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Original Article

Taking an Antibiotic Time-out: Utilization and Usability of a Self-Stewardship Time-out Program for Renewal of Vancomycin and Piperacillin-Tazobactam

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ABSTRACT

Background: Antibiotic time-outs can promote critical thinking and greater attention to reviewing indications for continuation.

Objective: We pilot tested an antibiotic time-out program at a tertiary care teaching hospital where vancomycin and piperacillin-tazobactam continuation past day 3 had previously required infectious diseases service approval.

Methods: The time-out program consisted of 3 components: (1) an electronic antimicrobial dashboard that aggregated infection-relevant clinical data; (2) a templated note in the electronic medical record that included a structured review of antibiotic indications and that provided automatic approval of continuation of therapy when indicated; and (3) an educational and social marketing campaign.

Results: In the first 6 months of program implementation, vancomycin was discontinued by day 5 in 93/145 (64%) courses where a time-out was performed on day 4 versus in 96/199 (48%) 1 year prior (P = .04). Seven vancomycin continuations via template (5% of time-outs) were guideline-discordant by retrospective chart review versus none 1 year prior (P = .002). Piperacillin-tazobactam was discontinued by day 5 in 70/105 (67%) courses versus 58/93 (62%) 1 year prior (P = .55); 9 continuations (9% of time-outs) were guideline-discordant versus two 1 year prior (P = .06). A usability survey completed by 32 physicians demonstrated modest satisfaction with the overall program, antimicrobial dashboard, and renewal templates.

Conclusions: By providing practitioners with clinical informatics support and guidance, the intervention increased provider confidence in making decisions to de-escalate antimicrobial therapy in ambiguous circumstances wherein they previously sought authorization for continuation from an antimicrobial steward.

Key Words—antibacterial agents, health education, hospital infections, inappropriate prescribing, piperacillin-tazobactam, vancomycin

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Optimal antimicrobial therapy should most specifically target a given pathogen or disease for the appropriate duration. In practice, antimicrobial usage is frequently inappropriate with regard to treatment indication, choice of agent, or treatment duration.[1-5] Inappropriate antimicrobial therapy leads to excess antimicrobial resistance, adverse events, and health care costs.[6-13] Promotion of excess in antimicrobial resistance is particularly troubling in an age when multidrug-resistant organisms can no longer be effectively treated by any available antibiotics and few potentially effective agents are under development.[14]

Antimicrobial stewardship may be broadly defined as a program or series of interventions to improve the appropriateness of antimicrobial use, and it is a key strategy in combating antimicrobial resistance.[9,15-17] Unfortunately, best practices in stewardship remain unclear.[18] Whereas available data indicate that restrictive interventions (ie, limiting access to antibiotics through formulary or approval policies) have a significantly greater impact on prescribing practices in the short term than do persuasive measures such as dissemination of educational resources and/or outreach, reminders, or audit-feedback, these benefits do not persist, are less scalable, and can provoke negative reactions from providers who prefer to maintain autonomy in decision making.[19,20] Thus, stewardship must find a balance between restrictive and persuasive methods of influencing antimicrobial prescription.

The antibiotic time-out, which encourages the provider or steward to review antibiotic therapy on the third or fourth calendar day of treatment, is a strategy that has been endorsed by the Centers for Disease Control and Prevention in the United States and the National Health Service in Great Britain.[21-23] This approach accommodates the need to initiate broad-spectrum therapy during periods of clinical uncertainty when the relevant pathogen is yet to be identified while encouraging more specific treatment after microbiologic data become available and the clinical scenario is better defined and can be either restrictive or persuasive, depending on its design and implementation.

We describe the development and implementation of an antibiotic time-out program where we sought to facilitate decision making at the point of care.[24] This program targeted providers who were using either of the 2 most commonly prescribed broad-spectrum antibiotics at our institution, vancomycin and piperacillin-tazobactam. Our goal was to allow providers to obtain automatic continuation (self-approval) of these medications by following a structured antibiotic time-out process that would occur after 3 days of therapy.

This article focuses on the utilization and usability of the antibiotic time-out program; additional work that examines the effect of the program on overall and targeted antimicrobial consumption will be described separately.

MATERIALS AND METHODS

Setting

The Self-Stewardship Time-out Project for Broad-Spectrum Antibiotics (SSTOP Broad-Spectrum Antibiotics) project was implemented at a tertiary care teaching hospital within a large Southern California Veterans Affairs (VA) health care system. This facility has approximately 200 active medical, surgical, and intensive care unit beds and more than 25,000 bed-days of care among 4,000 acute medical and surgical admissions per year. Attending physicians have academic appointments, and patient care on the acute medical and surgical wards and intensive care units includes resident and attending physicians. Medical teams have an assigned clinical pharmacist to assist in patient management. The antimicrobial stewardship program was established in 2004 and is staffed by an infectious diseases (ID) attending and pharmacist as well as rotating pharmacy residents. Rotating ID fellows also participate in stewardship.

Implementation

We chose 2 of the most commonly used broad-spectrum antibiotics at the facility for intervention: vancomycin and piperacillin-tazobactam. Prior to time-out implementation, continuation of these antibiotics past 3 days required approval by the ID fellow, pharmacist, or attending physician. With introduction of the antibiotic time-out, the need for approval by the ID service was waived, and approval was automatically given if the provider appropriately completed the antibiotic renewal template. Continuance was for 2 to 4 days, depending on algorithms built into the renewal template. All extensions of therapy beyond the duration specified by the time-out template required ID service approval. The facility policy of automatic ID consultation for all *Staphylococcus aureus* bacteremia, established in 2008, remained in effect.

Antibiotic time-outs were introduced stepwise to new services on an approximately monthly basis, starting with vancomycin time-outs on the general

medicine services in March 2013, followed by vancomycin time-outs on the medical intensive care unit (MICU) service in April 2013, piperacillin-tazobactam time-outs on the general medicine and MICU services in May 2013, and vancomycin and piperacillin-tazobactam time-outs on the surgical intensive care unit service in June 2013. The intervention was implemented under the supervision and approval of the facility's institutional review board.

Intervention

Electronic Antimicrobial Dashboard

Development of the electronic antimicrobial dashboards is described in **Appendix A**, which also contains a sample screenshot of a dashboard report. The electronic antimicrobial dashboards were reviewed on a daily basis by the project team to identify patients eligible for an antibiotic time-out (ie, vancomycin or piperacillin-tazobactam renewal on day 4 of therapy). During the 6-month implementation, a research assistant printed and distributed hardcopy dashboard reports daily to the providers caring for patients who were eligible for time-out.

Antibiotic Time-out Templates

As with all VA facilities, our electronic health record (EHR) supports progress notes that can incorporate current clinical data such as laboratory reports, vital signs, and other patient descriptors and can also be customized to include nested dialogs dependent upon responses to yes/no questions or free-text entries. Providers accessed the specific antibiotic time-out template by selecting a designated pre-populated progress note (eg, "TIME OUT – VANCOMYCIN RENEWAL NOTE" or "TIME OUT – PIPERACILLIN\TAZOBACTAM RENEWAL NOTE"). These notes prompted a series of questions on the presence of active infection, culture data, and current clinical status to determine the necessity of continuing broad-spectrum therapy. If the logic tree of the template renewal note (**Appendix B**) indicated that the antibiotic in question should be continued, the provider was instructed to enter an order for antibiotic renewal to extend therapy for the time period designated by the note (2 to 4 days, depending on the clinical situation). The note template also included a question about whether the decision regarding antibiotic renewal was discussed on team rounds. Upon template completion, a progress note was generated in the EHR that captured the logic tree of the template and whether or not the antibiotic in question should be continued. Once signed, this note was seen by the provider team's clinical pharmacists who processed the order for renewal of the antibiotic. If no time-out note was written and approval of continuation of the antibiotic was not otherwise obtained from the ID service, the order was allowed to expire (with verification by the team's clinical pharmacist to ensure patient safety). This was purposefully done so as to not force providers into doing extra work if the decision to discontinue the antibiotic was already made.

Ultimately, 3 sets of stakeholders were impacted by the time-out intervention: the prescribing providers, the antimicrobial stewardship team, and the inpatient clinical pharmacists. A schematic of how the time-out was integrated into the workflow of each stakeholder group is presented as **Figure 1**.

Social Marketing and Educational Program

The educational and social marketing campaign that accompanied time-out implementation is described in **Appendix C**. We utilized influential physician champions, including hospitalists, a MICU attending, a surgical intensive care unit (SICU) critical care attending, and a surgeon. These champions engaged in social marketing and formally and informally promoted the program. In particular, the facility's ID intranet site (accessible from the facility's home page), which contains links to antimicrobial formulary guidelines and locally adapted consensus guidelines for the management of common diseases, was heavily promoted.

Several educational documents were developed and placed in an "Antibiotic Time-outs" section of the ID intranet site (http://www.infectiousdiseases-ucla-affiliated.org/Intranet/GUIDELINES/Guidelines.html). Links to the educational documents and the electronic antimicrobial dashboard are also provided within the context of the antibiotic renewal templates, where appropriate. For example, when the provider is asked whether a patient can be converted to oral antibiotic therapy, a link is provided to the document that gives options for that conversion.

Outcome Measurement

Electronic Chart Review for Time-out Outcomes and Guideline Concordance

Records of time-out–eligible patients were reviewed to determine whether antibiotics were continued and whether the continuation was consistent with facility-specific guidelines, links to which were embedded in the antibiotic approval template. Reviews included all cases

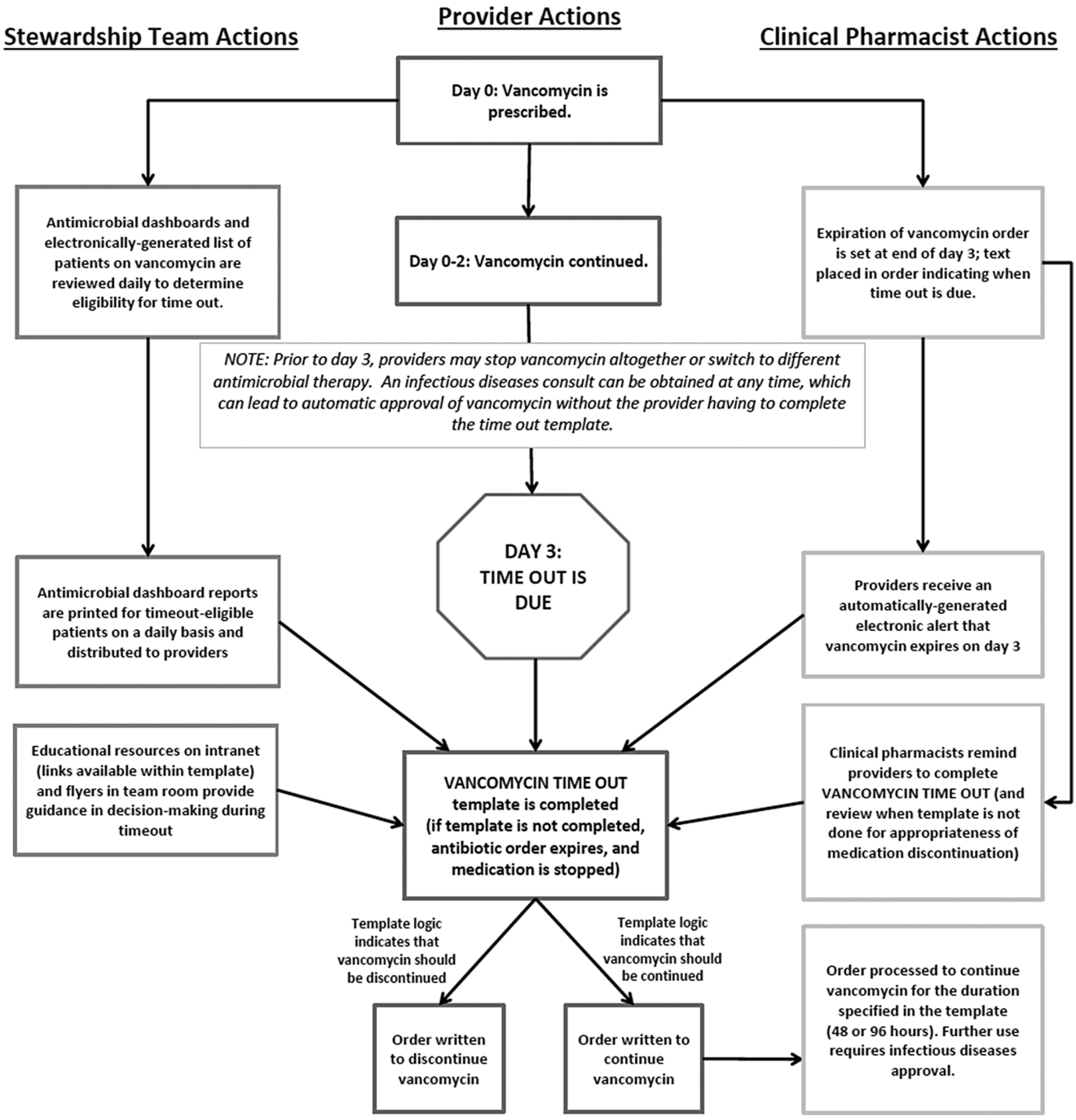

Figure 1. Antibiotic time-out workflow schematic. Vancomycin is used as an example; piperacillin-tazobactam time-out workflow is identical.

(145 vancomycin and 105 piperacillin-tazobactam) for which dashboard reports were distributed from April 19, 2013 to October 18, 2013. We also identified episodes in which vancomycin and piperacillin-tazobactam were continued past day 5 during a 6-month time frame 1 year prior to program implementation (April 19, 2012 to October 18, 2012).

The director of the antimicrobial stewardship program (C.J.G.) plus a second ID physician (M.B.G.) retrospectively reviewed each time-out episode where

vancomycin and/or piperacillin-tazobactam were renewed via template completion and the medication was still active through day 5 to determine guideline concordance. A similar review for guideline concordance was conducted of episodes in the pre-intervention period in which the ID pharmacist or fellow had approved antibiotic therapy through day 5. Discrepancies in determination of guideline concordance of vancomycin and/or piperacillin-tazobactam continuation were reconciled by joint chart review. Fisher's exact test was used to compare rates of antibiotic discontinuation and guideline discordance in the pre-implementation and implementation phases. A 2-sided *P* value of less than .05 was considered to be statistically significant.

Usability Survey

We used an adaptation of the System Usability Scale (SUS) to evaluate the usability and usefulness of the dashboard reports (**Appendix D**). The SUS is a publically available 10-item usability scale known for its broad applicability and easy administration and interpretation.[25-27] The Cronbach's alpha, a coefficient of internal consistency, for the entire scale was 0.89 (levels greater than 0.80 represent high internal reliability).[28] In addition, we included questions derived from user interviews assessing satisfaction with using the template as a replacement for asking for external approval (Cronbach's alpha = 0.76). Finally, we asked 3 questions related to overall attitudes regarding the value of the program in total (helpfulness, desirability, and a positive impression) and combined them into a scale. The Cronbach's alpha for this scale was 0.98.

Sixty-three physicians who completed antibiotic renewal templates in the first 6 months of time-out implementation were invited via e-mail to complete the SUS online via Survey Monkey (http://www.surveymonkey.com). No financial incentives were offered.

Three scales were created by (a) summing the SUS questions on dashboard usability, (b) summing the satisfaction questions regarding the note template process, and (c) summing the final overarching attitude questions for the entire program. Two linear regression analyses were conducted using IBM SPSS version 22 (IBM Corp., Armonk, NY) that examined predictors of intentions to use the dashboard (SUS and Attitude scores) and intentions to use the template (template experiences and Attitude scores).

RESULTS

Review of Vancomycin Time-outs

During the 6-month postintervention period, there were 145 time-out–eligible episodes among 130 unique patients for vancomycin for which dashboard reports were distributed to providers (**Table 1**). In 55 (38%) of these episodes, the template was completed. Among the other 90 episodes, vancomycin was allowed to expire in 77 cases (53%), whereas in 13 cases vancomycin was still active 24 hours later despite the time-out not being done. Of the 13, the ID service had recommended vancomycin continua-

Table 1. Antibiotic time-out outcomes

Eligible for review (*N* = 250)	Vancomycin (*n* = 145)	Pip-Tazo (*n* = 105)
Allowed to expire	77 (53.1%)	51 (48.6%)
Time-out template completed	55 (37.9%)	52 (49.5%)
Discontinued within 24 hour of time-out	13 (9.0%)	17 (16.2%)
Switched to oral agent	3 (2.1%)	2 (1.9%)
Vancomycin still active 24 hr following time-out	39 (26.9%)	33 (31.4%)
ID service consulted and agreed with continued use	5 (3.4%)	3 (2.9%)
Appropriate continuation per retrospective review	27 (18.6%)	21 (20%)
Inappropriate continuation per retrospective review	7 (4.8%)	9 (8.6%)
Antibiotic active 24 hr later without time-out	13 (9.0%)	2 (1.9%)
ID consult or ID pharmacist input requested in lieu of completing time-out template	7 (4.8%)	2 (1.9%)
Discontinued then restarted	2 (1.4%)	0 (0%)
Pharmacy renewed in error	4 (2.8%)	0 (0%)

Note: ID = infectious diseases; Pip-Tazo = piperacillin-tazobactam.

tion in 7, and in 2 episodes vancomycin was stopped but started again the next day. Two of the 4 remaining episodes occurred in the context of patients with impaired renal function receiving intermittent spot dosing of vancomycin.

In 13 of the 55 episodes where the template was completed, vancomycin was initially continued but was stopped within 24 hours, and in 3 episodes, patients were switched to oral therapy as dictated by the template, which left 39 episodes in which vancomycin was still active 24 hours following template completion. In 5 of these cases, ID was consulted and concurred with vancomycin continuation, leaving 34 cases to be reviewed for appropriateness of vancomycin continuation.

Review by 2 ID physicians determined that 7 continuations of vancomycin were guideline-discordant, accounting for 5% of all vancomycin time-outs. Two patients accounted for 4 of the vancomycin continuations that were guideline-discordant. No renewals of vancomycin were deemed to be guideline-discordant on retrospective chart review in the 6-month period 1 year prior when all renewals required approval of the ID service ($P = .002$) (**Table 2**).

The overall rate of discontinuation of vancomycin from day 3 through day 5 was 64% (93/145 episodes), significantly higher than the 48% (96/199 episodes) rate of discontinuation in the 6-month period 1 year prior ($P = .004$).

Review of Piperacillin-Tazobactam Time-outs

During the 6-month postintervention period, 105 time-out eligible episodes among 90 unique patients occurred in which dashboard reports were distributed to providers caring for patients on piperacillin-tazobactam (**Table 1**). In 52 (50%) of these episodes, the template was completed. Among the other 53 episodes, piperacillin-tazobactam was allowed to expire in 51 cases (49%), while in 2 cases piperacillin-tazobactam remained active 24 hours later, despite no time-out template having been done. In both of these cases, the primary team had consulted with and received approval for continuation of piperacillin-tazobactam from the ID service or the ID pharmacist.

In 17 of the 52 episodes where the template was completed, piperacillin-tazobactam was initially continued but stopped within 24 hours, and in 2 episodes, patients were switched to oral therapy as dictated by the template, leaving 33 episodes in which piperacillin-tazobactam was still active 24 hours following template completion. In 3 of these cases, the ID service was consulted and concurred with piperacillin-tazobactam continuation, leaving 30 cases to be reviewed for guideline concordance of piperacillin-tazobactam continuation.

Reviewers determined that 9 continuations of piperacillin-tazobactam were guideline-discordant, accounting for 9% of all piperacillin-tazobactam time-outs. In 7 of 9 of these episodes, lower respiratory tract infection was the indication for piperacillin-tazobactam continuation. Two renewals of piperacillin-tazobactam were deemed to be guideline-discordant on retrospective chart review in the 6-month period 1 year prior ($P = .06$).

The overall rate of piperacillin-tazobactam discontinuation from day 3 through day 5 was 67% (70/105 episodes), similar to the 62% (58/93 episodes) rate of discontinuation of piperacillin-tazobactam past day 5 in the 6-month period 1 year prior ($P = .55$) (**Table 2**).

There was no significant difference in frequency of guideline-discordant continuation of vancomycin compared to piperacillin-tazobactam during the time-out period, either as a proportion of all time-out episodes (5% vs 9%; $P = .30$, by Fisher's exact test) or of episodes associated with continuing the medication past day 5 without concurrence of the ID service (21% vs 30%; $P = .40$).

Table 2. Review of appropriateness of antibiotic continuation

	Before time-out	Time-out	*P*
Vancomycin			
Antibiotic courses eligible for renewal	199	145	
Inappropriate continuations	0 (0%)	7 (5%)	.002
Courses discontinued (through day 5)	96 (48%)	93 (64%)	.004
Piperacillin-tazobactam			
Antibiotic courses eligible for renewal	93	105	
Inappropriate continuations	2 (2%)	9 (9%)	.06
Courses discontinued (through day 5)	58 (62%)	70 (67%)	.55

Usability Survey

Thirty-two of 63 (51%) physicians (31 resident physicians and 1 attending physician) who completed an antibiotic renewal template within the first 6 months of time-out implementation also completed the user questionnaire. The Attitude rating for the overall time-out program was relatively modest, scoring close to the high middle of the 1 to 7 point scale (mean 4.78, median 5). Usability ratings for the antimicrobial dashboard were equally modest (mean 4.78, median 5). Satisfaction ratings for the renewal templates were also modest (mean 3.73, median 3.87).

Regression analyses indicated that, overall, perceived usability and general attitudes toward the program predicted a large proportion of the variance in intention to use the antimicrobial dashboard in the future ($R^2 = 0.66$, $P < .01$), though when examined individually, perceived usability was a significant predictor ($\beta = 0.12$) of intention to use the dashboard in the future and general attitudes were not ($\beta = 0.09$) after controlling for perceived usability. In contrast, both satisfaction with the antibiotic time-out templates ($\beta = 0.95$) as well as general attitudes about the overall program ($\beta = 0.52$) explained a large proportion of the variance in intentions to use the antibiotic renewal template ($R^2 = 0.74$, $P < .01$). One possible explanation for this difference is that, as the antibiotic time-out template determined whether antibiotics were to be continued, this aspect of the program might have been perceived as the heart of the program. In contrast, although the antimicrobial dashboard was intended to provide a useful summary of clinically relevant data, its use was not necessary to the time-out process. We did find that a positive response to the item "I find the dashboard useful in decision making" was highly correlated with intent to use the dashboard ($R^2 = 0.79$, $P < .01$), suggesting that the dashboard captured practitioners' attention and caused them to think about their decision, which resulted in an antibiotic time-out that functioned as intended to promote deep thinking about antibiotic continuation.

DISCUSSION

Our goal in designing this antimicrobial time-out intervention was to develop a novel antimicrobial stewardship intervention that would provide a useful clinical data summary with relevant clinical guidance and nudge practitioners to make appropriate de-escalation decisions while fitting into hospital workflow, allowing for increased provider autonomy but not increasing workload for antimicrobial stewards. Although a shift to such a stewardship model offers the opportunity for increased antimicrobial misuse, we found that when compared to a prior period of time when continuance was approved by ID personnel, vancomycin time-outs showed higher overall rates of discontinuation, although guideline-discordant continuations increased. Findings regarding piperacillin-tazobactam time-outs were more mixed in that rates of discontinuation were similar, with a nonsignificant trend of higher rates of guideline-discordant continuations. In reviewing for guideline concordance, we applied a practical and pragmatic "antimicrobial stewardship" standard where some benefit of the doubt was applied; a different standard would exist in the setting of a formal ID consultation.

Although it may seem paradoxical that guideline-discordant use of vancomycin rose with the time-out program whereas overall continuations of vancomycin fell, we posit that by providing practitioners with clinical informatics support and guidance, the intervention increased provider confidence in making decisions to de-escalate antimicrobial therapy in ambiguous circumstances wherein they previously sought authorization for continuation from an antimicrobial steward. In such circumstances, there may not have been enough data available to the steward to categorically refuse approval. Put another way, we think that the time-out program improved the ability of providers to decide when it could be appropriate to discontinue antimicrobial therapy, although perhaps, as one would expect, not to the level of expertise of an ID physician. One caveat to this hypothesis is that we only examined the appropriateness of antibiotic continuation and we did not specifically examine the appropriateness of antibiotic discontinuation; this is an area for further study.

It is important to keep in mind that the comparison period may have included different types of patients and that it primarily provides a contextual reference. Moreover, determination of when continuation or discontinuation of antibiotic therapy is appropriate is not always clear. Even though our facility has guidelines for when continuation of vancomycin and piperacillin are indicated, they do not reliably address all clinical situations that are encountered. Many of the indications for continuation of therapy directed against methicillin-resistant *Staphylococcus aureus* are reasonably straightforward (ie, abscess or complex skin-soft tissue infections where cultures can be readily obtained), whereas indications

for continuation of therapy directed against *Pseudomonas* and other multidrug-resistant gram-negative rods may be less clear. This is particularly true in the management of nosocomial or health care–associated lower respiratory tract disease, where society guidelines typically call for initiation of empiric antipseudomonal therapy but do not provide specific guidance on its narrowing when microbiologic data are missing, incomplete, or uninterpretable.[29] Furthermore, patients with nosocomial lower respiratory tract infection are often critically ill, and there is greater risk in changing management and thus more discomfort with uncertainty. Indeed, a frequent cause of renewal of piperacillin-tazobactam ultimately deemed guideline-discordant in this study was for ongoing management of suspected lower respiratory tract infection. Even when renewal was deemed appropriate, it was often in the setting of inadequate or pending microbiologic data.

In summary, we speculate that the main reason we were able to achieve a higher rate of discontinuation with the time-out program with vancomycin and not piperacillin-tazobactam is because we were able to reduce provider uncertainty more with indications for vancomycin discontinuation than piperacillin-tazobactam for the reasons mentioned previously. Though approaches using clinical assessment scores and protocols to promote de-escalation or discontinuation of broad-spectrum therapy in suspected nosocomial lower respiratory tract infection have met with some success in reducing antimicrobial therapy, more comprehensive studies are urgently needed.[30,31] The role that biomarkers such as procalcitonin and rapid diagnostics such as matrix-assisted laser desorption/ionization-time of flight (MALDI-TOF) play in antimicrobial stewardship and decision-making also requires further exploration, as early efforts in this regard have shown promise.[32,33]

We sought to steer providers toward desired behavior by giving them the necessary tools to act as self-stewards and thereby respect their autonomy, rather than to explicitly restrict their actions. The results of the analyses assessing intentions to use the template suggest that the overall approach of using a template to prompt individual assessment was acceptable to clinicians. This self-stewardship approach may also be valuable for hospitals that have limited resources to devote to stewardship. Although our approach relied on automated data systems, such a "culture of change" approach that incorporates specific recommendations and provides cognitive support (as compared to simpler, generic computerized prompts or checklists to reconsider indications for antibiotic continuation[34-36]) can be replicated in clinical care situations with less robust data systems.

Dual process theory integrates diverse programs in psychology ranging from economics to attitude research.[37] It posits 2 memory systems involved in human decision making: a "system 1," which requires little cognitive effort and functions through pattern recognition, intuitive associations, and heuristics, and a "system 2," which is much more deliberate, analytic, and deductive but requires much greater cognitive effort. Much of medical care is influenced by system 1 thinking,[38] particularly by trainees who rely on heuristics when prescribing antimicrobial therapy in an acute situation.[39] Stewardship requires system 2 thinking or increased attention to the reasoning process. Because of the increased cognitive effort required, this level of effort will always be avoided, if possible. The key to success of any intervention that increases cognitive effort and attention is to maximize individual control over when, where, and how the cognitive energy is to be expended. Interruptive interventions remove the individual's control and self-regulation of his or her attention and might even pose a danger. Thus, we hypothesized that providing multiple prompts that promote deliberative system 2 thinking while using visual graphic displays and structured templates to assist in deliberative decision-making to ease cognitive effort would influence providers to make better antimicrobial decisions. Although satisfaction with the time-out program was modest according to the SUS, any system that is designed to encourage deep cognitive processing is unlikely to quickly attain broad popularity. Because deliberative reasoning requires significant cognitive resources, the motivation to use those resources has to outweigh the cost. This program provides support for autonomy and enhanced control over workflow (as well as educational resources), thereby mitigating the extra effort required in thinking deliberatively about the time-out decision. Cognitive task analyses of the time-out program (manuscript in preparation) found that many resident physicians preferred the time-out mechanism to having to call for approval, although a subset did prefer being able to discuss the case with the ID pharmacist or fellow, an option that is still available to them even with the time-out program.

Further investigation is needed to determine whether our time-out program would work in hospitals without our electronic resources (perhaps with the use of static flowchart posters and templates). Even our program was not fully dependent on

electronic resources, as we manually delivered printed dashboard reports to providers of time-out eligible patients.

Approximately two-thirds of time-outs for both vancomycin and piperacillin-tazobactam resulted in discontinuation or de-escalation of therapy, most frequently in the context of providers not filling out the template and allowing the medication to expire, signifying that a decision to discontinue or de-escalate therapy was made in a large number of cases without the explicit assistance of the logic algorithm and educational resources available within the template. Thus, the inclusion of the antimicrobial dashboard reports and educational and social marketing campaigns in the time-out program, apart from the renewal template itself, likely play a critical role in determining its success. Prompting providers to fill out the template may have been sufficient to induce contemplative system 2 thinking as to whether or not the antibiotic is truly needed.

One issue that arises in assessing the effect of a time-out in an academic setting is that antibiotic decisions may not be made by the trainee who completes the template because the attending on service is ultimately responsible for patient care. This potential disconnect between implementation of computerized decision support for appropriate prescribing and the providers who are targeted for the decision support has been noted elsewhere.[40] We attempted to capture this aspect on the template by asking whether the decision was discussed with the attending physician. We only found 4 instances in which it was stated on the template that the decision was not discussed with the attending. Hence, although the trainees were targeted, it seems that the choice to continue an antibiotic was a collective decision in which the time-out program may have assisted.

Although one limitation of the time-out program was the potential for clinicians to "game the system" by providing incorrect information onto the template, we found a low proportion of inappropriate antibiotic continuation as a function of total number of time-outs. This may be influenced by the fact that providers knew that the time-out note would become a signed part of the permanent medical record.

Overall, this pilot study serves as a theory-driven bundle that indicates that providers can be autonomous actors within the context of an antibiotic time-out. The Centers for Disease Control and Prevention recommends that all hospitals implement stewardship programs. The antimicrobial stewardship program at our hospital was long-standing and robust, but the effect of a time-out program on a hospital with less robust programs with more limited resources (both with regard to personnel and EHR capability) deserves further study. Our program relied upon the specific informatics structure of the VA EHR, allowing for scalability and potential adoption across the VA system without a large additional investment in human capital. However, there is potential for implementation outside the VA system in facilities that have EHRs and the capability to create dashboards from antimicrobial and patient relevant data from a data warehouse. Larger health care systems are transitioning to EHRs, as a recent US national survey indicated that four-fifths of hospitals either had EHRs in place or were planning EHR implementation.[41] Given the success of the time-out concept in the surgical literature,[42] there is immense potential for time-outs to be applied to other health care settings. Time-outs that address vancomycin and piperacillin-tazobactam use 48 to 72 hours into therapy may only be the beginning of the potential applications of time-outs within the rubric of antimicrobial stewardship.

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APPENDIX A

Electronic Antibiotic Dashboard Development

The VA uses a comprehensive electronic medical record, the Veterans Health Information Systems and Technology Architecture (VistA), that includes inpatient and outpatient data, basic decision-support tools, provider order entry, and full electronic documentation. VA Corporate Data Warehouse (CDW), which extracts clinical data from VistA systems nationwide on a nightly basis, was used as a data source for an electronic antimicrobial dashboard that aggregated infection-relevant information into individual patient reports. These reports could be used directly during ordering or printed out and then used as decision aids during work and attending rounds. Microsoft SQL Server 2008 R2 Management Studio was used to query the CDW, and Microsoft SQL Server 2008 R2 Report Builder 3.0 was used to construct the dashboard, which was accessible via a Microsoft SharePoint Web site. Security and access permissions were granted based on user credentials according to VA policies and regulations.

The dashboard allows users to select a panel of patients for which reports can be generated, based on facility, ward location, and on eligibility for a time-out for a particular antimicrobial (see **Figure A1**). Each report contains basic patient information (eg, name and identifiers, ward location), vital signs (eg, temperature, blood pressure), and pertinent laboratory results (eg, white blood cell count, serum creatinine) and their respective graphically depicted trends over 5 days, as applicable, in order to provide objective criteria to assess the patient's response to treatment, allowing more time to be focused on time-out deliberation rather than information collection and interpretation. It also includes relevant antimicrobial information (including any antimicrobial agent started within the prior 30 days, start and end dates of therapy, and the current day of therapy for all active antimicrobials) and therapeutic serum levels (as appropriate); it also displays microbiology results, including all cultures performed within the previous 14 days, with organism identification and antimicrobial susceptibilities, if available. For the purposes of our report, we defined an antimicrobial as active if its order was active on the day of the report and BCMA recorded the patient as having received it within the previous 96 hours.

APPENDIX B

Antibiotic Renewal Template Logic

The antibiotic time-out template focuses on 4 basic questions: (1) Is a bacterial infection present? (2) Has the site of infection been determined? (3) Has the culprit bacterial pathogen(s) been identified? (4) Is the patient clinically stable? Providers enter answers to questions related to each of these themes; these answers are captured in structured data fields called health factors (a functionality that allows creation of any new variable to be stored in the medical record along with other clinical data). Health factors can then be extracted and analyzed. We added hyperlinks embedded within the templates to online resources, including a link to and instructions on how to access the electronic antimicrobial dashboards and educational materials and clinical guidelines pertinent to the antibiotic in question.

The template uses a basic logic tree to determine if renewal of the antibiotic in question is appropriate, based on the information entered by the provider. **Figure B1** demonstrates the logic tree used in determining whether or not continuation of vancomycin is appropriate; the piperacillin-tazobactam renewal template uses similar logic.

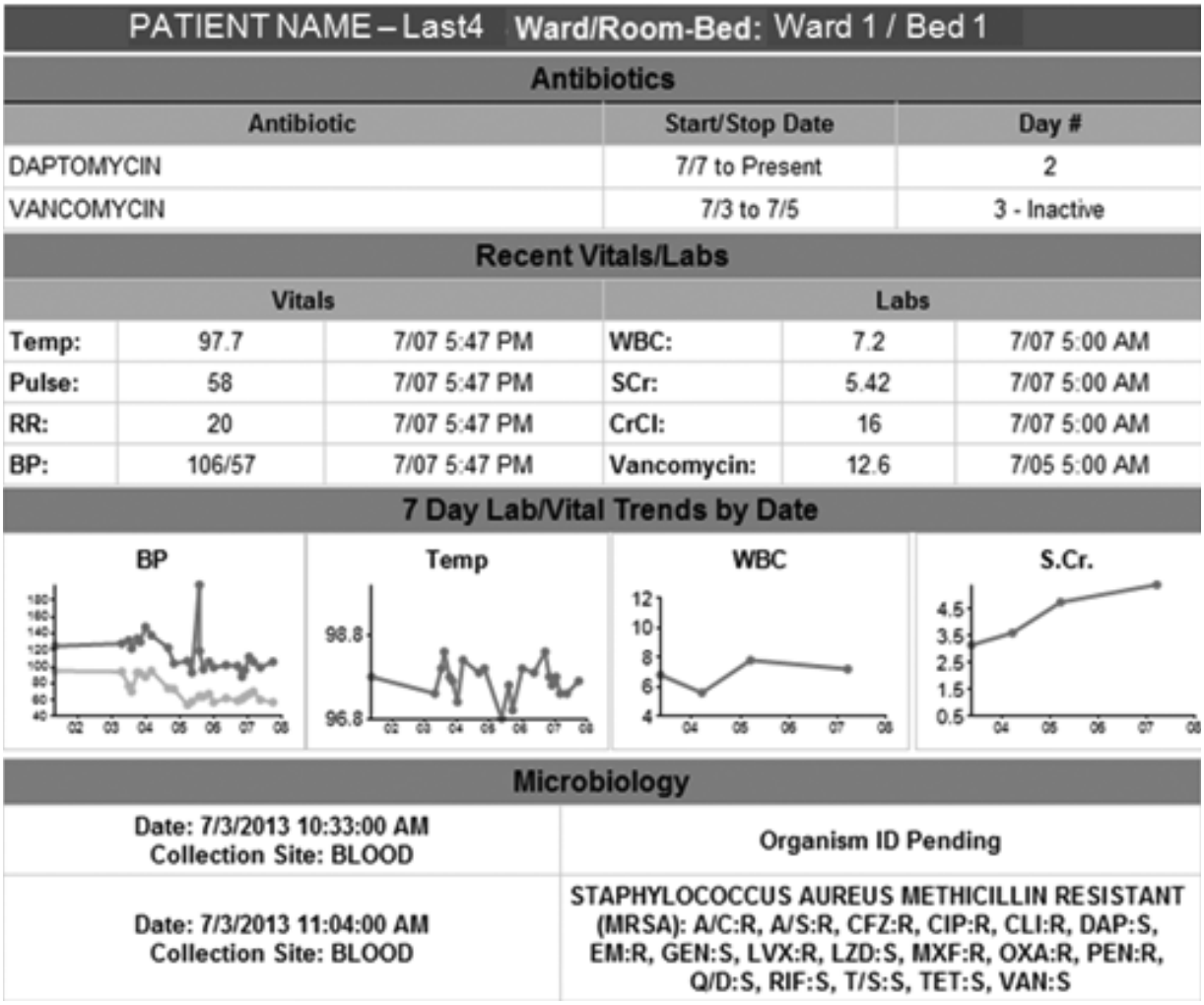

Figure A1. Electronic antimicrobial dashboard sample screenshot.

APPENDIX C

Educational and Social Marketing Campaign

The marketing component of the implementation used physician champions, multiple modes of education venues, and repetition to ensure house staff awareness and buy-in. The director of the antimicrobial stewardship program (C.J.G.) gave a Grand Rounds lecture to Department of Medicine faculty, house staff, and students 4 months prior to launch that focused on the importance of antimicrobial stewardship and made the case for a time-out intervention. Follow-up talks were also given at Medicine faculty meetings and morning reports in the weeks leading up to the initial vancomycin time-out launch and continued prior to subsequent expansion to piperacillin-tazobactam time-outs and inclusion of the medical intensive care unit. Immediately prior to the launch of vancomycin and piperacillin-tazobactam time-outs in the surgical intensive care unit (SICU), the medical director of the SICU and the house staff rotating on the service were given a tutorial on how the time-out approval process works. Immediately prior to launch in any new floor/unit, small notes were posted on computer screens in the house staff team rooms of that floor/unit detailing instructions on the time-out approval process, and flyers were posted on team room walls that encouraged de-escalation of vancomycin and piperacillin-tazobactam in the proper clinical settings

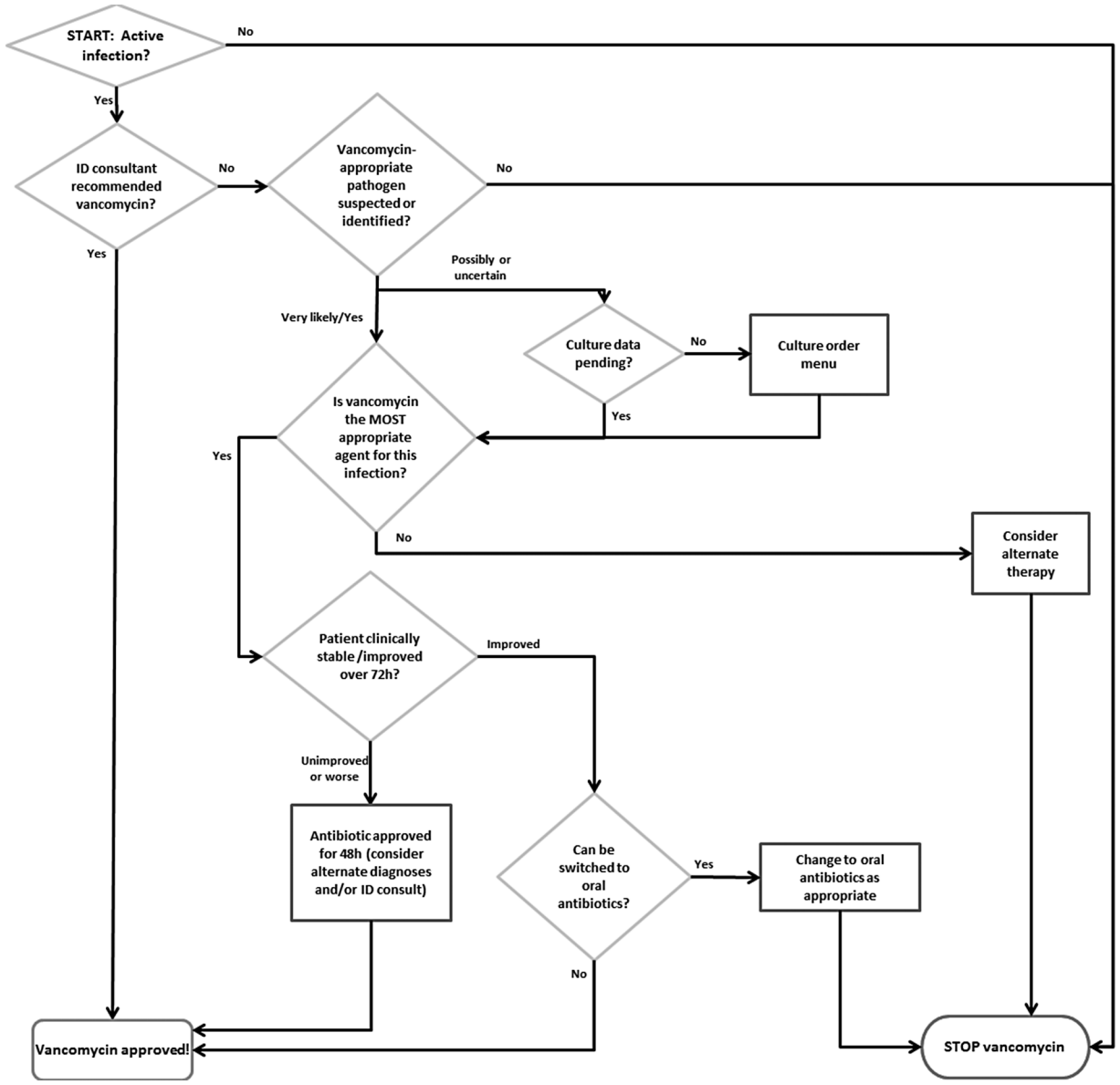

Figure B1. Antibiotic time-out approval template logic. Vancomycin is used as an example; piperacillin-tazobactam time-outs are similar. ID = infectious diseases.

and reinforced guidelines on when conversion from intravenous to oral antibiotic therapy was indicated. Clinical pharmacists were also briefed and updated as necessary as the time-out intervention was introduced and expanded. Pre-existing antibiotic order templates within the electronic medical record were updated with descriptions of the time-out renewal protocol, and links were embedded within these order sets to the electronic antimicrobial dashboards. With the beginning of the new academic year in July 2013, the antimicrobial stewardship program director gave a lecture to new house staff regarding the importance of antimicrobial stewardship that highlighted the antibiotic time-out intervention. Pocket cards were also distributed to house staff that detailed antibiotic stewardship policies, including the time-out.

Throughout the pre-implementation process of finalizing the electronic antimicrobial dashboards,

the time-out approval templates, and the educational materials, we relied on the input and feedback of 4 clinical champions of the project: 2 internal medicine hospitalists, a pulmonary/critical care intensivist, and a surgeon. These clinical champions were also involved in advertising the program to their colleagues, in eliciting further feedback, and in helping to arrange for qualitative evaluations of the antibiotic time-out program.

APPENDIX D
System Usability Survey

Instructions: The purpose of this survey is to evaluate the Antibiotic Renewal Program for vancomycin and for piperacillin/tazobactam. The program has 3 components. The *dashboard* displays patient specific data to help support the antibiotic renewal decision and ordering; the *template* structures and guides the self-approval process to create a note. In addition, there are links to *educational content* on antibiotic ordering.

Have you used any of the components of the Antibiotic Renewal Program? Yes No
If you answered No, STOP.
If you answered "Yes," then please circle the number that best reflects your feelings about using the Antibiotic Renewal Program. There are 3 sections: the dashboard, the template, and the educational content.

---

1. I found the *informational dashboard* to be [from disagree strongly (1) to agree strongly (7)]:

Easy to use. ___
Easy to access. ___
Well integrated into my workflow. ___
Accurate about my patient's data. ___
Awkward to use. ___
Internally inconsistent. ___
Helpful in decision making. ___
Easy to learn. ___
Comprehensive and complete. ___
Unnecessarily complex. ___
A program I intend to use frequently. ___

Comments _____
_____
_____
_____

2. I found that using the *templates* for self-approval [from disagree strongly (1) to agree strongly (7)]:

Made ordering renewals more difficult than calling someone for approval. ___
Increased my feelings of autonomy. ___
Increased my workload. ___
Decreased my confidence about decisions regarding antibiotics. ___
Improved discussions about antibiotic use during rounds. ___
Decreased conflict with pharmacist. ___
Increased the likelihood of making a good antibiotic ordering decision. ___
I intend to use the templates for self-approval frequently. ___

Comments _____
_____

3. Have you ever used the Antibiotic Informational Online *educational content?* Yes No

If No, STOP. If Yes, please circle the number that best reflects your opinion.
I found the Antibiotic Informational Online *educational content* to be [from disagree strongly (1) to agree strongly (7)]:
Easy to use. ___
Easy to access. ___
Unnecessarily complex. ___
Useful in everyday practice. ___

Comments _____
_____

4. Overall, based on your experience, the entire Antibiotic Renewal Program is:

Undesirable	1	2	3	4	5	6	7	Desirable
Negative	1	2	3	4	5	6	7	Positive
Not at all helpful	1	2	3	4	5	6	7	Very helpful