Infection Control & Hospital Epidemiology (2026), **47**, 334–341
doi:10.1017/ice.2026.10421

SHEA

Original Article

Optimization of vancomycin use in hospitalized patients with pneumonia through implementation of informatics based antimicrobial stewardship program (ASP) intervention

Ashlesha Kaushik MD, MS[1], Brittany Esty MD, MPH, CPPS[2], Corey Thieman PharmD[3], Susannah Kisvarday MD, MPH[4], Bijay Acharya MD, MPH[5], Dionne Graham PhD[6], Michael Padomek PharmD[3], Chakri Pureti MD[7] and Sandeep Gupta MD[8]

[1]Pediatric Infectious Diseases; Pediatrics, UnityPoint Health and University of Iowa Carver College of Medicine, Sioux City, USA; [2]Immunology, Boston Children's Hospital, Boston, USA; [3]Pharmacology, UnityPoint Health, Sioux City, USA; [4]Clinical Informatics, Harvard Medical School, Boston, USA; [5]Medicine, Clinical Informatics and Patient Safety, Harvard Medical School, Boston, USA; [6]Evaluation & Analytics, Boston Children's Hospital, Boston, USA; [7]Medicine, UnityPoint Health, Sioux City, USA and [8]Pulmonary and Critical Care, UnityPoint Health, Sioux City, USA

Abstract

Objective: Vancomycin overuse in pneumonia should be a key target for antimicrobial stewardship according to Centers for Disease Control and Prevention. High negative predictive value of nasal Methicillin Resistant Staphylococcus aureus (MRSA) polymerase chain reaction (PCR) (nMP) screening for pneumonia has been shown. We implemented informatics-based ASP intervention to reduce vancomycin use in pneumonia by 20% in 6 months.

Design: Quasi-experimental: Pre-intervention period (P1: 4/1/24–9/30/24) compared with post-intervention period (P2: 10/15/24–3/15/2025).

Setting: Quality improvement (QI) initiative in a tertiary-care center in Upper Midwest.

Patients: Hospitalized pneumonia patients.

Interventions: Automated default nMP order was incorporated in pneumonia order-set in electronic medical record while ordering vancomycin for hospital acquired/ventilator associated pneumonia, severe community acquired pneumonia.

Results: Outcome measures declined significantly: Average vancomycin use density as reported with days of therapy (DOT)/1,000 patient days decreased by 49.5% (from 72.2 DOT/1,000 patient days in P1 to 36.3 DOT/1,000 patient days in P2; $p < .0001$). Average vancomycin drug inventory cost decreased by 50% (from 1,089.5 U.S. Dollars (USD)/1,000 patient days in P1 to 546.3 USD/1,000 patient days in P2; $p < .0001$). All process measures showed significant changes: nMP ordering increased to 100% in P2 ($p < .0001$); proportion of pneumonia patients with negative PCR results with discontinuation of vancomycin within 48–72 hours increased to 71% ($p < .0001$) and time to vancomycin discontinuation declined by 46% ($p < .001$). Balancing measures (readmissions; nMP order-to-result time) remained unchanged.

Conclusions: Informatics-based ASP intervention was transformative leading to significant decline in vancomycin utilization, considerable healthcare-cost savings and significant increase in nMP screening among pneumonia patients.

(Received 22 October 2025; accepted 7 February 2026; electronically published 9 March 2026)

Introduction

According to the Centers for Disease Control and Prevention (CDC), broad-spectrum agents including vancomycin should be important targets for antimicrobial stewardship program (ASP) interventions.[1,2] These interventions are essential to prevent emergence of multi-drug-resistant organisms (MDROs).[3–6] It is estimated that over 2.8 million MDROs occur annually in the United States (U.S.), entailing substantial patient harm, and contributing to more than $4.6 billion in health-care costs.[1,7]

Vancomycin is recommended for hospital acquired pneumonia (HAP), ventilator associated pneumonia (VAP) and severe community-acquired pneumonia (CAP) with risk factors for MRSA, defined as isolation of MRSA in past year or hospitalization with intravenous antibiotic use within 90 days.[8,9] Vancomycin overuse can lead to increased patient safety risks and adverse effects including renal failure.[10] Nasal MRSA PCR (nMP) screening has been shown to reduce vancomycin use[11–14] and studies have shown

Corresponding author: Ashlesha Kaushik; Email: ashleshakaushik@gmail.com

Prior Presentation: Poster Presentation "Significant decline in Vancomycin Use and cost of therapy in Patients with Pneumonia with QI Informatics-based Antibiotic Stewardship Program (ASP) Interventions" Infectious Disease Week Conference, Atlanta, GA (October 2025).

Cite this article: Kaushik A, Esty B, Thieman C, *et al.* Optimization of vancomycin use in hospitalized patients with pneumonia through implementation of informatics based antimicrobial stewardship program (ASP) intervention. *Infect Control Hosp Epidemiol* 2026. 47: 334–341, doi: 10.1017/ice.2026.10421

© The Author(s), 2026. Published by Cambridge University Press on behalf of The Society for Healthcare Epidemiology of America.

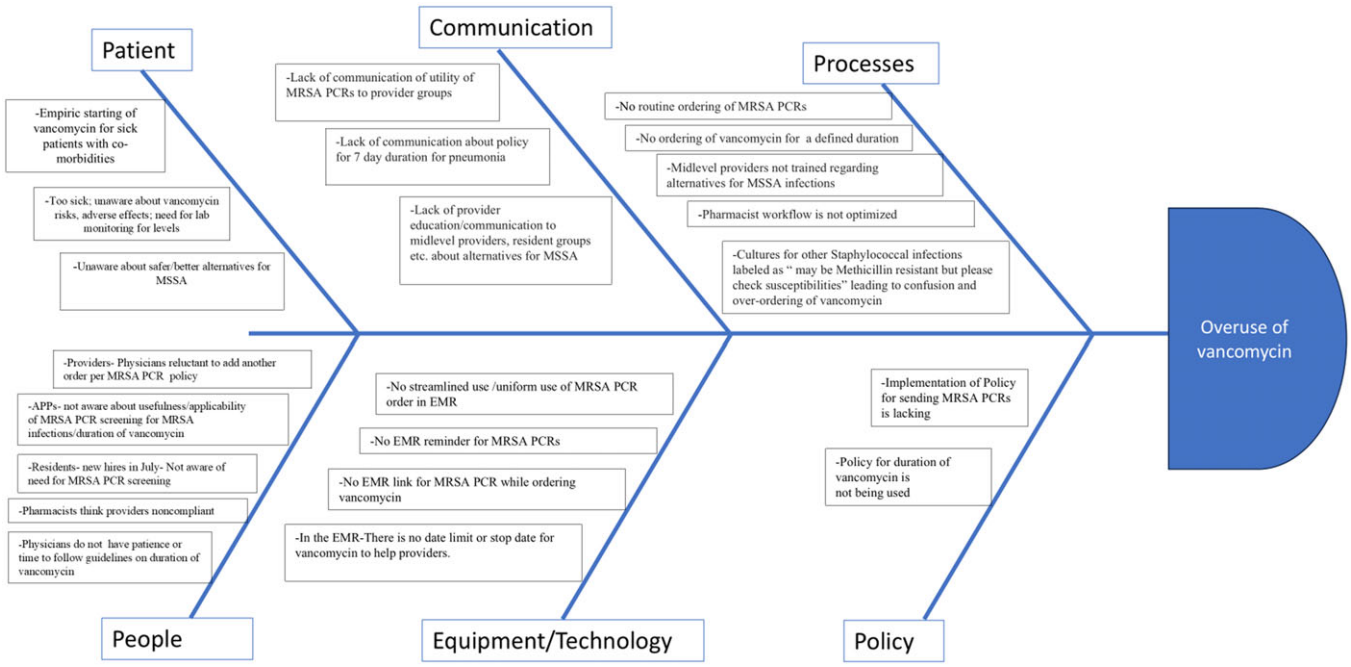


Figure 1. Fishbone (cause effect) diagram.

a high negative predictive value of nMP for pneumonia.[9,14,15] It has also been shown to be cost-effective[16,17] thus providing an opportunity for early discontinuation of vancomycin.

The average vancomycin use density for pneumonia in our regional hospital was at 72 days of therapy [DOT]/1,000 patient days which was higher than other regional affiliates (average 45 DOT/1,000 patient days). Baseline data showed vancomycin use to be the highest among hospitalized pneumonia patients (42% [40/95]) admitted to the intensive care unit (ICU) and floors (Supplementary Figures 1A and 1B). nMP tests were infrequently ordered and vancomycin overuse was associated with additional financial costs as well.

Given the large percent of vancomycin use in pneumonia, this quality improvement (QI) project was conducted with the aim to decrease vancomycin use in hospitalized pneumonia patients by 20% at our tertiary-care center in 6 months.

Methods

Context

Our healthcare system (a 180-bed tertiary-care hospital with 24 ICU beds) in Northwestern Iowa is among the largest tertiary-care centers catering to underserved populations in the Upper Midwest. We selected stakeholders for this QI initiative including antimicrobial stewardship team (composed of pharmacist ASP lead, pharmacy director, chief medical officer, chief nursing officer, chief hospitalist, chief of critical care, microbiology director), pharmacy staff, information technology (IT) informaticist and front-line providers. Current state information was collected by observation of pneumonia order-set with special attention to computerized physician order entry system for vancomycin and nMP orders in electronic medical record (EMR, Epic). Interviews (*going to Gemba ie interaction with frontline personnel*) and focus-groups involving 15 providers and staff were conducted.

Discussions with stakeholders led to the preintervention process map (Supplementary Figure 2). Vancomycin was only used for pneumonia patients categorized as HAP, VAP or severe CAP as designated by the admitting clinicians. In our system, use of pneumonia order-set is ~ 99% to order antibiotics for patients in whom severe CAP, HAP/VAP is suspected. The admitting clinicians designated patients to have HAP/VAP or severe CAP based on their clinical presentation/course and had to preselect the designations according to the definitions provided in the pneumonia order-set to be able to order vancomycin as vancomycin was only indicated for these categories of pneumonia per the order-set. Only those pneumonia patients designated as HAP/VAP or severe CAP in pneumonia order-set received vancomycin.

Once vancomycin was ordered in the order-set, an assigned pharmacist followed all orders for vancomycin. Preintervention, nMP ordering was not contained within the pneumonia order-set and had to be ordered separately. The overall rate of ordering nMPs was low (ordered in only 13% [5/40] pneumonia patients receiving vancomycin in April 2024). When nMP (Xpert® MRSA NxG [Cephid, Sunnyvale, CA]) was ordered, the swab was collected, processed in the lab with results available within 24–48 hours. Patients colonized with MRSA underwent decolonization according to guidelines.[18] If nMP was ordered by the provider, the assigned pharmacist followed up on the results: if negative, the pharmacist notified the primary team to discontinue vancomycin by a sticky note in the EMR. For all nMPs sent at baseline, sticky notes were placed for all of the negative results; however, nMPs were not being routinely ordered.

While assessing contributing factors for vancomycin overuse, we found that despite our pharmacy MRSA policy requiring nMP for pneumonia, they were rarely ordered. Frontline providers reported that the biggest gap was lack of guidance or direction for ordering nMP in pneumonia order-set. Many advanced practice providers and new residents were unaware of application of nMP in pneumonia. Based on these activities, we developed a fishbone/cause effect diagram as shown in Figure 1. Additionally, during the 15 interviews and focus-groups, frontline personnel completed check-boxes highlighting factors contributing to high vancomycin

https://doi.org/10.1017/ice.2026.10421 Published online by Cambridge University Press

Table 1. Outcome, process and balancing measures

Category	Measure	Calculation	Variable	SPC chart
Outcome measures	Vancomycin use density for pneumonia (HAP, VAP, severe CAP)	Average days of therapy (DOT) for vancomycin (numerator)/1,000 patient days for pneumonia (HAP,VAP, severe CAP) (denominator)	Continuous	SPC chart-XmR
	Average vancomycin related inventory cost per 1,000 patient days for pneumonia	Average vancomycin drug inventory cost in USD (numerator)/1,000 patient days for pneumonia (HAP,VAP, severe CAP) (denominator)	Continuous	SPC chart-XmR
Process measures	Proportion of patients hospitalized with pneumonia [HAP, VAP, severe CAP] that had nMP tests ordered	Number of nMP tests ordered (numerator)/number of patients hospitalized with pneumonia (HAP, VAP, severe CAP) receiving vancomycin (denominator)	Continuous	SPC chart-p chart
	Proportion of pneumonia patients with negative MRSA PCR results with discontinuation of vancomycin within 48–72 h	Number of negative PCRs with discontinuation of vancomycin within 48–72 h (numerator)/number of patients hospitalized with pneumonia (HAP, VAP, severe CAP) (denominator)	Continuous	SPC chart-p chart
	Time to discontinuation of vancomycin in patients hospitalized with pneumonia (HAP, VAP, severe CAP)	Average number of hours from vancomycin initiation to vancomycin discontinuation	Continuous	SPC chart - XmR
	Time to discontinuation of vancomycin from negative nMP result in patients hospitalized with pneumonia (HAP, VAP, severe CAP)	average number of hours from negative nMP result to vancomycin discontinuation	Continuous	SPC chart - XmR
Balancing measures	Time from nMP order to nMP result	Average number of hours from nMP order to nMP result	Continuous	SPC chart-XmR
	Readmission rates within 30 d ie No. of readmissions within 30 d with a diagnosis of pneumonia	Number of patients readmitted within 30 d (numerator)/ no. of patients discharged with diagnosis of pneumonia (HAP, VAP, severe CAP)(denominator)	Continuous	SPC chart-XmR

use and data was collected, collated and assessed through Pareto chart (Supplementary Figure 3). Vancomycin overuse was related with lack of ordering nMP due to difficulty/not remembering to order nMP.

Upon thorough review of the current state, a key driver diagram was constructed (Supplementary Figure 4).

Intervention

As a team, we created an impact-effort matrix and prioritized interventions to optimize vancomycin use. Based on our policy, as informed by guidelines,[8,9] we agreed to add default nMP order in pneumonia order-set when vancomycin is selected for treatment of patients with HAP/VAP or severe CAP. Adding default nMP to the pneumonia order-set would be a relatively low-effort but highly impactful intervention as it would affect ordering providers uniformly across the hospital, and would be permanent. This change would align with Nielson's heuristic principles as reliance on provider recall would be eliminated[19] and meet criteria for "5 Rights" of clinical decision support (*right information, to the right person, in the right intervention format, through the right channel, at the right time in workflow*).[20,21]

Auto-checked nMP order in order-set for HAP/VAP went live on 10/7/24 and the pilot was observed to be smoothly functioning in terms of the workflows. After HAP/VAP was successfully piloted as observed by rounding on floors, ICUs, pharmacy and microbiology lab, we implemented the default nMP order for severe CAP category of pneumonia order-set on 11/4/24. The new auto-checked nMP order in pneumonia order-set for HAP/VAP and CAP is shown in Supplementary Figures 5A and 5B. There were extensive discussions with stakeholders and education for providers. After implementation, qualitative interviews of frontlines and plan-do-study-act cycles were undertaken to discern changes needed to address any discrepancies/unexpected observations.

Measures

The outcome, process and balancing measures are presented in Table 1.

Cost analysis

The cost analysis was based on average wholesale price (AWP) of both injectable vancomycin and 0.9% sodium chloride sterile compounding fluids ($7.53/dose). This value was multiplied by 2, the average number of vancomycin doses given in a 24-hour period of time and then multiplied by our days of therapy/1,000 patient days value to determine inventory cost of therapy in USD (U.S. dollars)/1,000 patient days. For surveillance costs, MRSA PCR cost was determined using laboratory's cost of the nMP test ($30.24/test) multiplied by the number of tests that were administered in the observed time period, divided by patient days, and the value was expressed as cost of tests in USD/1,000 patient days.

Data analysis

We conducted a quasi-experimental study using a pre and post study-design to compare the measures between preintervention period (P1: 4/1/24 to 9/30/24) and postintervention period (P2: 10/15/24–3/15/25).

Data was analyzed using Microsoft Excel (Microsoft, Richmond, WA) and statistical process control (SPC) charts were used for display and analysis of data. Table 1 details types of SPC charts used for the measures. QI Macros SPC Software for Excel 2023 (KnowWare International, Inc., CO) was used to create SPC charts and significance/sustained shift was defined per SPC rules of

https://doi.org/10.1017/ice.2026.10421 Published online by Cambridge University Press

significance.[22] These rules help differentiate special cause variation that signals change from common cause variation, ie occurring randomly or by chance.[22] Additionally, comparisons for continuous variables were performed by *t*-tests and for proportions by Chi-square (χ^2) or Fisher exact test, where applicable, with a *P*-value of <.05 considered statistically significant.

This project was conducted according to local institutional standards for QI initiatives; therefore, IRB approval was not obtained. We followed Standards for Quality Improvement Reporting Excellence (SQuIRE) guidelines for reporting.

Results

During P1, a total of 239 patients with pneumonia (20 [8%] with HAP/VAP and 219 [92%] with severe CAP) received vancomycin, while during P2, a total of 281patients with pneumonia (19 [7%] with HAP/VAP and 262 [93%] with severe CAP) received vancomycin.

Postintervention, the outcome measures (vancomycin utilization and cost of therapy) showed a significant decline. There was a significant and sustained decrease in vancomycin use density as shown in the X chart and the phase analysis (Figure 2(A)). The average vancomycin use density decreased from 72.2 days of therapy (DOT)/1,000 patient days to 36.3 DOT/1,000 patient days postintervention ($P < .0001$).

The average vancomycin drug inventory cost decreased from 1,089.5 USD/1,000 patient days in P1 to 546.3 USD/1,000 patient days in P2 ($P < .0001$) and the new process was sustained and in control (Figure 2(B)). The average vancomycin drug inventory cost decreased by 50% with net vancomycin drug inventory cost savings of 543.20 USD/1,000 patient days.

The average surveillance cost denoted by average nMP test cost/1,000 patient days, increased from 42 USD/1,000 patient days in P1 to 419.6 USD/1,000 patient days in P2, increasing by 377.6 USD/1,000 patient days. Taking into account mean surveillance costs, the net average cost savings were 165.6 USD/1,000 patient days solely in vancomycin drug inventory costs.

All process measures showed significant changes. The average number of nMP tests ordered in hospitalized patients with pneumonia receiving vancomycin increased from 13% (31/239) in P1 to 87% (37/43) after the first intervention and to 100% (238/238) after second intervention (Figure 3) ($P < .0001$). After implementing the default nMP order in pneumonia order-set for HAP/VAP category on 10/7/24, we observed that nMP ordering increased for HAP/VAP patients and to some extent for CAP patients possibly due to Hawthorne effect of rounding after implementation. Once we implemented the default order for severe CAP category on 11/4/24, the nMP orders showed a significant and sustained increase to 100%. The proportion of pneumonia patients receiving vancomycin with a negative nasal MRSA PCR result that had vancomycin discontinued within 48–72 hours increased significantly (Supplementary Figure 6A), with the average increasing from 8% (20/239) in P1 to 71% (200/281) in P2 ($P < .0001$). Overall, this was also the proportion of all patients with pneumonia that had vancomycin discontinued within 48–72 hours (8% in P1 compared to 71% in P2). All patients that had vancomycin discontinued within 48–72 hours had a negative nMP. With the proportion of increased nMP testing in P2, the discontinuation rates within 48–72 hours also increased significantly from P1 to P2.

The average number of hours of vancomycin therapy, i.e., vancomycin initiation to vancomycin discontinuation in patients with pneumonia declined significantly (Supplementary Figure 6B) from mean of 122.4 (±6.1) hours during P1 to mean of 66.4 (±9.5) hours in P2 ($P < .001$). The time to discontinuation of vancomycin from negative nMP results showed a sustained decrease in P2 (supplementary Figure 6C), with the average number of hours decreasing from 117 (±5.4) hours in P1 to 52.9 (±7.2) hours during P2 ($P < .0001$).

There were no special causes detected for balancing measures (supplementary Figures 7A and 7B). The turnaround time from nMP order to nMP results did not show any significant change (average of 24.3 and 24.1 hours during P1 and P2 respectively). Readmission rates among patients discharged with pneumonia within 30 days remained stable without any significant changes. The average readmission rates during P1 and P2 were 10.3 and 10.1 % respectively.

Qualitative interviewing of frontlines revealed smoothly running workflows and an overall positive attitude about this change.

Discussion

In this QI initiative, with engagement from stakeholders, we made significant improvement in reducing vancomycin utilization in pneumonia patients. Our outcome and process measures showed significant and sustained changes while our balancing measures remained unchanged.

Our primary outcome was vancomycin use density that decreased significantly by 49.5% postintervention. Thus, we were able to achieve more than our desired objective of 20% decrease stated in our aim.

Our secondary outcome was vancomycin drug inventory cost that also showed a significant decrease by 50% postintervention with net vancomycin drug inventory cost savings of 543.20 USD/1,000 patient days. The average surveillance cost increased by 377.6 USD/1,000 patient days. Taking into account mean surveillance costs, the net average cost savings were 165.6 USD/1,000 patient days solely in vancomycin drug inventory costs. Thus, this cost minimization analysis showed net cost savings. This was an underestimation as did not include overhead vancomycin costs, including close monitoring of vancomycin drug levels and additional vancomycin infusion costs. Added expense of MRSA testing was thus offset by savings from administering less vancomycin. Additionally, money saved by prevented MDRO infections as shown in the literature[16] would also justify the added expense of universal testing in pneumonia patients receiving vancomycin. Hence, overall, this was a cost-effective intervention, with estimated total cost savings projected to be around 40 million USD since intervention.

All of our process measures intended to gauge processes around ordering of nMP and discontinuation of vancomycin within 48–72 hours among pneumonia patients showed significant and sustained changes. Nasal MRSA PCR ordering reached 100% in P2. Among pneumonia patients receiving vancomycin, we were successfully able to discontinue vancomycin in the majority (71%) within 48–72 hours, compared to 8% preintervention. All patients that had vancomycin discontinued within 48–72 hours had a negative nMP test. With the proportion of increased nasal PCR testing in P2, the discontinuation rates within 48–72 hours increased significantly postintervention.

Postintervention, the average length of vancomycin therapy in pneumonia patients was noted to significantly reduce by 46% (from > 120 h in P1 to 66.4 h in P2). Our process measure of time from negative nMP results to discontinuation of vancomycin

https://doi.org/10.1017/ice.2026.10421 Published online by Cambridge University Press

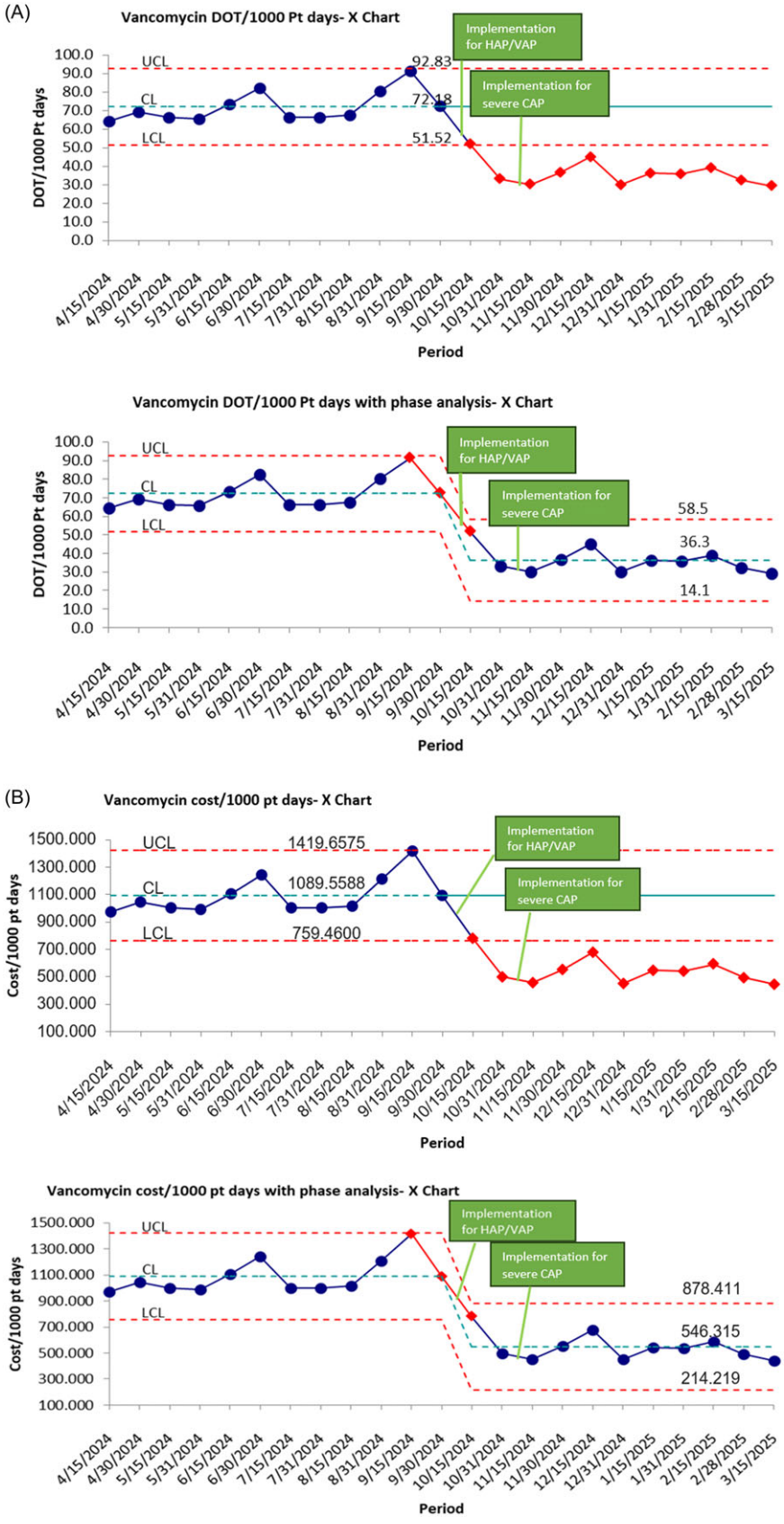


Figure 2. Significant and sustained decline in outcome measures (vancomycin utilization and cost of therapy for hospitalized pneumonia patients). (A) vancomycin use density. (B) cost of vancomycin drug inventory (USD)/1,000 patient days.

https://doi.org/10.1017/ice.2026.10421 Published online by Cambridge University Press

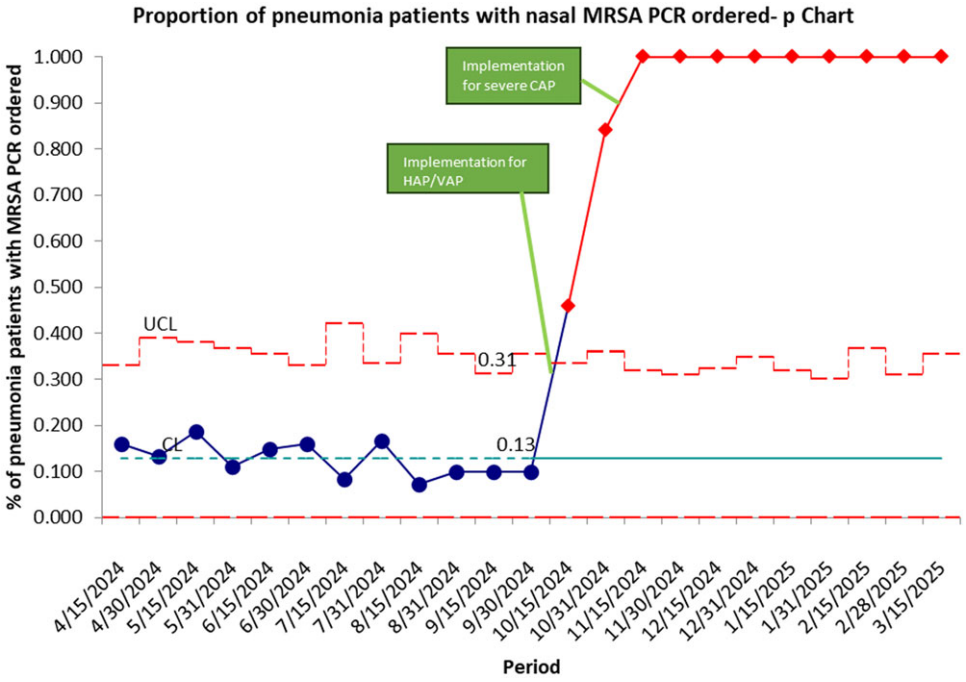


Figure 3. Proportion of hospitalized pneumonia patients who had nasal MRSA PCR tests ordered.

decreased significantly by 55% (from average of 117 to 52.9 h), showing improved provider compliance. The reasons for not discontinuing vancomycin in a few patients with negative nMPs were associated with provider clinical decision-making for vancomycin continuation for critically ill patients.

There were no special causes detected for balancing measures. Our balancing measure of 30-day readmission rates for patients discharged with pneumonia remained unchanged postintervention and interestingly, our 30-day readmissions were lower than reported data (our average readmission rates were around 10% compared to reported national average rates of 17%).[23] The other balancing measure of turnaround time from ordering of nMP to results was unchanged and was important to evaluate as we did not want the nursing staff or microbiology lab personnel to get overwhelmed after implementation. HAP/VAP admissions also remained low throughout the study period which is considered a desirable observation in accordance with expected standards for high quality healthcare.

While previous studies have explored impact of ASP efforts and evaluated the use of nasal MRSA PCR testing on vancomycin de-escalation,[4,5,11–17] our study distinguishes itself by use of standardized QI methodology focusing on applicability of informatics in ASP to optimize vancomycin use. To our knowledge, this is the first report utilizing informatics-based order-set changes for automated nMP tests to reduce vancomycin use that demonstrates application of forcing function/automation for ASP efforts. Our intervention of an automated order-set for nMP in Epic was able to effectively reduce vancomycin utilization with resultant cost savings. The prevalence of MRSA in the U.S. has shown varying trends[24] and MRSA prevalence at our healthcare facility is around 12.5%. Adoption of automated nMP testing with its high negative predictive value[9,14,15] was a cost-effective intervention for our institution and can be considered for implementation in other hospital systems.

The transformative, automated informatics-based intervention was one of the major strengths of our successful QI initiative. Through building an automated, preselected order-set for nMP in Epic, we were able to circumvent human factors, change behavior, and have an effective implemented intervention. Another strength was engaging the frontlines that led to a thorough understanding of the problem. Listening to the providers helped us in identifying their needs and creating an effective solution. Our teams worked well together and conducted plan-do-study-act cycles embodying the core principles of QI work. The new standardized process fit in our workflows and was favorably received by the frontlines. The automation eased the process for nMP ordering, while not adding any extra clicks for physicians or other providers. The project appealed to the rational and emotional side of the stakeholders and was aligned with Kotter's principles of change management.[25] This QI project provides an example of EMR automation aiding clinical tasks and supports previous studies showing applicability of informatics in improving workflows.[26]

Our study had limitations. We did not evaluate and are not aware of any indication shifting for vancomycin use. Another limitation is that pneumonia was presumed based on utilization of a pneumonia order-set; however, some patients may have had an alternative primary diagnosis, including heart failure, chronic obstructive pulmonary disease exacerbation or pulmonary embolism. Rates of order-set use vary across hospitals nationally[27,28] The high rate of order-set use in our single-center study may not reflect the practice across other hospitals and could have impacted vancomycin reduction. Data that could not be analyzed and needs evaluation in future studies includes length of hospitalization and acute kidney injury data.

To summarize, the uptake of our intervention was highly successful with percent of nMP tests ordered reaching 100% and vancomycin utilization for pneumonia declining by 49.5% with considerable cost savings. We were successfully able to discontinue vancomycin in the majority (71%) of pneumonia patients within 48–72 hours and the average duration of vancomycin therapy decreased by 46% postintervention.

In conclusion, the implementation of an automated default nMP order in pneumonia order-set in Epic led to 100% uptake in

https://doi.org/10.1017/ice.2026.10421 Published online by Cambridge University Press

nasal MRSA PCR ordering, resulting in significant decline in vancomycin use among hospitalized pneumonia patients. This automated informatics intervention was shown to be highly effective and transformative as a solution. Smooth implementation required collaboration, education and engagement of stakeholders at every step. This highly impactful intervention can be considered for wider application in streamlining antimicrobial stewardship efforts in other institutions and hospital systems.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/ice.2026.10421

Acknowledgments. We thank Anjala Tess, Katherine Santos, Jeffrey Durney, Erin Mothershead, Ashika Gupta, and Kendra Goeden for editing and technical support.

Author contributions. Concept and design: All authors. Acquisition, analysis, or interpretation of data: Kaushik, Gupta, Thieman, Padomek, Esty, Kisvarday, Acharya, Graham, Pureti. Drafting of the manuscript: Kaushik, Esty, Gupta, Thieman, Kisvarday, Acharya, Padomek, Graham, Pureti. Critical revision of the manuscript for important intellectual content: Kaushik, Esty, Gupta, Thieman, Kisvarday, Acharya, Padomek, Graham, Pureti. Administrative, technical, or material support: Kaushik, Esty, Thieman, Gupta, Padomek. Supervision: Kaushik, Esty, Gupta, Kisvarday, Acharya.

Financial support. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Competing interests. None of the authors have any financial disclosures or other conflicting relationships. The authors fully acknowledge and comply with the Journal's Conflict of Interest policy. All authors are aware of and in agreement with submission of this paper to *Infection Control & Hospital Epidemiology*.

References

1. Centers for Disease Control and Prevention. CDC: The CDC's Antimicrobial Resistance 465 report. https://www.cdc.gov/antimicrobial-resistance/data-research/threats/?CDC_AAref_Val=https://www.cdc.gov/drugresistance/biggest-threats.html. Accessed October 9, 2025.
2. Centers for Disease Control and Prevention. The Core Elements of Hospital Antibiotic Stewardship Programs. Atlanta, GA: US Department of Health and Human Services, CDC, 2019. https://www.cdc.gov/antibiotic-use/media/pdfs/hospital-core-elements-508.pdf. Accessed September 10, 2025.
3. Abdel Hadi H, Eltayeb F, Al Balushi S, Daghfal J, Ahmed F, Mateus C. Evaluation of hospital antimicrobial stewardship programs: implementation, process, impact, and outcomes, review of systematic reviews. *Antibiotics (Basel)* 2024;13:253. doi: 10.3390/antibiotics13030253
4. Papastergiou P, Tsioutis C, Mendris M. Implementation of a hospital antimicrobial stewardship program to improve vancomycin use in Cyprus: challenges and opportunity. *Infect Prev Pract*. 2022;4:100254. doi: 10.1016/j.infpip.2022.100254
5. Chiotos K, Fitzgerald JC, Hayes M, *et al.* Improving vancomycin stewardship in critically Ill children. *Pediatrics* 2022;149:e2021052165. doi: 10.1542/peds.2021-052165
6. Baroudi R, Flaugher M, Grace E, Zakria D. The importance of an antimicrobial stewardship program. *Fed Pract* 2015;32:20–24.
7. CDC Partners Estimate Healthcare Cost of Antibiotic-resistant Infections. 2025. https://www.cdc.gov/antimicrobial-resistance/stories/partner-estimates.html. Accessed September 10, 2025.
8. Kalil AC, Metersky ML, Klompas M, *et al.* Management of Adults With Hospital-acquired and Ventilator-associated Pneumonia: 2016 Clinical Practice Guidelines by the Infectious Diseases Society of America and the American Thoracic Society. *Clin Infect Dis* 2016; 63:e61–e111. Erratum in: Clin Infect Dis. 2017 May 1;64(9):1298. doi: 10.1093/cid/ciw799. Erratum in: Clin Infect Dis. 2017 Oct 15;65(8):1435. doi: 10.1093/cid/cix587. Erratum in: Clin Infect Dis. 2017 Nov 29;65(12):2161. doi: 10.1093/cid/cix759. PMID: 27418577; PMCID: PMC4981759.
9. Metlay JP, Waterer GW, Long AC, *et al.* Diagnosis and treatment of adults with community-acquired Pneumonia. An official clinical practice guideline of the American Thoracic Society and Infectious Diseases Society of America. *Am J Respir Crit Care Med* 2019;200:e45–e67. doi: 10.1164/rccm.201908-1581ST
10. Liu J, Tong SYC, Davis JS, Rhodes NJ, Scheetz MH, CAMERA2 Study Group. Vancomycin exposure and acute kidney injury outcome: a snapshot from the CAMERA2 study. *Open Forum Infect Dis* 2020;7:ofaa538. doi: 10.1093/ofid/ofaa538
11. Mulugeta SG, Kantharia S, Veve MP, Vincent S, Beaulac A, Patel N. Impact of Methicillin-resistant *Staphylococcus aureus* Nasal PCR versus culture on vancomycin utilization in pneumonia management. *J Pharm Technol* 2025;6:87551225251359508. doi: 10.1177/87551225251359508. Epub ahead of print.
12. Lin A, Luo E, Gottesman E, *et al.* Methicillin-resistant Staphylococcus aureus nasal screening with polymerase chain reaction for early de-escalation of empiric vancomycin in the treatment of suspected/confirmed respiratory infection in critically Ill patients. *Am J Ther* 2025;32:e217–e222. doi: 10.1097/MJT.0000000000001809
13. Thayer B, Edwards JD, Belk MG, Durham SH. Evaluation of a pharmacist-led Methicillin-resistant Staphylococcus aureus nasal PCR testing protocol. *Antibiotics (Basel)* 2024;13:1195. doi: 10.3390/antibiotics13121195
14. Gentges J, El-Kouri N, Rahman T, Mushtaq N, Hudson E, Scheck D. Use of nares swab to de-escalate vancomycin for patients with suspected Methicillin-resistant Staphylococcus aureus. *Antimicrob Steward Healthc Epidemiol* 2023;3:e167. doi: 10.1017/ash.2023.444
15. Parente DM, Cunha CB, Mylonakis E, Timbrook TT. The clinical utility of Methicillin-resistant Staphylococcus aureus (MRSA) nasal screening to rule out MRSA pneumonia: a diagnostic meta-analysis with antimicrobial stewardship implications. *Clin Infect Dis* 2018 67:1–7. doi: 10.1093/cid/ciy024.
16. Henson G, Ghonim E, Swiatlo A, *et al.* Cost-benefit and effectiveness analysis of rapid testing for MRSA carriage in a hospital setting. *Clin Lab Sci* 2014;27:13–20.
17. Meng L, Pourali S, Hitchcock MM, *et al.* Discontinuation patterns and cost avoidance of a pharmacist-driven methicillin-resistant *Staphylococcus aureus* nasal polymerase chain reaction testing protocol for de-escalation of empiric vancomycin for suspected pneumonia. *Open Forum Infect Dis* 2021;8:ofab099. doi: 10.1093/ofid/ofab099
18. Liu C, Bayer A, Cosgrove SE, Infectious Diseases Society of America. Clinical practice guidelines by the infectious diseases society of america for the treatment of methicillin-resistant *Staphylococcus aureus* infections in adults and children. Clin Infect Dis. 2011 Feb 1;52:e18-55. doi: 10.1093/cid/ciq146. Epub 2011 Jan 4. Erratum in: *Clin Infect Dis* 2011;53:319.
19. Nielsen J. Proceedings of the SIGCHI Conference On Human Factors in Computing Systems. 1992. ACM; Monterey, California, USA: Finding usability problems through heuristic evaluation.
20. Osheroff JA, Teich JM, Middleton B, Steen EB, Wright A, Detmer DE. A roadmap for national action on clinical decision support. *J Am Med Inform Assoc*. 2007 Mar–Apr;14:141–5. doi: 10.1197/jamia.M2334. Epub 2007 Jan 9. Erratum in: *J Am Med Inform Assoc* 2007;14:389.
21. Bates DW, Kuperman GJ, Wang S, *et al.* Ten commandments for effective clinical decision support: making the practice of evidence-based medicine a reality. *J Am Med Inform Assoc* 2003;10:523–530. doi: 10.1197/jamia.M1370. Epub 2003 Aug 4.
22. Carey RG, Lloyd RC. *Measuring Quality Improvement in Healthcare: A Guide to Statistical Process Control Applications*. Milwaukee: Quality Press; 1995.
23. Weinreich M, Nguyen OK, Wang D, *et al.* Predicting the risk of readmission in pneumonia. A systematic review of model performance. *Ann Am Thorac Soc* 2016;13:1607–1614. doi: 10.1513/AnnalsATS.201602-135SR.
24. iggs HM, Li R, Jackson KA, *et al.* Trends in incidence and epidemiology of Methicillin-resistant Staphylococcus aureus bacteremia, six emerging infections program surveillance sites, 2005-2022. *Open Forum Infect Dis* 2025;12:ofaf282. doi: 10.1093/ofid/ofaf282.
25. Kotter J. *Leading Change*. Boston, MA: Harvard Business Review Press; 2012.

26. Bright TJ, Wong A, Dhurjati R, *et al.* Effect of clinical decision-support systems: a systematic review. *Ann Intern Med* 157:2012;29–43. doi: 10.7326/0003-4819-157-1-201207030-00450.
27. Pham H, Stein MJ, Worden LJ. Impact of order-set implementation on appropriate treatment of community-acquired pneumonia (CAP). *Antimicrob Steward Healthc Epidemiol* 2025;5:e7. doi: 10.1017/ash.2024.467.
28. Naicker, S, Tariq, A, Donovan, R, *et al.* Patterns and perceptions of standard order-set use among physicians working within a multihospital system: mixed methods study. *JMIR Form Res* 2024;8:e54022. doi: 10.2196/54022.

https://doi.org/10.1017/ice.2026.10421 Published online by Cambridge University Press