ClinicoEconomics and Outcomes Research

Dovepress
Taylor & Francis Group

Open Access Full Text Article

ORIGINAL RESEARCH

Cost-Effectiveness of Automated Blood Culture Systems: Comparison of BACT/ALERT VIRTUO and BD BACTEC FX from a Provider Perspective

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Background: The BACT/ALERT® VIRTUO® system (VIRTUO system) and BD BACTEC™ FX (FX system) can rapidly detect microbial growth in patients with bloodstream infections (BSIs). The cost-effectiveness model presented in this study compared the estimated economic and clinical consequences of adopting these systems.

Methods: A decision tree framework with a one-year time horizon, for a hypothetical population of 10,044 patients was developed to estimate differences in clinical and economic outcomes between the VIRTUO and FX systems. Outcomes included hospital-based mortality, hospital length of stay (LOS) and costs, and total costs (USD, $) for 2023. One-way sensitivity (OWSA) and scenario analyses were performed to evaluate the robustness of the model.

Results: From a US provider's perspective, the base case showed a reduction in mortality rate (VIRTUO system: 18.03%; FX system: 19.67%) and cumulative hospital LOS (VIRTUO system: 12,804 days; FX system: 12,871 days) for patients with blood cultures tested with the VIRTUO system compared to the FX system. Total cost reduction from a provider perspective, led to estimated cost savings of $216,062 per year with the adoption of the VIRTUO system. In the scenario analysis, when the bottle cost of the VIRTUO system increased or decreased by 50%, the testing costs between the VIRTUO and FX systems differed by 35% from the base case. OWSA showed the positivity rate, proportion of patients receiving empirical treatment and septic shock hospital costs were the most influential variables for the model.

Conclusion: Adopting the VIRTUO systems by hospitals has the potential to improve patient-related outcomes and economic savings.

Keywords: bloodstream infections, blood culture system, time to detection, mortality rate, time to gram stain report, cost-effectiveness, decision tree model, US

Introduction

Bloodstream infections (BSIs) are associated with high mortality rates, morbidity and increased health-care costs and are considered a major public health concern. Every year about 536,000–628,000 BSIs and 72,000–85,000 BSI-related deaths are reported in the United States (US).[1] Early identification of BSI and subsequent empirical interventions may aid in reducing mortality and morbidity among patients and may also contribute to decreasing the burden of health-care costs by averting downstream consequences such as sepsis and septic shock.[2–4] Blood culture remains the gold standard for identification of BSIs.[5] Currently, several automated blood culture systems are available for detection of BSIs. These fully automated blood culture systems electronically monitor blood culture bottles and detect changes associated with microbial growth based on sophisticated algorithms.[6] Automated blood culture systems reduce the time to detect positivity and time to report Gram stain results.

Previous studies have shown that prompt and effective antibiotic therapy are crucial for ensuring improved outcomes in patients with serious complications of bloodstream infections, such as sepsis. A retrospective cohort study among

https://doi.org/10.2147/CEOR.S560812
Received: 15 August 2025
Accepted: 6 February 2026
Published: 8 July 2026

patients with BSI involving 131 US hospitals and 26,036 patients reported that approximately 1 in 5 patients received discordant empirical antibiotic therapy, which was associated with high mortality among patients regardless of the presence or absence of septic shock.[7] A meta-analysis of 27 published reports indicated a high (14.1% to 78.9%) rate of inappropriate empirical antibiotic use in patients with severe in-hospital infections, which was shown to be associated with an increase in 30-day and in-hospital mortality in these patients.[8] Another systematic review of 70 prospective studies showed that inappropriate empirical antibiotic treatment was associated with significantly higher mortality.[9] These studies underscore the importance of a timely and effective antibiotic therapy in improving outcomes for patients with severe BSIs. Published literature also highlight the benefits of preventing the progression to septic shock, which may lead to reduced length of hospital and ICU stays, as well as lower the mortality rates.[9]

One of the consequences of faster results of microbiological testing is the ability to modify antimicrobial therapy. Prompt identification of positive blood cultures and Gram stain results can shorten the time to effective therapy for patients not receiving empiric antimicrobials, correct Gram stain-based inappropriate therapy, and enable Gram stain-guided antimicrobial de-escalation. Decreased time to effective therapy and antimicrobial de-escalation has been associated with lower rates of mortality, reduced incidence of septic shock, and reduced length of stay (LOS).[2–4,10] Antimicrobial de-escalation has been associated with improved patient outcomes and reduced LOS.[11–13]

Several automated blood culture systems are available that can rapidly detect positive blood cultures, such as the BACTEC™ FX system (BD, Sparks, MD; henceforth referred to as the FX system), the BACT/ALERT® 3D (BTA3D system), and the BACT/ALERT® VIRTUO® system (bioMérieux, Inc., Salt Lake City, UT; henceforth referred to as the VIRTUO system).[14–16] A prospective cross-over diagnostic clinical trial reported significantly shorter time to detection (TTD- time from loading of sample into the incubator to the positivity signal) of positive blood cultures and significantly shorter time to Gram stain report (TGS – time from sample loading to Gram stain report) for the VIRTUO system when compared to the FX system.[17] In addition, this study observed a significantly higher rate of organism recovery for blood culture samples incubated in the VIRTUO system. A subsequent study also observed a higher rate of organisms recovery for VIRTUO when blood samples were cultured in parallel with the FX system.[18]

Based on this data, in the present study, a cost-effectiveness model (CEM) was developed to assess the economical and clinical consequences of reduced TTD and TGS among patients with BSI in hospital settings. The CEM model also compared the differences in costs of performing blood culture, compared the downstream clinical consequences of early pathogen identification, and compared the proportion of positive blood cultures between VIRTUO and FX systems.

Materials and Methods

Model Overview

A decision tree framework was developed by IQVIA Inc., in Microsoft Excel, using a hypothetical cohort of 28 patients per day—selected to represent a hospital processing approximately 40,000 blood culture bottles per year—resulting in an annual modeled population of 10,044 patients (Figure 1) based on Halperin et al, a prospective cross-over diagnostic clinical trial.[9] The model estimated differences in mortality rates, length of hospital stays, and total hospital costs between the VIRTUO and FX systems from a provider perspective. The model assumed that 4 BC bottles were collected per patient (2 aerobic and 2 anerobic bottles) based on current literature.[17] The cost of implementing these blood culture systems was obtained from publicly available sources to estimate the daily and annual cost of each comparator arm.[19,20] Additionally, the model estimated the clinical consequences of reduced mortality, reduced incidence of septic shock, and reduced LOS because of shorter time to effective treatment.

To capture the clinical and economic impact of automated blood culture systems on the management of BSIs, the model mapped the clinical consequences of receiving faster results and increased organism recovery for VIRTUO versus FX system. To isolate the impact of the blood culture systems themselves and avoid confounding from subsequent workflow steps, post–Gram stain workflow steps (eg, time to organism identification, time to antimicrobial susceptibility testing) were held constant across comparators, allowing the model to attribute differences in outcomes solely to the observed variation in time-to-detection (TTD), time-to-Gram stain (TGS), and positivity rates. Depending on hospital contracts for BSI testing, test costs are incurred by the hospital, or the laboratory set up within a hospital. Therefore, the model was developed

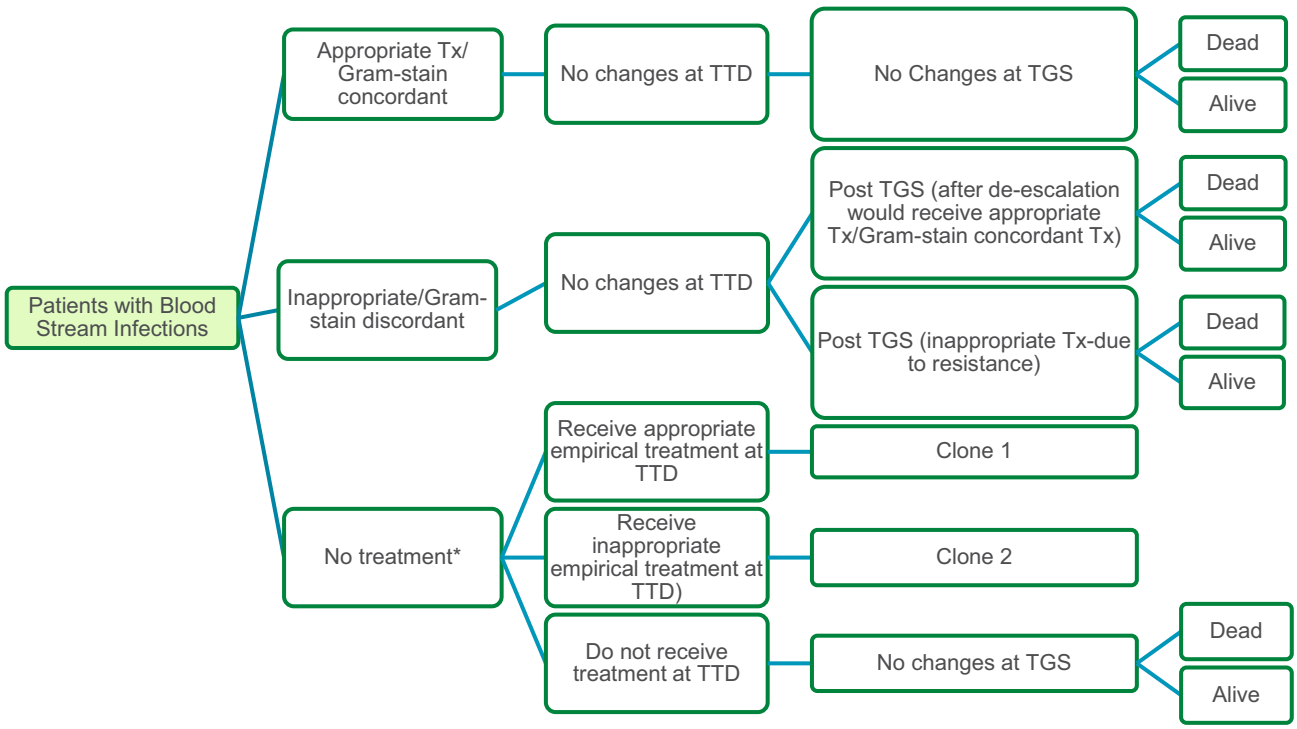

Figure 1 Decision Tree structure. *No treatment arm is applicable for those patients with BSI who did not receive antibiotics at the time of BC positivity.
Abbreviations: TTD, Time to detection; TGS, time to Gram stain report.

including a provider perspective with laboratory costs. The model showed how extended periods of stay in hospitals incurred costs for the providers, and estimated laboratory costs by considering efficiencies provided by automation.

A regression model was created using time at initiation of antibiotic treatment and mortality rates that were derived from published literature (Table 1). Linear, logistic, exponential, and power-fitted regression models were explored to plot mortality against TTD/TGS. Among all the explored regression models, linear, power and exponential models over-estimated mortality while logistic regression was determined as the distribution with best fit since the mortality values were a closer to the clinical mortality reported in the literature,[21–23] hence, a logistic model was used. The logistic regression model related to mortality for appropriate treatment was used in the decision tree to adjust mortality rates based on the formula shown below, where x is TTD/TGS. Patients with reduced TTD and TGS have lower associated mortality.

$$y = 100/[1 + exp(-0.01 * (x - 349.92))]$$

The model follows patients arriving at the hospital and assigns a proportion of them to receive empirical treatment (appropriate or inappropriate), or no empirical treatment and a proportion of patients with Gram stain-based inappropriate therapy (discordant) vs Gram stain-based appropriate therapy (concordant) treatment based on data from the literature (Table 2). Those receiving empirical treatment can be assigned to inappropriate empirical antibiotic treatment (DEAT) where the causative organism is not susceptible to the prescribed antibiotics or appropriate empirical treatment where the

Table 1 Time to Antimicrobial Treatment Initiation and Mortality in Patients Who Received Appropriate Treatment

S.no.	Time at Initiation of Antimicrobial Treatment (Hours)	Mortality in Case of Appropriate Treatment (%)	Reference
1	4	17.83	[21]
2	44.75	19.3	[22,23]

https://doi.org/10.2147/CEOR.S560812

Table 2 Model Input Variables

Proportion of Patients	**Value**		**Source**
Blood culture organism type (%)			
% bacterial	93.9%		Calculated
% fungal	6.1%		[25]
Empirical antimicrobial treatment (%)			
Antibacterial	83.0%		[7]
No treatment	17.0%		
Antifungal	3.0%		
Antimicrobial treatment effectiveness (%)			
Inappropriate empirical treatment	19.3%		[7]
Gram stain-based inappropriate therapy	3.7%		
Appropriate empirical treatment	80.7%		Calculated
De-escalation			
De-escalate antimicrobial therapy after Gram stain results (TGS)	6.9%		[26]
Clinical inputs	**VIRTUO system**	**FX system**	
Total positive	18.2%	15.5%	[17]
True positive	17.8%	15.2%	[17]
False positive	0.4%	0.3%	[17]
Negative reports	81.8%	84.5%	[17]
Time to results			
Time to detection, TTD in hours	15.4	16.9	[17]
Time to Gram stain report, TGS in hours	26	28.4	[17]
Time to antimicrobial susceptibility test, AST in hours	58.1	58.5	[17]
Length of stay in hospital			
Inappropriate antimicrobial therapy	10		[24]
Appropriate antimicrobial therapy	7		[24]
Hospitalization costs (Room and board charges)			
ICU per day	$2893.32		[27]
Hospitalization bed day	$1137.40		[27]
Septic Shock (Hospital costs)	$69,412.00		For average of 17.8 days of hospital stay[28]
Laboratory Costs	**VIRTUO system**	**FX system**	
Costs per bottle	$3.73	$3.39	[19,20]
Annual equipment cost	$0.00	$0.00	Included in costs per bottle
Hourly Wage (Clinical Laboratory Technologists)	$27.80	$27.80	[29]
Resource consumption	**VIRTUO system**	**FX system**	
Total minutes per day for 110 bottles	2.4	13.3	[17]
Positive unloaded bottles/day	3.1	1.8	[17]
Negative unloaded bottles/day	0.0	2.9	[17]
Daily maintenance	0.0	3.0	[17]
Waste bin change (every 72 bottles)	0.2	0.0	[17]
Weekly maintenance	0.2	0.0	[17]

Abbreviations: AST, antimicrobial susceptibility test; ICU, intensive -care unit; HCUP, healthcare cost and utilization project; TTD, time to detection; TGS, time to Gram stain report.

causative organism is susceptible to the prescribed antibiotics, based on data from the literature (Table 2). The model assessed changes in treatment patterns after BSI findings. This is especially consequential for patients who initially did not receive empirical treatment but later tested positive; the model assumes that these patients will start appropriate treatment immediately after testing positive. Patients were assigned LOS based on whether they received appropriate vs inappropriate empirical treatment.[24] The model reported LOS for the proportion of patients with BSI and economic costs incurred per year. This study did not require ethical approval as it did not involve human participants, patient-level interventions, or the use of identifiable clinical data. All analyses were based solely on published literature.

Model Inputs

Target Population

A hypothetical population of 28 patients per day or 10,044 patients per year was assessed in the model. The target population included patients with BSI, which varies depending on the positivity rate of the BC system. Base case results were reported for the target patient population with bacterial and fungal BSI.

Clinical Inputs

The model started with a hypothetical population of 28 patients per day or 10,044 patients per year and assume 4 BC bottles were collected per patient (2 aerobic bottles and 2 anerobic bottles) to quantify the total number of bottles processed per day. The model first identified the patients receiving empirical antimicrobial treatment and no empirical antimicrobial treatment. Among those who received empirical antimicrobial treatment, the model characterized those who received empirical antibacterial treatment and those who received empirical antifungal treatment.[7] Proportion of patients with bacterial and fungal BSI and proportion of patients receiving bacterial, fungal or no empirical treatment were based on published resources.[7,25] Subsequent to identifying the proportion of patients receiving empirical treatment, the percentage of patients with inappropriate and appropriate empirical treatment were identified, where appropriate empirical treatment was calculated as (1 – %inappropriate empirical treatment).[7]

Within the proportion of patients with inappropriate empirical treatment, 100% of those patients with Gram-stain-based inappropriate therapy (eg. empiric vancomycin monotherapy in case of Gram-negative BSI) were assumed to receive appropriate treatment following reporting of the Gram stain results (TGS).

Consequences of the clinician's decision to de-escalate antibiotic therapy based on Gram stain results at TGS were captured by the model. The model assigned mortality and LOS rates based on the proportion of patients receiving appropriate antimicrobial treatment versus the proportion who received Gram-stain-based inappropriate therapy, assuming that they received the correct treatment post TGS results.

The clinical data for positivity rates for the VIRTUO system versus the FX system were obtained from published reports.[17] The model assumed that one of the consequences of missed diagnosis, which was the proportion of patients who had a blood culture test positive using VIRTUO system and negative using FX system, was an increased likelihood of progression to septic shock. The model estimated that 34% of patients who had a missed diagnosis caused by a clinically significant organism(s) (excluding missed diagnoses likely attributable to contaminants) developed septic shock.[7] In the base-case analysis, the model estimates results with the positivity rate difference between BC systems. Model results without a positivity rate difference (ie, model assigned the same positivity rate for both arms) were also estimated in scenario analysis.

Resource Use and Costs

From the provider's perspective, the model estimated the hospital costs incurred per day based on the hospitalization room and board charge published by the Cleveland Clinic price list (Table 2).[27] Total hospitalization cost included room and board charges applied to the LOS and septic shock costs (assumed for an average LOS of 17.8 days in the hospital based on MS-DRG 870).[28] Costs from the laboratory included bottle costs, which included equipment and service costs within the pricing model, and laboratory resource utilization (ie, labor costs) (Table 2).[19,20]

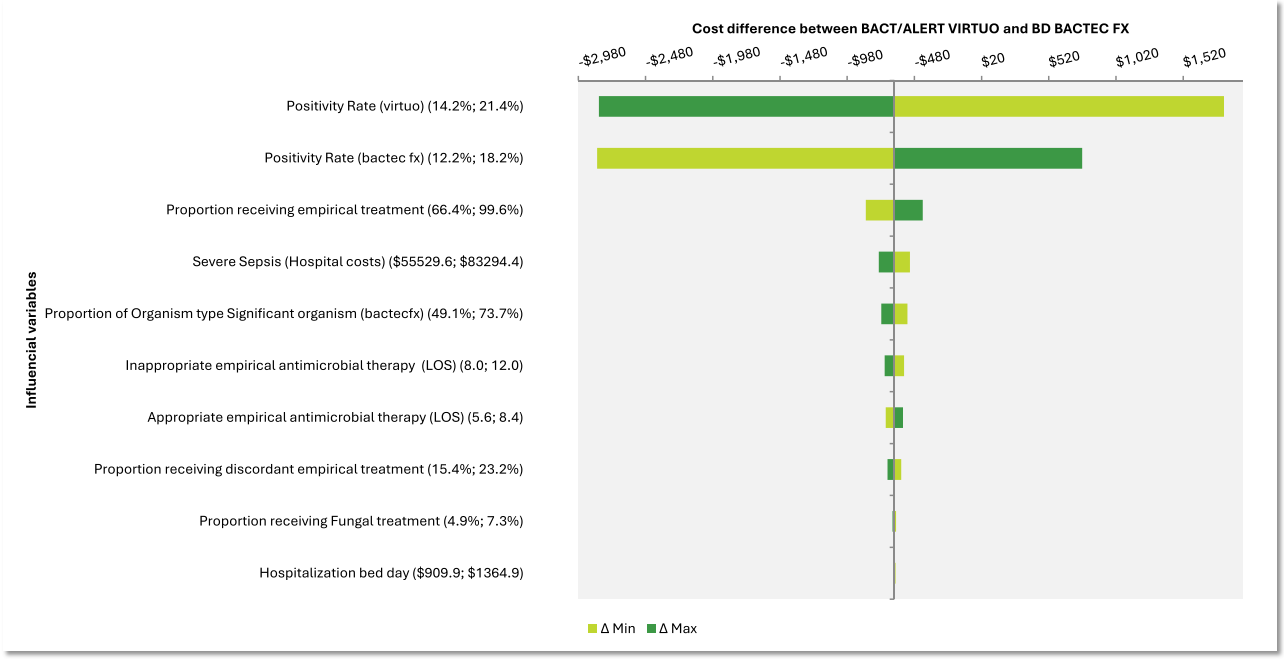

Figure 2 One-way sensitivity analysis-Tornado diagram.
Abbreviation: LOS, length of stay.

Model Outcomes

Outcome metrics included hospital-based mortality, hospital LOS and costs, and total costs presented in 2023 US dollars ($). In addition to base case results, an automated one-way sensitivity analysis (OWSA) was performed to examine the robustness of the model's assumptions and individual parameter uncertainty. The model base case individual inputs were varied for each parameter, and the impact on the outcome was plotted on a tornado diagram (Figure 2). Uncertainty around model parameter was based on a 20% variation. In the tornado diagram, all parameters were sorted as per the decreasing order of their impact on the outcome, with longest bars being the most influential parameters.

Scenario Analyses

To identify the specific drivers of cost differences between the VIRTUO system and the FX system, additional scenarios were examined by altering one variable at a time. Variables altered in these scenarios included costs for the laboratory, positivity rates, costs for sepsis, bottle costs for the VIRTUO system, and the patient counts per day.

Results

Base Case Analysis

The base case analysis compared the costs to a provider when VIRTUO system was implemented for patients with suspected BSI (Table 3). Starting with a population assumption of 28 patients per day or 10,044 patients per year, the mortality rate among patients with BSI using VIRTUO system was 18.03% (330 patients), compared to 19.67% (360 patients) for those screened using the FX system, resulting in a difference of 30 patients during the entire year (Table 3).

The total costs and cumulative LOS for 10,044 patients tested were $14,713,635 and 12,804 days for patients with BSI screened through the VIRTUO system, compared to $14,929,698 and 12,871 days for those screened through the FX system (Table 3). Therefore, screening with the VIRTUO system resulted in a 68-day reduction in length of hospital stay and $216,062 savings in hospitalization costs compared to the FX system (Table 3).

https://doi.org/10.2147/CEOR.S560812

Table 3 Base Case Analysis

Mortality Percentage	VIRTUO System		FX System		Difference	
	%	n	%	n		
Mortality due to bacterial BSI	16.93%	310	14.49%	265	2.44%	
Mortality due to missed diagnosis (Not identified as positive by FX system)	0.00%	0	4.03%	74	(4.03%)	
Mortality due to fungal BSI	1.10%	20	1.16%	21	(0.06%)	
Total mortality for all BSI patients	18.03%	330	19.67%	360	(1.65%)	
Costs and Hospital length of stay	**VIRTUO system**		**FX system**		**Difference**	
	Costs ($)	**LOS (days)**	**Costs ($)**	**LOS (days)**	**Costs ($)**	**LOS (days)**
% Received empirical treatment or appropriate treatment	$14,562,775	12,804	$14,446,269	12,701	$116,505	102
Not identified as positive by FX system						
% that do not develop septic shock	0	0	$131,702	116	($131,702)	(116)
% that develop septic shock	0	0	$211,974	54	($211,974)	(54)
Laboratory costs per year	$150,861	–	$139,753	–	$11,108	–
Total costs per year (10, 044 patients tested)	$14,713,636	12,804	$14,929,698	12,871	($216,062)	

Abbreviations: BSI, bloodstream infection; LOS, Length of stay.

Sensitivity Analyses

Figure 2 shows that positivity rate, proportion of patients receiving empirical treatment and septic shock hospital costs were the most influential variables for the model.

Scenario Analyses

Scenario 1: Laboratory Perspective

In this scenario (Table 4), we examined the cost-effectiveness of the uptake of VIRTUO system from a laboratory perspective. The total laboratory cost per year for the VIRTUO system was higher ($150,861/year) compared to the FX system ($139,753/day) (Table 4). The difference of $11,108 in higher laboratory costs per year for the VIRTUO system was driven mainly by the bottle cost. However, when clinical consequences were included, the savings in hospitalization costs offset the higher costs of the bottles used in the VIRTUO system. Additionally, the efficiencies gained in the

Table 4 Scenario Analysis

Scenario	VIRTUO System		FX System		Difference	
	Total Cost $	Difference from Base Case	Total Cost $	Difference from Base Case	Total Cost $	Difference from Base Case
Scenario 1: Laboratory perspective	$150,861	N/A	$139,753	N/A	$11,108	N/A
Scenario 2: Set positivity rates to be equal	$14,713,636	0%	$14,702,527	(2%)	$11,108	105%
Scenario 3: Sepsis excluded	$14,713,636	0%	$14,752,458	(1%)	($38,823)	82%
Scenario 4a: Cost variation of VIRTUO system compared to FX system (+50%)	$14,788,567	1%	$14,929,698	0%	($141,131)	35%
Scenario 4b: Cost variation of VIRTUO system compared to FX system (−50%)	$14,638,704	1%	$14,929,698	0%	($290,993)	(35%)
Scenario 5: Reduced per day patient count to represent smaller hospitals (For 7 patients per day)	$3,745,314	N/A	$3,800,668	N/A	($55,353)	N/A

https://doi.org/10.2147/CEOR.S560812

laboratory (such as daily operational time) further help balance these increased bottle costs. Overall, the savings from reduced hospitalization and improved workflow efficiencies outweigh the initial higher bottle costs of the VIRTUO system. Despite workflow efficiencies and reduced hands-on time in the laboratory, the higher bottle costs of VIRTUO system increased the overall laboratory costs (Table 4).

Scenario 2: Set Positivity Rates to Be the Same for Both Systems

In this scenario, when the positivity rate was set same, then same proportion of samples were identified as positive by both VIRTUO and FX systems. The mortality rate among patients screened using VIRTUO system was 18.03% (330 patients), compared to 18.15% (332 patients) for those screened using the FX system. Mortality rate difference of only 0.12% improvement in VIRTUO system compared to FX system was mainly driven by differences in TTD and TGS for the overall subgroup. In this scenario, VIRTUO system had increased costs ($14,713,636) compared to FX system ($14,702,527), and the overall cost differences were mainly driven by the difference in the laboratory costs (Table 1).

Scenario 3: Sepsis Excluded

The base model assumed that a proportion of patients who were not identified as positive by the FX system developed septic shock, leading to additional hospitalization costs. However, in a scenario when septic shock costs were excluded from the model, the total hospitalization cost difference between patients screened with the VIRTUO and FX systems decreased from the -$216,062 observed in the base case to -$38,823 (Table 1).

Scenario 4: Cost Variation of VIRTUO System Compared to FX System

In this scenario, cost of bottles for VIRTUO system was varied by 50% higher and lower from the base case value of $3.73 per bottle. In both the scenarios, VIRTUO system was cost saving when compared to FX system. When the bottle cost of the VIRTUO system increased to $5.60 per bottle, the difference in screening costs between the VIRTUO and FX systems was a savings of $141,131, which was 35% lower than the base case. Conversely, when the bottle cost decreased to $1.86 per bottle, the VIRTUO system saved $290,993 more compared to the FX system, which was 35% higher than the base case (Table 4).

Scenario 5: Reduced per Day Patient Count to Represent Smaller Hospitals

In this scenario, we tested an average of 7 patients per day to simulate a scenario from the perspective of smaller hospitals (ie, ~10,000 BC bottles/year). The results reported a cost saving of $55,353 for 2557 patients per year for VIRTUO system when compared to FX system (Table 1).

Discussion

The study estimated and compared the clinical consequences, resource utilization, and economic impact of implementing the VIRTUO system compared to FX system in a hospital setting that processes 40,000 blood culture bottles per year.

Overall, VIRTUO and FX systems screened 10,044 patients per year each, 1829 patients tested positive for BSI with VIRTUO and spend fewer days in hospital (30 days) than BACTEC, resulting in a total cost saving of $216,062 per year. The reductions were mainly due to patients receiving appropriate care sooner when tested with VIRTUO system compared to FX system. This implies patients who may have received inappropriate empirical treatment would be corrected sooner due to reduced TGS for VIRTUO system. Further, de-escalation of broad-spectrum antibiotic therapy would allow patients to receive targeted treatment and avoid potential issues with antibiotic resistance development and other antibiotic adverse events. In countries where the cost of new and high-cost broad-spectrum antibiotics can have a bigger impact due to low health-care budgets, identifying patients that need to be de-escalated is of high importance.

Earlier studies showed that risk of mortality increases with inappropriate empiric antibiotic therapy among BSI patients.[30,31] This aligns with the model findings that showed earlier detection of bloodstream infection improved mortality among patients. Overall, patients with blood cultures processed through the VIRTUO system had a lower mortality compared to FX system, driven by reduced TTD and TGS. This finding aligns with other studies that compared the TTD between VIRTUO and FX systems for clinically relevant microbes and reported significantly shorter TTD for

VIRTUO systems.[14,18,32] Estimated lower mortality rate for patients with BSI screened with VIRTUO system translated into reduced length of hospital stays and total hospitalization costs.

The laboratory cost per year increased by $11,108 for VITRUO system compared to FX system, which was driven by higher bottle costs. Interestingly, the cost increase with VIRTUO system was offset by the treatment costs leading to an overall cost savings with VIRTUO system. The total cost savings with VIRTUO system compared to FX system for 10,044 patients per year were $216,062. Scenario analysis further showed that despite varying the costs of bottle or even excluding the costs related to septic shock, the VIRTUO system was still economically favorable, suggesting the robustness of the model findings. It should be noted that the difference in the overall hospitalization costs between the two systems were highly influenced by positivity rates.

Clinical decisions to provide targeted antimicrobial regimen are made after the identification of the pathogen and its antimicrobial susceptibility. One implication is that workflow modifications that can reduce the time to detect positivity and report Gram stain results can lead to the earlier initiation of appropriate antibiotics, which, in turn, can improve clinical outcomes and reduce mortality. In this regard, further optimization of automated blood culture systems may lead to greater benefits in terms of total costs and resource utilization. In one study, involving ICU patients with BSI compared the clinical and economic outcomes of pre-optimization workflow with the post-optimization of logistical process steps reported a reduction of time to identification and antimicrobial susceptibility by 16.72 hours, a reduction in average hospitalization time by 6.49 days and a lowered hospitalization costs by $9514.17, suggesting improvements in technology can further improve speed and accuracy of pathogen detection.[33] The improvements in the TTD and TGS in the automated blood culture systems will enable clinicians facilitate appropriate antibiotic use and improve clinical outcomes of patients with BSI.

The CEM model in the study was developed following certain assumptions. The decision tree approach traces the proportion of patients receiving appropriate and inappropriate empirical treatment and the reduction in mortality from reduced TTD and TGS. The analysis assumes hospitals have an established Antimicrobial Stewardship Program for both the intervention and comparators. Hence, associated benefits and costs to the hospital are assumed to be the same. The starting population is set at 45 years based on the cross-over clinical study. The overall positivity rate determines the true positive cases for BSI. A one-year time horizon was used for this analysis. Given that there is limited evidence available on TGS for fungal organisms, the mortality benefits for fungal organisms are only due to reduced TTD. This analysis assumed the same time to AST for bacterial and fungal organisms. Also, capturing benefits from de-escalation is not straightforward. The model attempts to show the benefits of faster TGS results that may inform the clinician's decision to modify empirical treatment. The analysis assumed that sepsis costs are to be applied only to those patients who are not identified as positive by the comparator tests and the proportion among them who are affected by significant organisms only. A cost-to-charge ratio of 0.23 is applied to the charges from the provider perspective.[34] Based on real-world evidence, there was no difference in time to identification or time to AST; therefore, no antibiotic treatment decisions following TGS were modeled as they were unlikely to be impacted by the blood culture system.

Limitations

The study has several limitations. First, the study used financial information on bottle costs from publicly available sources. These costs and contracts between manufacturers and hospitals may vary and may impact CEM results. Second, capital and maintenance costs were intentionally excluded from the comparative economic model. Use of a single universal estimate for capital and maintenance costs would reduce generalizability given substantial variability across purchase/lease agreements, and because these costs are typically amortized over multiple years, they represent a relatively small per-patient cost compared to clinical and hospitalization costs. Third, the blood culture positivity rates were derived from a cross-over study, where positivity rate for VIRTUO system and FX system were derived from different populations by study design. Fourth, the model used published data to calculate an increase in positivity between the two comparators and these values had not been calculated using sensitivity and specificity of the blood culture systems. Fifth, modeled outcomes (mortality rates, LOS and in costs) are complex and can be impacted by patient factors (eg, comorbidities) that are beyond the scope of the study.

Conclusion

This study showed that use of VIRTUO system may reduce mortality, hospitalization costs, and LOS, for patients with BSI due to faster TTD/TGS and higher recovery of pathogens, while decreasing laboratory costs due to the reduced hands-on time required to operate VIRTUO system. The estimated benefits of adopting VIRTUO systems by hospitals are not only based on economic savings but also on the improved patient-related outcomes.

Data Sharing Statement

All data generated or analyzed during this study, which support the findings of this study, are included within this article. Any data not present in the manuscript will be available from the corresponding author upon reasonable request.

Acknowledgments

Medical writing service was provided by Lakshman Puli and Saurabh Trikha from IQVIA. The study was funded by BioMérieux Inc. The funder had a role in the design and conduct of the study; management, analysis, and interpretation of the data; review and approval of the manuscript, as well as the decision to submit the manuscript for publication.

The poster of this paper was presented at the *ISPOR 2024* as an poster presentation with interim findings. The poster's abstract was published in "ISPOR Abstracts 2024" in *Value In Health*: https://www.valueinhealthjournal.com/article/S1098-30152400510-2/fulltext.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agreed to be accountable for all aspects of the work.

Disclosure

Kristen L. Jurcic Smith, Amanda L. Suchanek, Hari P. Dwivedi, and Shawn H. MacVane worked on the study as full-time employees of bioMérieux. Pallavi Krishnamurthy, Pablo Anaya, and Pinar Bilir worked on the study as full-time employees of IVQIA, Inc. The authors report no other conflicts of interest in this work.

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