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## Concise Communication

# The impact of a blood-culture diagnostic stewardship intervention on utilization rates and antimicrobial stewardship

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### Abstract

Blood-culture overutilization is associated with increased cost and excessive antimicrobial use. We implemented an intervention in the adult intensive care unit (ICU), combining education based on the DISTRIBUTE algorithm and restriction to infectious diseases and ICU providers. Our intervention led to reduced blood-culture utilization without affecting safety metrics.

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Diagnostic stewardship promotes appropriate, timely diagnostic testing to guide safe and efficient patient care.[1] In the intensive care unit (ICU) setting, excessive testing for bacteremia in patients with a low probability of disease can lead to overdiagnosis and unnecessary treatments.[2] However, specific guidelines on when to obtain initial or follow-up blood cultures are limited, resulting in inconsistent blood-culture utilization.[3]

Fabre et al[3,4] developed and implemented the DISTRIBUTE (DIagnostic STewaRdship Improves Blood CUlTurEs) intervention to guide decision making regarding indications for blood culture based on pretest probability (Appendix online). Following the intervention, blood-culture utilization rates decreased and blood-culture positivity increased significantly in both the medical ICU and general medicine units.[4]

We designed a comprehensive approach integrating education and restriction[5] to improve blood-culture utilization in medical (MICU) and surgical (SICU) ICUs. We assessed the impact of this multifaceted intervention on appropriate blood-culture ordering practices and patient outcomes.

## Methods

The study was performed at a 600-bed quaternary medical center in Houston, Texas. The preimplementation period was from October 2020 through March 2021, the washout period for intervention implementation was April 2021, and the post-implementation period with restriction was from May 2021 through October 2021. This study was approved by our institutional review board.

We adopted the DISTRIBUTE blood-culture algorithm (Appendix online) to guide decision making for blood-culture ordering.[3,4] In April 2021, education was provided to ICU and infectious disease (ID) physicians on the algorithm through 2 in-person lectures (1 hour each), along with printed handouts and a shared online link to the algorithm. From May 2021 through October 2021, a restriction policy was established among ICU units to limit accepted orders to only ID and ICU providers.

The study outcomes included blood culture utilization per 1,000 patient days, blood culture positivity (%), antimicrobial days of therapy (DOT) per 1,000 days present, antimicrobial length of therapy (LOT) per 1,000 days present, 30-day hospital readmission, and 30-day ICU mortality.

The incidence rate ratio (IRR) was calculated to compare blood-culture utilization rates per 1,000 patient days, DOT per 1,000 days present, and LOT per 1,000 days present before and after the intervention. The Pearson $\chi^2$ test was used to compare the pre- and postintervention blood-culture positivity percentages.

We fit 2 Cox proportional-hazards models to evaluate the balancing metrics of 30-day mortality and 30-day hospital readmission. Based on the literature review, several factors were assessed for model inclusion, including study period, age, sex, severe acute respiratory coronavirus virus 2 (SARS-CoV-2) status, blood culture category, ICU location, and length of stay, among others. A *P* value of .05 was considered statistically significant. R version 4.2.2 (R Foundation for Statistical Computing, Vienna, Austria) was used for statistical analyses.

## Results

In total, 6,303 patients (2,087 MICU and 3,636 SICU patients) were included in the study. After the intervention, total blood-culture utilization rates decreased from 154.29 to 124.20 per 1,000 days present (IRR, 0.80; 95% CI, 0.76–0.85) (Fig. 1).

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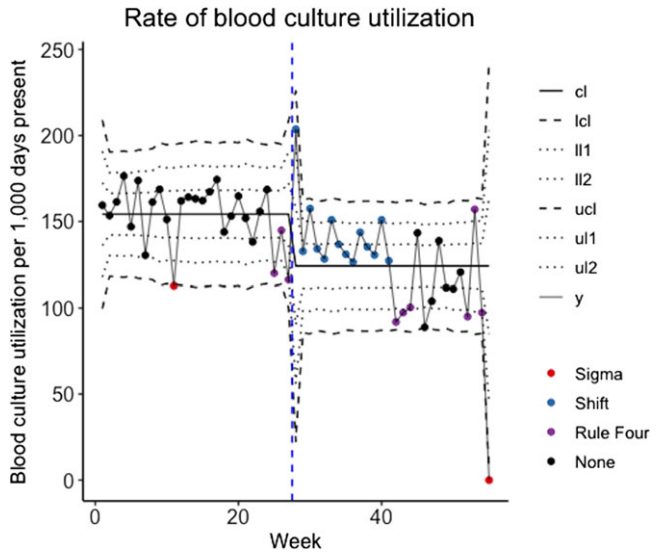


**Figure 1.** Rate of blood-culture utilization across the study periods. *U*-chart (control) for the rate of blood-culture utilization per 1,000 days present (y-axis) over the study period (x-axis). The blue dashed line represents the start of the intervention (week 28).

We did not detect a difference in blood culture positivity between the preintervention group (11.05%) and the postintervention group (11.64%; $P = .498$). Blood-culture positivity rates were 11.91% and 11.97% in the MICU ($P = 1.0$), respectively, compared to 10.47% and 11.44% in the SICU ($P = .376$).

Antimicrobial DOT decreased significantly following the intervention from 1,175.45 per 1,000 patient days to 1131.43 (incidence rate ratio [IRR], 0.96; 95% confidence interval [CI], 0.95–0.98) (Fig. 2). In the MICU, the DOT was similar across the 2 groups: 1,000.39 in the preintervention group and 982.88 in the postintervention group (IRR, 0.98; 95% CI, 0.95–1.02). In the SICU, however, the DOT decreased from 1,265.80 to 1,203.28 (IRR, 0.95; 95% CI, 0.93–0.97). Similarly to DOT, LOT decreased from 601.63 per 1,000 patient days before the intervention to 578.63 after the intervention (IRR, 0.96; 95% CI, 0.94–0.99) (Fig. 2).

Moreover, 798 patients (12.67%) were readmitted within 30 days. Factors associated with lower rates of 30-day hospital readmission were no history of solid program transplantation (vs transplantation history; $P < .001$), positive SARS-COV2 during admission (vs negative; $P < .001$), no blood culture (vs negative; $P = .03$), stay in both the MICU and SICU (vs SICU alone; $P < .001$), and the number of negative blood cultures during admission ($P < .001$). The intervention did not affect 30-day hospital readmission ($P = .888$).

In addition, 595 patients (9.44%) died within 30 days, and 30-day mortality was associated with increased age ($P < .001$), positive SARS-COV-2 during admission (vs negative; $P < .001$), no SARS-COV2 testing during admission ($P < .001$), positive blood culture (vs negative; $P = .001$), stay in MICU alone (vs SICU alone; $P < .001$), and antimicrobial days of therapy per days present ($P < .001$). Also, 30-day mortality was lower in patients with a history of solid organ transplantation ($P < .001$), no blood culture ($P < .001$), number of negative blood cultures during admission ($P = .045$), and longer length of stay ($P < .001$). The intervention did not affect 30-day mortality ($P = .241$).

## Discussion

Our findings showed that a multifaceted intervention could effectively reduce the proportion of inappropriate blood cultures in

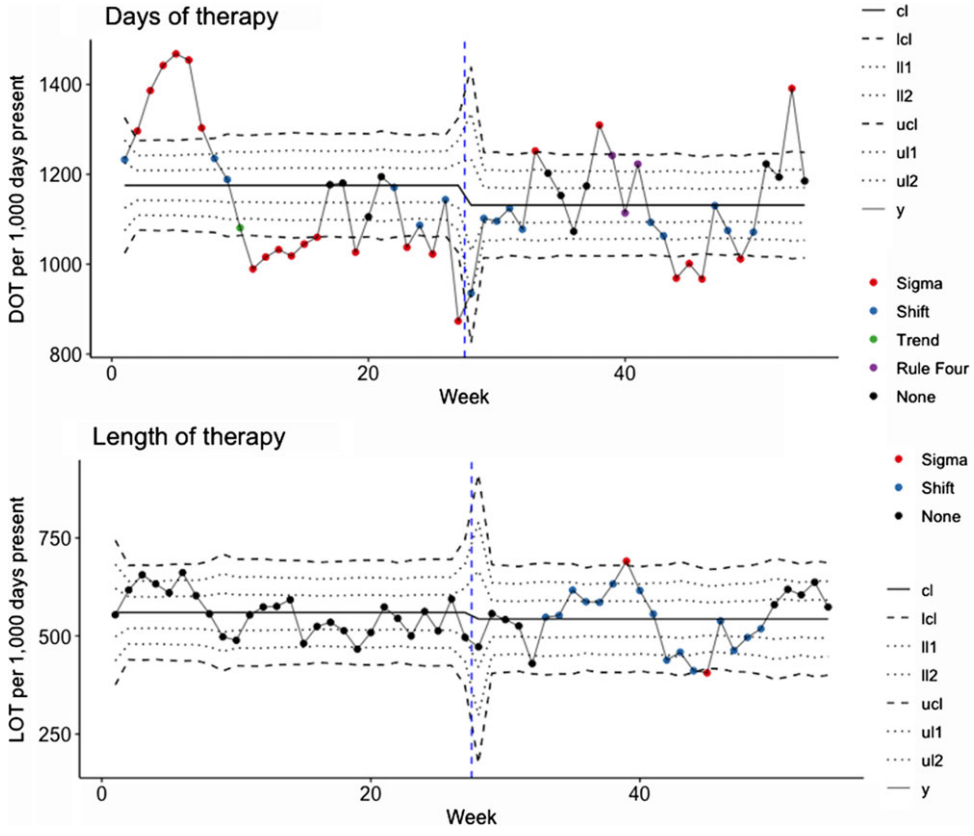


**Fig. 2.** Days of therapy (DOT) and length of therapy (LOT) across the study periods. *U*-chart (control) for the rate of DOT (top) and LOT (bottom) per 1,000 days present over the study periods (x-axis). The blue dashed line represents the start of the intervention (week 28).

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the ICU setting. Our MICU blood-culture utilization rate of 140–180 per 1,000 patient days was relatively lower than the 220–270 rates reported by Fabre et al.[4] In their study, 24% of initial blood cultures were inappropriate in the MICU. In a subsequent study of blood-culture appropriateness in the ICU setting, 61.4% were inappropriate.[6] We did not assess the appropriateness of blood cultures ordered, which could have helped delineate discrepancies across different institutions.

Although Fabre et al. reported an increase in blood-culture positivity from 8.1% to 11.5%, we did not observe a difference in positivity. It is possible that the intervention did not accurately select patients with a higher positivity yield. Another possibility is that the proportion of contaminants was greater in the preintervention period. Identifying and comparing contamination rates across the study periods would have clarified whether the intervention had correctly identified patients requiring blood-culture collection. However, our balancing metrics did not indicate a negative impact on patient outcomes.

To our knowledge, this is the first study to directly compare MICU and SICU blood-culture utilization and positivity rates, as well as DOT and LOT following a standardized blood-culture intervention. Although DOT and LOT decreased significantly in the SICU, both metrics remained relatively unchanged in the MICU. One explanation is that MICU providers already had higher rates of appropriate blood-culture use prior to the intervention. Surgical ICU patients have been reported to be 2–6 times more likely than MICU patients to have bacteremia, probably due to a greater number of invasive procedures.[7–9]

Our study had several limitations. We did not collect information on provider compliance with training. Also, we did not evaluate infectious disease physician or ICU provider opinions regarding the restriction policy, including unanticipated problems. With the study duration of 13 months, we did not consider seasonal variation, which could have manifested as varying fever or COVID-19 prevalence between the study periods. Our analyses would have been strengthened by extending the study period and evaluating which patients received antibiotics while febrile.

Furthermore, co-occurring ICU interventions may have confounded the intervention effects, including initial specimen diversion devices (implemented in the emergency department and 3 ICUs in May 2021), minocycline and rifampin-impregnated central catheters (in 2 ICUs starting April 2021), and hemodialysis antimicrobial catheter caps (in all inpatient units starting January 2021). Due to these ongoing initiatives, we did not include blood-culture contamination as a measure across intervention periods. Finally, the intervention was conducted in only 1 academic center, limiting the generalizability of our findings.

In conclusion, our findings have demonstrated the safety and effectiveness of implementing blood-culture education and restriction interventions across ICU services. Further research is needed to assess the safety of the intervention in other populations.

**Supplementary material.** To view supplementary material for this article, please visit https://doi.org/10.1017/ice.2023.265

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**Competing interests.** All authors report no conflicts of interest relevant to this article.

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## Appendix

DISTRIBUTE (DIagnostic STewaRdship Improves Blood CUlTurEs) Algorithm. Flowchart developed by Fabre et al for bacterial blood-culture recommendations in nonneutropenic patients, based on literature review evaluating blood-culture indications in common clinical scenarios.[3] Reproduced with permission from the original authors at https://doi.org/10.1093/cid/ciaa039, with the following caption and copyright information: "Algorithm for bacterial blood cultures recommendations in nonneutropenic patients. The algorithm is not a substitute for clinical judgment. *Blood culture required by US Centers for Medicare and Medicaid Services severe sepsis criteria of the Severe Sepsis and Septic Shock Early Management Bundle. †Blood cultures positive for *Candida* spp require routine follow-up blood culture (FUBCx). ‡Septic thrombophlebitis, infected endovascular thrombi, implantable cardioverter defibrillator (ICD)/pacemaker-lead infections, intravascular catheter infections, and vascular graft infections. §Consider > 2 sets for suspected endocarditis. ||Patients at risk of endovascular infection: ICD/pacemaker, vascular graft, prosthetic valves and prosthetic material used for cardiac valve repair, history of infective endocarditis, valvulopathy in heart transplant recipient, unrepaired congenital heart disease, repaired congenital heart disease with residual shunt or valvular regurgitation, or within the first 6 months postrepair. ¶Before ordering a blood cutlure, assess the patient's clinical history and perform a physical examination to identify infectious and noninfectious sources for the isolated fever episode and review the potential benefit added by the blood culture. £Prosthesis: joint or intravascular prosthesis. **Routine additional FUBCx for a single blood culture with skin flora (eg, coagulase-negative staphylococci) in an immunocompetent patient are not necessary unless bacteremia is suspected or a prosthesis is present. ††Cellulitis in patients with comorbidities: immunocompromised hosts or those at risk of poor outcomes from sequelae from missed Staphylococcus aureus bacteremia. Note. CAP, community-acquired pneumonia; HCAP, healthcare-associated pneumonia; PSI, Pneumonia Severity Index; *S. aureus*, *Staphylococcus aureus*; *S. lugdunensis*, *Staphylococcus lugdunensis*; UTI, urinary tract infection; VAP, ventilator-associated pneumonia; VO, vertebral osteomyelitis. Unless provided in the caption above, the following copyright applies to the content of this slide: ©The Author(s) 2020. Published by Oxford University Press for the Infectious Diseases Society of America. All rights reserved. For permissions, e-mail: journals.permissions@oup.com. This article is published and distributed under the terms of the Oxford University Press, Standard Journals Publication Model (https://academic.oup.com/journals/pages/open_access/funder_policies/chorus/standard_publication_model)."

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