations demonstrated the intervention was feasible (Table 1). Based on observations (N = 18), antibiotic timeouts took on average 2.5 minutes (median 2 minutes). Pharmacists reported their total work related to each timeout (N = 288) was a median 5 minutes (interquartile range: 5-10 minutes). Notably, if the timeout occurred after a prescription had been sent to an outpatient pharmacy, time spent calling the pharmacy to change the prescription substantially increased pharmacist workload (up to 20 minutes).

In nearly all observed timeouts, pharmacists had prepared for timeouts by reviewing the charts of patients on antibiotics prior to the timeout and had already decided whether they planned to recommend changes. This plan often changed in real time based on new clinical data provided by the hospitalists during the actual timeout. Though we designed the pocket card to be used by both hospitalists and pharmacists, only the pharmacists were observed using it (55% [10/18] of timeouts); hospitalists instead reported relying on the pharmacists for antibiotic guidelines.

Barriers to feasibility identified from interviews and observations included interruptions to the timeout (eg, patient emergency) and limited information transfer (between hospitalists or pharmacists) during service handoffs. The main enhancers of feasibility were existing strong, collaborative relationships between hospitalists and pharmacists, familiarity with discussing antibiotic use, and ease of integration of the timeout into existing workflows (Table 1).

In the post-intervention survey, hospitalists who had worked a day shift during the intervention reported they were aware of the intervention (45/48; 94%) and that pharmacists usually or always discussed antibiotic use in patients who might be discharged on oral antibiotics (42/48 [88%]). Notably, based on both survey and observation data (Table 1), pharmacists were more likely to query about antibiotic selection and duration as opposed to indication and documentation. When asked about the reasons for this during interviews, pharmacists noted the question on documentation made them "uncomfortable" either because they worried the question would offend hospitalists or because they had no baseline data to support the need to improve documentation:

> "I personally think the question is a little awkward because I think some providers get like a little offended, like do you not think I document on this?"- Pharmacist (Interview)

During observations, we noted that the question on documentation (particularly early in the intervention) could provoke a defensive response from hospitalists, *"I always do that!"* Toward the end of the intervention period, hospitalists began to anticipate this question and respond preemptively, *"Okay that [antibiotic change] is fine. I'll make sure [I] document that in the discharge summary."* As for why pharmacists did not ask about indication, pharmacists reported they skipped this question if unnecessary:

> "You can kind of fast-forward through [the indication] because, you know, asking if a patient has a bacterial infection with a confirmed culture supporting it… is somewhat elementary."- Pharmacist (Interview)

The number of timeouts conducted increased over time (eg, 34 in May, 54 in October; eFigure 2). Although our pharmacists documented 288 timeouts, only 125 were included in our electronic database created from ICD-10 codes. In fact, based on ICD-10 codes there were 417 patients potentially eligible for a timeout of which only 30% (125) received one. Though part of the discrepancy between cases captured by pharmacists and those identified by ICD-10 codes is due to the difficulty identifying "potential discharges on antibiotics" using ICD-10 codes, we also sought to determine other causes for non-adherence. Thus, we reviewed 10 medical charts of confirmed eligible patients without a timeout. Of those, 5 had a length of stay ≤ 3 days and 3 was discharged on the weekend (when timeouts were not performed).

Though witnessed adherence to the intervention was high overall, we observed pharmacists adapting the exact questions and flow to fit their conversation style (100%, 18/18 observations). When asked about adaptations, pharmacists noted they individualized their approach over time:

> "I found myself and a lot of my colleagues may have drifted away from [the scripted conversation] and kind of felt out a style…"-Pharmacist (Interview)

As discussed previously, pharmacists and hospitalists noted early in the intervention that it was difficult to define the study population due to initially complex exclusion criteria. Addressing these exclusions increased the pharmacist workload and early data demonstrated pharmacists were often inaccurate in determining whether a patient should or should not be excluded from a timeout. In addition, pharmacists believed the timeout would still be helpful

in complex patients, as it gave the team an opportunity to discuss the patient and provided a second pair of eyes. In response to this feedback, we expanded our inclusion criteria to include all patients discharged on oral antibiotics for any acute indication. Pharmacists appreciated this change:

> [How do you feel about reducing the exclusion criteria?] "even though we have a lot of ID consults in, it was still important to look at the actual duration of the antibiotics that we are discharging people on because, sometimes, those can look a little bit muddy and we need to fix them… it was a good move."–Pharmacist (Interview)

After this change, timeouts began to occur on nearly all patients discharged on oral antibiotics: patients reviewed and excluded by pharmacists before the change, 43.5% (64/147) versus 20.2% (52/257) postchange, ($P < .001$). However, the pocket card recommendations for narrow, short antibiotic courses still only applied to the least complicated patients. This created some confusion which we overcame through additional training. Regardless, for more complicated patients (eg, bacteremia, failure to improve, infectious complications), it was difficult to provide standard recommendations for treatment at discharge given the lack of national guidelines for these patients. Lack of clear guidelines and definitions for certain groups remained a barrier throughout the intervention.

> "So, is this more like a transient bacteremia…from [pyelonephritis] or is it more of a serious [bacteremia]?"-Pharmacist (Observation)

> "Like it doesn't necessarily fit a certain treatment pathway"-Pharmacist (Observation)

Post-implementation survey responses demonstrated the intervention was well accepted and that hospitalists believed the intervention improved care and should be continued (Table 1). During interviews, pharmacists reported the intervention was useful and they believed it had improved patient care. Hospitalists reported appreciating the structure of the timeout as it forced them to think about their prescribing plans and that having pharmacists was like a "second set of eyes."

Unlike hospitalists, pharmacists were more cautious about committing to continuing the intervention—they requested efficacy data and expressed concerns about workload as another new project was about to begin. They noted the timeout had been accepted by pharmacists initially because it had replaced another project that was ending, but they were concerned about the time commitment with other competing initiatives.

We identified substantial contamination between intervention and control groups. It should be noted that clinical pharmacists participating with the hospitalists in the intervention phase were often simultaneously covering patients in our control population. During our observations, we discovered intervention pocket cards had been photo-copied, posted in the general medicine team rooms, and circulated among house officers. One pharmacist reported seeing the pocket card posted near the emergency department's pharmacy (the emergency department was not included in this study). In addition to visible contamination, pharmacists noted:

> "I think whether we admit it or not the [intervention] and pocket card would have affected decisions we made on our [general medicine] services."-Pharmacist (Interview)

Antibiotic use and outcome data

After exclusions, we identified 711 patients from the electronic data warehouse discharged after a hospitalization for pneumonia (222, 31.2%), SSTI (134, 18.8%), intra-abdominal infection (27, 3.8%), or UTI (275, 38.7%). Over half (58%, 417) were on the hospital medicine service (intervention arm) and 41% (294) on general medicine service (control arm; see Table 2). Generally, patients hospitalized on hospital medicine and general medicine services were similar.

Differences in patient characteristics in the control (general medicine) versus intervention (hospital medicine) groups were evaluated using Pearson's chi squared or t-tests, as appropriate. $P < .05$ considered significant.

Prior to the intervention, 50.2% (402/801) patients on hospital medicine services were discharged on antibiotics with a median discharge duration of 5 days. During the intervention 48.9% (204/417) were discharged on antibiotics with a median discharge duration of 5 days. After adjustments, there were no differences pre versus during intervention in percentage of patients discharged on antibiotics ($P = .95$ for slope change and $P = .74$ for level change) or in discharge antibiotic duration ($P = .58$ for slope change and $P = .32$ for level change).

Prior to the intervention, in the control group, 53.8% (341/634) of patients were discharged on antibiotics with a median discharge duration of 5 days. During the intervention, 56.1% (161/287) of patients were discharged on antibiotics with a median discharge duration of 5 days. After adjustments, there was no difference in antibiotic use pre versus during the intervention for the control versus intervention groups (Fig 3).

DISCUSSION

This pilot study demonstrated the feasibility of a pharmacist-facilitated antibiotic timeout at hospital discharge. To our knowledge, this is the first study of a pharmacist-facilitated timeout targeting antibiotic use at hospital discharge. Pharmacist recommendations to change the antibiotic prescription occurred in 25% of cases and led to frequent changes, most commonly decreasing duration and narrowing spectrum.

Primary barriers to timeout feasibility included interruptions during face-to-face rounds (ie, pager going off) and difficulty arranging a face-to-face meeting if the hospitalist was unable to attend the existing afternoon rounds. Furthermore, patients with a short length of stay or who were discharged on the weekend may have been less likely to receive a timeout. Despite these barriers, there were notable strengths of the intervention that led to its feasibility. The timeout was adaptable, and pharmacists found they could easily mold the intervention into their workflow and clinical style. Both hospitalists and pharmacists found the structure of the antibiotic timeout beneficial and believed it improved

patient care. Notably, a defensive emotional response from the hospitalists was sometimes generated when the pharmacist asked them to ensure documentation of the antibiotic dose, indication, and duration in the discharge summary. This emotional response may be why we observed such a high rate of antibiotic documentation in the discharge summary compared to prior studies,[5] as emotional drivers are a potential way to promote desired behaviors.[15] Improved documentation plays an integral part in The Joint Commission's efforts to reduce communication breakdowns during transitions of care.[16] Facilitators of feasibility included a good pre-existing relationship between hospitalists and pharmacists, strong champions on both services, and certain features of the intervention including that it created a "structure" and ensured a "second pair of eyes" for discharge prescriptions.

We also learned strategies which may improve future feasibility including minimizing and streamlining exclusion criteria and ensuring a back-up system in case in-person timeouts did not occur. Though we initially hesitated to include patients with an ID consult, pharmacists noted the intervention was useful even in these patients, as it helped improve interpretation of ID recommendations. In future iterations, the intervention should have as few exclusions as possible to increase usability and promote adherence.

Traditional hospital-based antibiotic stewardship programs have been shown to reduce antibiotic use, costs, adverse events, and infection or colonization with antibiotic-resistant bacteria.[17–20] More recently, Barnett and Yogo et al. evaluated interventions around the time of discharge as a potential tool for stewardship. Initial findings suggest discharge stewardship is well received and associated with less frequent use of broad-spectrum antibiotics and shorter antibiotic durations following hospitalization.[21,22] Compared to both the Barnett and Yogo studies, we observed higher rates of pharmacist interventions at discharge (25% vs 9.7% and 23%, respectively) and higher acceptance of pharmacist recommendations (70% vs 58% and 67%, respectively). Possible contributors to this difference include the structured nature of our timeout, the prospective quality of the study, and an established stewardship role of pharmacists in our hospital system.[21,22]

Although our timeout led to frequent changes in discharge antibiotic prescriptions, no significant differences were observed in antibiotic use compared to the control. This lack of effect is likely multifactorial. First, our study was designed to measure feasibility and thus was underpowered to determine a difference in antibiotic use. Second, half of patients eligible for a timeout did not receive one—likely due to short hospitalizations, weekend discharges, or timeout interruptions. Third, there was substantial contamination between intervention and control groups which likely biased results to the null. Fourth, only 6% of timeouts were observed which could have led to an omission of timeouts that were impractical and inefficient. Lastly, pharmacists varied in their comfort level making recommendations; if they erred toward withholding recommendations this could limit the timeout's effect. Given demonstrated feasibility, additional, larger studies with control groups less susceptible to contamination are needed to assess effectiveness. In addition, given the critical role nurses play in patient education and care coordination at discharge, future interventions should consider incorporating nurses into antibiotic stewardship during care transitions.

CONCLUSIONS

A pharmacist-facilitated antibiotic timeout at time of hospital discharge was feasible. Barriers to adherence include brief hospital stays, weekend hospital discharges, and strict inclusion criteria. These barriers could be overcome by expanding inclusion criteria and creating a back-up alert for weekend discharges. Further studies are needed to evaluate intervention effectiveness including assessing the effect on antibiotic use and clinical outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Availability of data and materials:

The data relevant to the study are included in the article or uploaded as supplemental information. Other data sets generated during the study protocol are available from the corresponding author on reasonable request through dgiesler@med.umich.edu.

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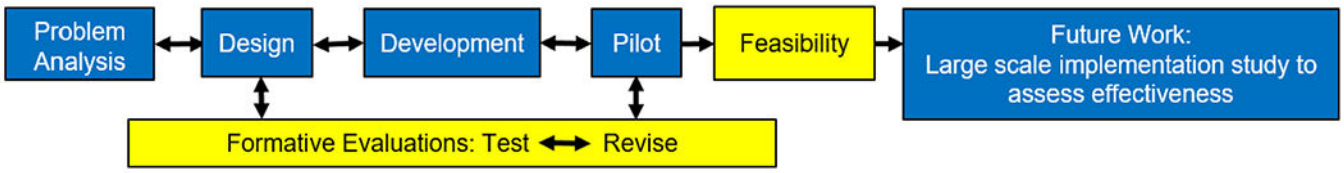
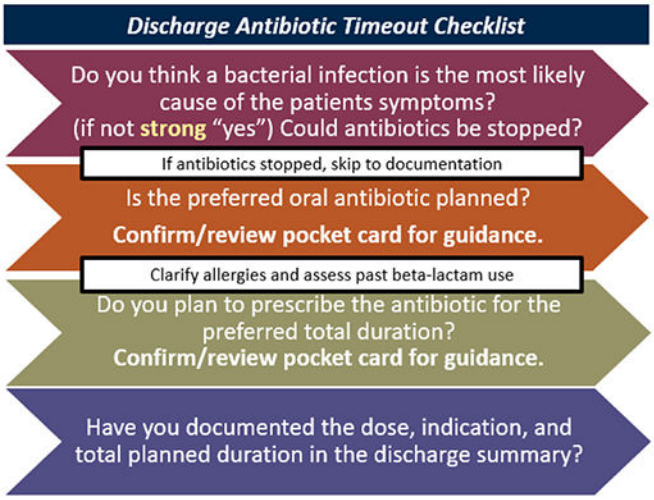


Fig 1.

Implementation Strategy The project's implementation strategy relied on an iterative approach to inform design, development and pilot testing. After each stage of design and development, formative evaluations (including observations and feedback from pharmacists and hospitalists) were used to update the projects design. The result of the project is a feasible intervention ready for large scale testing and implementation to assess effectiveness.

Pocket card side 1 - Antibiotic Timeout Checklist



Pocket card side 2 - Recommended Discharge Antibiotics for Common Infections

Disease State	Preferred Oral Antibiotic (Doses for normal renal function)	Preferred Total Duration (Including effective inpatient duration)	Penicillin Allergy	
			Non-Severe	Severe ¶
Recommendations apply to patients who improved clinically in <72h. If ID consulted follow their recommendations. If available, target therapy to cultures & susceptibilities. Bacteremia, infectious complications (e.g. empyema), & severe immunosuppression (e.g. recent chemo) may require alternative/longer abx.				
GI Infections: Community-Acquired,* Mild-Moderate Severity*				
Acute Uncomplicated Diverticulitis	Amoxicillin/clavulanic acid 875 mg BID	4 days	Cefuroxime + Metronidazole	Ciprofloxacin + Metronidazole
Cholangitis with Successful ERCP	Amoxicillin/clavulanic acid 875 mg BID	4-7 days	Cefuroxime	Ciprofloxacin
Spontaneous Bacterial Peritonitis	Amoxicillin/clavulanic acid 875 mg BID	5 days	Cefuroxime	Ciprofloxacin
Skin/Soft Tissue Infections				
Non-Purulent Cellulitis	Cephalexin 1000 mg TID (add TMP/SMX 1-2 DS BID if risk factors for MRSA*)	5 days	Cephalexin ± TMP/SMX	Clindamycin
Purulent Cellulitis	TMP/SMX 1-2 DS BID; **I&D if abscess**	5 days	(Doxycycline if sulfa allergy)	
Pneumonia				
Pathway A* (Community-Acquired)	Amoxicillin/clavulanic acid 875 mg BID + azithromycin	5 days	Cefuroxime + azithromycin	Levofloxacin
Pathway B* (MDRO Risk Factors or Nosocomial Pneumonia)	If respiratory cx is negative or susceptible: Amoxicillin/clavulanic acid 875 mg BID	7 days	Cefuroxime	Levofloxacin
UTI: Treatment should only be given to patients with urinary symptoms.			**Alternative** (doses for normal renal fxn)	
Uncomplicated Cystitis	Nitrofuantoin 100 mg BID (CrCl>30)	5 days	TMP/SMX 1 DS BID (3 days); Fosfomycin 3gm (1 dose); Cephalexin 500mg BID (7 days)	
Complicated Cystitis* (CAUTI, male, immunosuppressed)	Nitrofurantoin 100 mg BID (CrCl>30); **Remove or replace catheter if present**	7 days	TMP/SMX 1 DS BID (7 days); Cephalexin 500mg QID (7 days); Fosfomycin 3gm q48h (3 doses)	
Uncomplicated Pyelonephritis	TMP/SMX 1 DS BID	7-14 days (7 days if ≤ 65 y/o)	Ciprofloxacin 500 mg BID (7 days); Cephalexin 500mg QID (10-14 days)	

Renal dose adjustment may be necessary for amoxicillin/clavulanic acid, TMP/SMX, beta-lactams, and fluoroquinolones.
* Please see Antimicrobial Stewardship Guidelines for definitions.
¶ Any IgE-mediated features (urticaria, angioedema, bronchospasm, hypotension).

Fig 2.

Pocket card side 1 - Antibiotic Timeout Checklist, Pocket card side 2 - Recommended Discharge Antibiotics for Common Infections The timeout checklist was distributed to pharmacists and hospitalists on a pocket-card for easy reference. The timeouts were led by clinical pharmacists who had a structured conversation with hospitalists including four questions targeting common ways to improve antibiotic prescribing at discharge: (1) stopping unnecessary therapy (ie, antibiotics prescribed for a non-infectious or non-bacterial

syndrome), (2) reducing excessive duration, (3) improving appropriate selection, and (4) documenting antibiotic plan in the discharge summary.

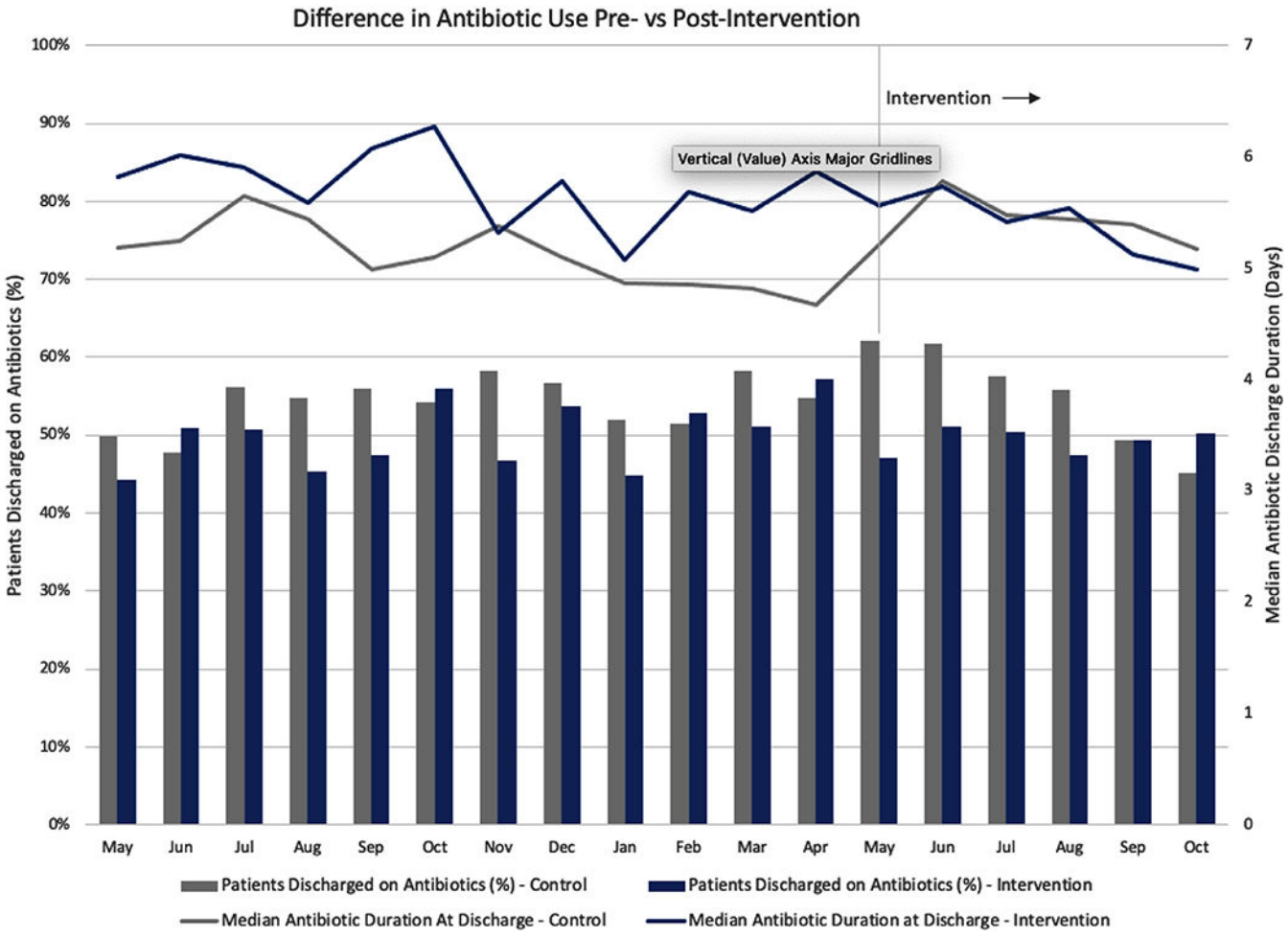


Fig 3.

Difference in Antibiotic Use Pre- versus Postintervention in General Medicine versus Hospital Medicine Groups No differences in pre- versus postmedian antibiotic duration after discharge or percentage of patients discharged on antibiotics were found for the intervention (hospital medicine) group, as compared to the control (general medicine) group. The pre-intervention was May 1, 2018-April 30, 2019 and the intervention period was May 1, 2019-October 31, 2019. A difference in differences approach with logistic regression models was used to evaluate slope/level change pre- versus postintervention in antibiotic use at discharge compared to the control group. Antibiotic use was controlled for patient age, sex, race, Charlson Comorbidity Index, qSOFA (sequential organ failure assessment score, higher scores indicate high risk of mortality) at 24 hours, infectious diagnosis, presence of infectious diseases consultation, prehospitalization steroid use, length of stay, and source of admission (eg, home vs nursing facility).

Table 1

Intervention feasibility: usability, accessibility, awareness, adherence, adaptions, and acceptability

Outcome	Themes and Example Interview Responses	
Usability The extent to which the intervention is practical	Timeout workload was not substantial • "Documentation really didn't take that much longer than it would for like our other things that we are documenting on our scoring tool. I think the timeouts themselves aren't too time consuming." -Pharmacist (Interview) Difficulty arranging face to face meeting • "I would rather have a face to face but if somebody is like [out] seeing a patient or whatnot then, I can't be here just kind of waiting."-Pharmacist (Interview) Workload increased during care transitions • "It's probably more workload… when you are just covering for a day, but I mean it's probably adding like, I don't know, 10 to 20 minutes per day if I was to quantify."-Pharmacist (Interview) Interruptions • Hospitalist received multiple pages during one timeout. The pharmacists continued to talk while the hospitalist read their pager. When the hospitalist returned to the conversation there was almost a medical error (wrong antibiotic dosing) because the hospitalist had not heard the pharmacists' recommendation. (Observation) • One timeout ended abruptly when the physician was called to attend a medical emergency. (Observation) The intervention fit into existing workflow • "Most of the pharmacists I work with, we discuss every single patient every day then, mainly, antibiotic issues, that's one of the major issues so we discuss indication, how long, you know, narrowing down, whatever."-Hospitalist (Interview) • "Historically, before this, I would still ask what patients were being discharged but it's more of an emphasis on the anticoagulation portion of it, to make sure they are educated."-Pharmacist (Interview) • "I think it naturally flows into that meeting time that we have every day"-Pharmacist (Interview) Extra Workload If Antibiotic Prescription Sent to Outpatient Pharmacy Before the Timeout • "So, sometimes, if they haven't sent [the antibiotic] in then, you know, I ask them to make the change. If it's something that's already sent then, I will make sure that they update their note but then I will contact the pharmacy to make sure that it's clear."-Pharmacist (Interview) • "When there actually needs to be a change then, that can take up more time."- Pharmacist (Interview)	
	Post-Intervention Hospitalist Survey	**Responses of Usually/Always (N = 48 respondents), N(%)**
	How often did the timeout intervention fit into your work-flow?	41 (85%)
	How frequently were Pharmacist's suggestions provided in time for changes to be made prior to discharge?	32 (67%)
	How often did discussions with Pharmacists help you make decisions about antibiotic prescribing at discharge?	25 (52%)
	How often were the Pharmacist's suggestions accurate?	46 (96%)
	When you and the pharmacist discussed patients being discharged on antibiotics, how often did you agree with the pharmacists' recommendation?	44 (92%)
Accessibility How accessible the guidelines and recommendations are	Pharmacists—but not hospitalists—found the pocket card accessible: • "I think the pharmacist is actually taking a second to look at the pocket card"-Hospitalist (Interview) • "I like having all duration and agents right at my fingertips so, in that sense, I think it's helpful."-Pharmacist (Interview) • "I try to have it with me as much as I can. I would say probably like 80, 90 percent compliant with having it on me."-Pharmacist (Interview)	

Outcome	Themes and Example Interview Responses		
	• "I have seen the [pocket cards]; I haven't used them because I have a pharmacist available to ask questions."-Hospitalist (Interview) Pharmacists were observed referring to the pocket card during 61% (11/18) of observations. Hospitalists in 0 observations.		
Awareness The extent to which hospitalists are aware of and familiar with the recommendation	Hospitalists are generally aware of the intervention • "I do feel like they [hospitalists] are, like, aware that this is going on and they have been – at least based on my experience – receptive to our interventions."-Pharmacist (Interview) • "I know you have been doing it [the timeouts], but this is the first time I have done it." -Hospitalist (Interview) •"A lot of them [hospitalists] seem to understand, at least know the name 'ROAD Home'"-Pharmacist (Interview) • "I think in the beginning it was kind of challenging because there were some hospitalists that weren't informed on the whole ROAD Home work flow, but once everybody got used to it, •I think that, you know, everybody knew like, yep, it's time for antibiotic timeout and we were able to have a productive conversation."-Pharmacist (Interview)		
	Post-Intervention Hospitalist Survey Responses (N = 48 respondents), N (%)		
	Were you aware of the intervention to improve antibiotic prescribing at discharge?	45 (94%)-Yes	
	Were you aware there was a pocket card available as a reference tool for discharging patients on antibiotics?	35 (73%)- Yes	
	If yes, did you use it?	12 (34%)- Usually/Always	
Adherence The degree to which pharmacists followed study protocol	**How often did the pharmacist discuss the following?, N(%)**	Post-intervention Hospitalist Survey Response of Usually/Always (N=48 respondents)	Observations (N = 18)
	Whether there were any patients who might be discharged on antibiotics	42 (88%)	5 (28%)
	Whether diagnosis was bacterial	24 (50%)	13 (72%)
	Antibiotic selection	43 (90%)	15 (83%)
	Antibiotic duration	45 (94%)	17 (94%)
	Ask you to document antibiotic treatment in the discharge summary	16 (33%)	8 (50%)
Adaptations When pharmacists begin to alter their approach and use of the timeout over time	Pharmacists often adapted timeout questions • "Some of them are like you can kind of fast-forward through them because, you know, asking if a patient has a bacterial infection with a confirmed culture supporting it I think is somewhat elementary."-Pharmacist (Interview) • "I don't like reading directly off the card; I kind of like formulating it into our own … what's the word that I am looking for … explanation of what something is just so they don't feel like they are just being triggered [indiscernible] so I kind of try to get the most out of them."-Pharmacist (Interview) In 18 observations, pharmacists commonly used adapted versions of the timeout questions: indication (50%), selection (72%), duration (94%), and documentation (28%).		
Acceptability	People liked structure provided by the timeout "Talking to my pharmacist about antibiotics is always helpful. And if this makes us do it more formally then, I mean, I think that can only be a positive thing."-Hospitalist (Interview) "I mean we were always talking about antibiotics when we would go on pharmacy rounds but		

Outcome	Themes and Example Interview Responses	
	never like nail down the nitty gritty like, okay, you are discharging this amount for this duration to get that exact plan set in place verbally.”-Pharmacist (Interview) “I think being prompted to look at the actual discharge orders to see like the actual duration or number of tablets the patient has been prescribed is very beneficial and I think we probably made a significant amount of interventions in that regard.”-Pharmacist (Interview) Hospitalists liked having the pharmacists weigh in “One of the things that I liked about the antibiotic timeout was that it was like a second pair of eyes … you know, looking at the … duration.”-Hospitalist (Interview) Some hospitalists disagreed with certain recommendations “There are occasional episodes where even though guidelines might argue for something, it may not fully account for the complexity of the patient.”-Hospitalist (Interview) “Of course, that’s going to change the direction of therapy and like, you know, there’s a few people who are a bit set in their ways and like clindamycin, per se, but those are kind of individual problems.”-Pharmacist (Interview)	
	Post-intervention Hospitalist Survey Response of Agree/Strongly Agree (N=48 respondents), N (%)	
	Overall, the discharge antibiotic intervention was helpful.	40 (85%)
	Overall, the discharge antibiotic intervention improved antibiotic prescribing at discharge.	40 (85%)
	Overall, the discharge antibiotic intervention reduced antibiotic-associated adverse-events.	26 (55%)
	Overall, the discharge antibiotic intervention improved patient care.	37 (79%)
	Overall, the discharge antibiotic intervention improved my knowledge related to antibiotic use at discharge.	34 (72%)
	I think we should continue the discharge antibiotic intervention in the future.	39 (83%)

Table 2

Characteristics of included patients on hospital medicine and general medicine services during the intervention, bivariable comparisons

	All Patients (N=711)	Hospital Medicine Patients (n = 417)	General Medicine Patients (n = 294)	*P*-value
Age (years), median (IQR)	67 (55-78)	68 (57-78)	66 (51-77)	.11
Female Sex, N (%)	383 (53.9)	217 (52.0)	166 (56.5)	.24
Charlson Comorbidity Index, median (IQR)	5 (2-8)	5 (2-8)	5 (2-8)	.37
qSOFA score at 0-24 h *, median (IQR)	1 (0-2)	1 (0-2)	1 (0-2)	.09
Length of hospital stay (days), median (IQR)	5 (3-9)	5 (3-9)	5 (3-8)	.08
Infectious disease treated, N (%)				.91
Urinary Tract Infection	275 (38.7)	162 (38.8)	113 (38.4)	
Pneumonia	222 (31.2)	127 (30.5)	95 (32.3)	
Skin and soft tissue	134 (18.8)	78 (18.7)	56 (19.0)	
Multiple	53 (7.5)	32 (7.7)	21 (7.1)	
Intra-abdominal	27 (3.8)	18 (4.3)	9 (3.1)	
Infectious diseases consultation during hospitalization, N (%)	125 (17.6)	72 (17.3)	53 (18.0)	.79
Had an antibiotic prescribed on discharge, N (%)	368 (51.8)	204 (48.9)	164 (55.8)	.07
Amoxicillin/Clavulanic	122 (17.2)	66 (15.8)	56 (19.0)	.26
Cephalexin	55 (7.7)	32 (7.7)	23 (7.8)	.94
Fluoroquinolone	51 (7.2)	26 (6.2)	25 (8.5)	.25
Sulfamethoxazole/Trimethoprim	51 (7.2)	30 (7.2)	21 (7.1)	.98
Other	125 (17.6)	67 (16.1)	58 (19.7)	.21
Antibiotic Duration on discharge (days); Median [IQR] (patients who received antibiotics)	5 (3-8)	5 (3-8)	5 (3-8)	.60
Antibiotic Duration on discharge (days); Median [IQR] (all patients)	1 (0-5)	0 (0-5)	2 (0-5)	.15
Had Antibiotic Timeout Data Documented, N (%)	128 (18.0)	125 (30.0)	3 (1.0)	<.001

*Quick sequential organ failure assessment score (qSOFA) identifies patients outside of the intensive care unit who have a high predicted risk of sepsis-related mortality.