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Estimated clinical and economic impact through use of a novel blood collection device to reduce blood culture contamination in the emergency department: A cost-benefit analysis

Running title: Initial specimen diversion device

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Abstract

Background: Blood culture contamination results in increased hospital costs and exposure to antimicrobials. We evaluated the potential clinical and economic benefits of an Initial Specimen Diversion Device® (ISDD®) when routinely utilized for blood culture collection in the emergency department (ED) of a quaternary care medical center.

Methods: A decision analysis model was created to identify the cost benefit of use of the ISDD device in the ED. Probabilistic costs were determined from published literature and direct observation of pharmacy/microbiology staff. The primary outcome was the expected per-patient cost savings (microbiology, pharmacy, and indirect hospital costs) of routine use of an ISDD using a hospital perspective. Indirect costs included increased hospital length of stay, additional procedures, adverse drug reactions, and hospital-acquired infections. Models were created for hospitals that routinely or do not routinely use rapid diagnostic tests (RDT) on positive blood cultures.

Results: The routine implementation of ISDD for blood culture collection in the ED was cost-beneficial compared to conventional blood culture collection methods. When implemented in a hospital utilizing RDT with a baseline contamination rate of 6%, ISDD use was associated with a cost-savings of $272 (3%) per blood culture in terms of overall hospital costs and $28 (5.4%) in direct-only costs. Main drivers of cost were baseline contamination rates and duration of antibiotics given to patients with negative blood cultures.

Conclusion: These findings support the routine use of ISDD during blood culture collection in the ED as a cost-beneficial strategy to reduce the clinical and economic impact of blood culture contamination in terms of microbiology, pharmacy and wider indirect hospital impact.

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Introduction

Blood culture contamination is a routine complication of patient care. The clinical uncertainty created by contaminated blood cultures decreases the diagnostic value of an initial report of positive growth and often results in detrimental downstream effects, such as increased diagnostic evaluations, unnecessary antibiotic exposure, increased hospital length of stay, increased risk of nosocomial infections, and increased strain on microbiology labs (1-6). The Clinical and Laboratory Standards Institute (CLSI) recommends an overall blood culture contamination rate of less than 3%, however many institutions fail to meet this threshold with rates of blood culture contamination ranging from 2 to greater than 10% using conventional techniques (2, 3, 6-8). Increased blood culture contamination rates have been observed in EDs compared to general wards and ICUs (9).

Several interventions have been utilized to decrease the risk of blood culture contamination, including sterile collection kits and phlebotomy team (8-10). However, even with best-practices, contaminants can represent up to half of all positive blood culture growth (7). Additionally, the cost-benefit and sustainability of available interventions vary, preventing widespread adoption. A novel closed-system, mechanical blood culture diversion device that is preassembled and end-to-end sterile, Steripath® (Magnolia Medical Technologies, Seattle, WA) which is also known in the literature as Initial Specimen Diversion Device® or ISDD®, has been previously demonstrated to reduce the incidence of blood culture contamination by nearly 90% by diverting and sequestering the initial 1.5 to 2.0 mL of blood prior to culture bottle inoculation (4). However, an economic model to evaluate the cost-benefit of ISDD implementation for routine blood culture collection does not exist. We sought to build a decision-tree healthcare economic model to assess the cost-benefit of routine use of ISDD in a health-system ED and evaluate the downstream clinical and economic impacts of routine ISDD use in terms of microbiology, pharmacy, and indirect hospital costs.

Methods

Decision model

A decision analysis model was built using TreeAge software (Williamstown, MA). The structure of the decision tree was modified from a previously published model assessing the cost-implications of blood culture contamination in the ED (10). This model was used to perform a cost-benefit analysis comparing routine use of ISDD for blood culture collection in the ED to the use of conventional practices without ISDD for blood culture collection in the ED. Conventional methods were defined as a nurse or phebotomist collection by venipuncture with clean, but non-sterile, technique using 2% CHG in 70% isopropanol as the antiseptic or similar. The primary outcome was per-patient costs associated with ordering a blood culture in the ED including microbiology, pharmacy, and indirect hospital expenditures. The tree model is shown in Supplemental figure 1.

Target population

The target cohort for our decision tree model comprised all patients in the ED with an order for blood culture collection. Patients were excluded if they did not have two blood culture sets drawn as part of the initial order in the ED or if the blood culture yielded fungal growth (3). Culture results were adjudicated into three groups at the time of culture finalization for the purpose of evaluating costs: no bacterial growth, true bacteremia, or contaminated growth. Published studies used a definition of contamination to be blood culture growth due to skin residing organisms (coagulase-negative staphylococci, *Propionibacterium* spp., *Micrococcus* spp., viridians group streptococci, *Corynebacterium* spp., or *Bacillus* spp.) if the growth was identified in ≤50% of available bottles as previously defined generally considered one of two blood culture sets (2, 4).

Data sources

Information and model parameters for this study was primarily derived from published literature using the primary data from the publication source usingr a systematic review of literature. When necessary, hospital charges were converted to hospital costs using a 0.3 cost-to-charge ratio (11). All costs were adjusted to 2017 US dollars (USD) using the consumer price index (CPI) (12). In the absence of published data, information was obtained from institutional databases at an 884-bed quaternary care hospital with 78,000 annual ED visits located in the Texas Medical Center, Houston Texas. Collection of institutional data was approved by the institutional review board of the University of Houston and participating hospital. Baseline estimates as well as ranges included in the sensitivity analyses are presented in Table 1.

Rate of blood culture contamination

The incidence of bacterial growth from blood cultures drawn in the ED and the proportion of overall growth due to contamination were obtained from multiple observational studies. Published blood culture contamination rates using conventional collection methods have ranged from 2% to over 10%.(1, 3, 4, 8, 9, 13, 14) Rates of overall bacterial growth and contamination using ISDD were obtained from a controlled matched-pair trial by Rupp et al. in which a blood culture contamination rate of 0.22% was observed among 904 blood cultures (4). Investigators furthermore demonstrated that the observed prevalence of true bacteremia was not affected by use of the ISDD (7.2%) when compared to conventional techniques (7.6%, p=0.41).

Microbiology costs

The cost of materials needed for conventional collection of blood cultures was estimated based on institutional costs and corroborated by published data.(10, 15) Opportunity labor costs were determined

either by surveying or direct observation by the authors of microbiology staff over a period of four-weeks at two sites: an 884-bed academic medical center and a 792-bed community hospital. Hourly wages for laboratory technicians were assigned according to the Bureau of Labor Statistics (BLS) occupational handbook (12). Initial instrument and material costs to process cultures were estimated based on institutional costs and corroborated by published data (6, 16-18). The costs of organism identification and antimicrobial susceptibility testing were determined separately for hospitals that utilize rapid diagnostic testing (RDT) (e.g. multiplex PCR, MALDI-TOF, PNA-FISH) and those that use conventional methods. Microbial identification and antimicrobial susceptibility testing costs were estimated as a composite that included the cost of reagents, supplies and instrument acquisition divided by the expected number of samples to be processed over the life of the instrument (19-21). Cost estimates were calculated assuming routine identification and antimicrobial susceptibility testing was performed for all initial microbial growth isolated from blood samples.

Antimicrobial administration and duration

The duration of antibiotic therapy was estimated based on the probability of two separate events: A) receiving empiric therapy at the time of blood culture collection, and B) stopping therapy at the time of culture finalization. Patients were assumed to universally receive antibiotics at the initial report of unidentified bacterial growth from a blood culture if they were not started empirically. The duration of antibiotic therapy for patients with true bacteremia was not dependent on empiric therapy or de-escalation and was estimated based on published observational data and the minimum recommended duration by the Infectious Diseases Society of America (22, 23). For other blood culture result categories, an institutional database was utilized to estimate the probability of starting or stopping inpatient antibiotics. A composite daily pharmacy cost of antibiotic provision was constructed utilizing institutional purchasing data for

several broad-spectrum, intravenous antibiotics at standard daily doses that are commonly given as empiric therapy in patients with suspected bloodstream infections: vancomycin ($20/day), cefepime ($25/day), meropenem ($30/day), linezolid ($80/day), and piperacillin-tazobactam ($20/day). Opportunity labor costs for preparation and delivery of IV antibiotics were determined by direct observation of pharmacy staff with hourly wages assigned according to the Bureau of Labor Statistics (BLS) occupational handbook (12). A point estimate of $75 was determined to represent the daily provision cost of antibiotics to a single patient, which included pharmacy purchasing and labor and was based on retrospective data that demonstrated patients with pathogenic or contaminated blood culture results were likely to concomitantly receive multiple antibiotics (24). Additional pharmacy labor costs were considered for therapeutic drug monitoring of vancomycin. Our model assumed that a patient receiving three or fewer days of vancomycin underwent one serum concentration assay, while patients receiving more than three days of vancomycin underwent two serum concentration assays (5, 24, 25). Pharmacist labor costs associated with a serum vancomycin level was determined by direct observation of staff and estimated to require 45 minutes to conduct an assessment and response.

Indirect hospital costs

Indirect costs included increased hospital length of stay, additional procedures, adverse drug reactions, and hospital-acquired infections. Published observational data was utilized to estimate the probabilistic cost of additional diagnostic or therapeutic interventions as a result of a positive blood culture, including central line placement/removal ($1,272), bone scan ($980), echocardiogram ($1,254), additional laboratory assays ($130), and diagnostic imaging ($1,700), with a final point estimate of $1,100 of additional diagnostic/procedural cost due to a positive blood culture (26-28). Costs associated with hospital length of stay were determined by published observational data and corroborated with institutional records of

n=3,325 unique patient encounters with blood cultures ordered in the ED (1). Occupation of a single-patient, non-ICU hospital room was valued at $1,500 per day based on published data and institutional financial valuation.(29) The risk of a hospital-acquired infection (HAI) was modeled using an incremental 1.37% risk per hospital day due to observational data demonstrating the majority of HAIs are experienced in the first 10 days of hospitalization in which timeframe the incidence HAIs increases linearly (30). The risk of experiencing an antibiotic-associated adverse drug reaction (ADR) such as nephrotoxicity or an infusion reaction was estimated to increase incrementally at 6% per day of antibiotic therapy (31, 32).

Cost-benefit analysis plan

Expected value calculations were used to evaluate the cost-benefit of routine use of ISDD to collect all blood cultures in the ED. Separate analyses were performed for hospitals that did and did not use RDT for organism identification and antimicrobial susceptibility testing. One-way sensitivity analyses were performed to assess the robustness of results. Variables that were determined to have a significant effect on the outcome of our analysis were further subjected to two-way sensitivity analyses.

Results

Clinical parameters associated with blood culture contamination and healthcare costs

Data not available from our systematic review of the literature was obtained using our institutional database. Patients with contaminated blood cultures drawn in the ED were screened in a quaternary care hospital with a historical ED contamination rate of 6%. Between January and February 2017, 48 unique patient encounters were observed in which a contaminated blood culture was collected in the ED. To characterize the timing and duration of antibiotic therapy, this cohort was consecutively matched over the same period in a 1:1.5 ratio with patients whose ED blood cultures yielded no growth. Empiric therapy was

initiated in 34 of 48 patients (71%) with contaminated cultures, and 50 of 70 patients (71%) whose cultures yielded no growth.

Of the 20 patients (29%) whose blood cultures yielded no growth and who were not started on empiric antibiotics on the day of culture collection, 14 (70%) were eventually started on antibiotics. Of these, antibiotics were stopped by the date of culture finalization in 10 patients (71%). Likewise, among patients whose blood cultures collected in the ED yielded no growth and did receive empiric therapy, 36 patients (72%) were discontinued off antibiotics by the date of culture finalization. Durations of antibiotic therapy for these groups are displayed in table 1.

Of the 14 patients (29%) with contaminated blood cultures who were not started on empiric antibiotics on the day of culture collection, 8 patients (57%) were eventually started on antibiotics. Of these, antibiotics were discontinued by the date of culture finalization in 6 patients (75%). Among patients with contaminated blood cultures who were started on empiric therapy, 23 patients (68%) were discontinued off antibiotics by the date of culture finalization (Table 1).

Additional data from the same quaternary care hospital regarding hospital length of stay was extracted from 3,325 unique patient encounters in 2017 during which a blood culture was collected in the ED. Among these patients, receipt of at least one dose of IV vancomycin was observed in 1,634 of 2,867 patients (57%) who had no bacterial growth identified from the initial ED blood culture, 136 of 206 patients (66%) who had true bacteremia, and 212 of 252 patients (84%) who had contaminated bacterial growth from the initial ED blood culture. Detection of bacterial growth from the initial ED blood culture was also associated with longer hospital stay in this cohort. The median length of stay among patients with a contaminated blood

culture (n=253) was 7 days (IQR 4-11 days), while the median length of stay among patients with a negative culture (n=2,866) was 5 days (IQR 3-9 days) ($p<0.0001$).

Costs due to blood culture contamination stratified by hospital use of RDT

In hospitals that did not routinely use RDT, the overall hospital cost for patients with contaminated blood cultures was $12,824/patient including costs from pharmacy ($422/patient), microbiology ($275/patient), and indirect hospital costs ($12,126/patient). The overall costs increased in hospitals with routine use of RDT ($13,026) due to increased costs in microbiology ($477). Total cost per contaminated blood culture, per negative blood culture, and attributable cost per blood culture contamination are shown in Table 2.

Base-case cost-benefit analysis of routine ISDD implementation

Using baseline estimates from the quaternary care hospital and literature estimates, the routine implementation of ISDD for blood culture collection in the ED was cost-beneficial compared to conventional blood culture collection methods. Using a baseline contamination rate of 6%, the total expected cost of a blood culture patient-episode was $8,893 using ISDD and $9,165 with conventional methods in a hospital utilizing RDT, resulting in a cost-savings of $272 (3.0% reduction in costs) per blood culture collection (Table 3). In a hospital not utilizing RDT, the total expected cost of a blood culture patient-episode was $8,868 with ISDD and $9,130 with conventional methods, resulting in a cost-savings of $261 (2.9% reduction in costs) per blood culture collection. When considering only direct microbiology and pharmacy costs, the expected cost-savings per blood culture collection was $28 (5.4% reduction in costs) in hospitals using RDT and $16 (3.4% reduction in costs) in hospitals not using RDT.

The cost-benefit analysis also showed that routine ISDD implementation was associated with a reduction in antibiotic usage, adverse drug reactions and hospital-acquired infections. ISDD implementation was associated with a 1.7% absolute reduction in the number of patients receiving at least one dose of vancomycin after blood culture collection in the ED. In a setting with 350 patient-unique blood cultures collected in the ED every month, ISDD implementation is associated with the complete avoidance of vancomycin administration in 6 additional patients per month.

Sensitivity analyses

The results of the sensitivity analysis confirmed the robustness of the model to a range of variation in base-case parameter values. Variables that most influenced the model in hospitals that use conventional collection techniques vs. routine use of the ISDD are shown in Figure 1. To perform a more conservative evaluation of the cost-benefit of routine ISDD implementation in the ED, one- and two-way sensitivity analyses were also performed considering only direct purchasing and labor costs within the pharmacy and microbiology departments. Under these conditions, the threshold value for the unit cost of ISDD at which the strategy of routine ISDD use was equal in direct-costs to the conventional blood culture collection strategy was $28 with RDT and $16 without RDT. When considering total hospital expenditure, including indirect costs, the threshold value for the unit cost of ISDD at which the strategy of routine ISDD use was equal to the conventional blood culture collection strategy was $272 with RDT and $261 without RDT. Total hospital costs associated with a blood culture collection using Steripath vs. conventional methods over a range of baseline blood culture contamination rates is shown in Figure 2

A two-way sensitivity analysis on the expected, per culture, direct (pharmacy and microbiology) cost of routine ISDD vs. conventional methods of blood culture collection in a hospital with RDT demonstrated

241 that ISDD was the least costly strategy at an ISDD unit cost of $30 over a range of baseline blood culture
242 contamination rates above 6% (Figure 3). Likewise, ISDD was the least costly strategy in hospitals using
243 RDT at a unit cost of $30 when the median duration of antibiotic therapy was less than 3 days among
244 patients with negative blood cultures whose therapy was discontinued by culture finalization.
245
246 **Discussion**
247 Blood culture contamination in emergency departments increases hospital costs and affects patient
248 outcomes. In this cost-benefit study, routine use of ISDD was a cost-saving strategy compared to
249 conventional methods over a range of baseline variables. The results of this study demonstrate that the use
250 of ISDD to decrease blood culture contamination rates also decreases associated hospital costs from
251 multiple hospital departments. Strengths of the study include the use of a systematic literature review
252 supplemented with real-world observation and databases to provide estimates, dual analyses based on
253 microbiology use of rapid diagnostic tests, and identification of costs drivers that are affected by blood
254 culture contamination.
255
256 The clinical utility of the Steripath ISDD was demonstrated using a cohort of phlebotomist-collected blood
257 cultures (4). In this study, blood culture sets were collected with and without ISDD. Rates of blood culture
258 contamination without using ISDD was 1.78% which decreased to 0.22% with use of ISDD; an 87.6%
259 reduction. While no published studies have evaluated the economic impact of routine implementation of
260 ISDD, the cost-effectiveness of other interventions designed to decrease the rate of blood culture
261 contamination have been studied. A decision tree cost-analysis with a baseline contamination rate of 4.34%
262 demonstrated that the use of sterile kits or phlebotomy teams for blood culture collection was associated
263 with a net hospital cost-savings compared to usual practices (10). Our results showed a similar cost-

effectiveness benefit in addition to a more granular analysis of areas where cost savings are observed. Sustainability and work flow practicality associated with dedicated phlebotomy teams in a busy ED was a limitation of the previous study. Interventions that rely on new methodology vs. constant staff education or presence of specialists may also be more sustainable over time (10, 33). Other antimicrobial stewardship benefits associated with the ISDD device should be studied in the future.

While this study was designed within a framework that could be generalized to a wide range of institutions, (e.g. those with or without access to RDT), there are important considerations to note. This study assumed that all bacterial growth identified from a blood culture was subjected to full microbiologic identification and susceptibility testing; however, not all institutions are likely to subject every organism identified as a potential skin contaminant to full antimicrobial susceptibility. Furthermore, this study utilized an aggregated composite estimate for RDT comprising a range of available laboratory instruments with varying acquisition and operating costs. We accounted for these differences in clinical practice by performing separate analyses for hospitals that do or do not routinely perform RDT as well as a wide range of possibility in the sensitivity analysis. Hospital vary widely in their use of RDT and further refinements to the model could be undertaken for differing scenarios. We did not account for any wastage of the ISDD or additional time needed to use or dispose of the device. We modeled the effect of the ISDD in the ED, an area of healthcare with high rates of contamination. Models to predict economic benefit in other areas of the healthcare continuum will be needed. The cost-benefit analysis in this study was predicted probabilities only, further real-world clinical trial evidence will be required to confirm these results. Additional limitations to this study to consider include the heterogeneous nature of data used to compile point estimates, however data obtained from disparate sources were corroborated or reconciled by review of institutional databases when available.

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288 **Conclusion**

289 These findings support the routine use of ISDD for the collection of blood cultures in the ED as a cost-

290 beneficial strategy to reduce the clinical and economic effect of blood culture contamination in terms of

291 microbiology, pharmacy and wider indirect hospital implications.

292 **Acknowledgments**

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294 Seattle, WA.

295 *Potential conflicts of interest.* All authors report no conflicts of interest relevant to this article.

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400 **Figure legends**

401

402 **Figure 1**. Tornado diagram for estimated hospital cost per blood culture collection when routinely utilizing

403 Steripath vs. conventional methods in the ED

404

405 **Figure 2**. Total hospital costs associated with a blood culture collection using Steripath vs. conventional

406 methods over a range of baseline blood culture contamination rates

407 **Figure 3**. Two-way sensitivity analyses for direct (microbiology and pharmacy) costs per blood culture

408 collection in the ED associated with two blood culture collection strategies; break even analysis

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410 **Table 1.** Baseline decision tree parameters and ranges used in sensitivity analyses

Variable	Value at baseline	Sensitivity range	References
Prevalence of true bacteremia	7%	7-7.5%	(2-4, 6, 8, 19)
Rate of blood culture contamination at baseline	6%	2-10%	(2-4, 6, 8, 19)
Rate of blood culture contamination with Steripath	0.25%	0-0.5%	(4)
Probability of empiric antibiotics at culture collection			
Negative or contaminated blood culture	71%	64-78%	Institutional database
True bacteremia	95%	85-100%	(22, 23)
Probability of stopping antibiotics by culture finalization (negative or contaminated culture)	71%	64-78%	Institutional database
Administration of IV vancomycin			
Negative blood culture	57%	52-62%	Institutional database
Contaminated blood culture	84%	76-92%	Institutional database
True bacteremia	66%	60-72%	Institutional database
Duration of inpatient antibiotics with negative blood culture, days			
Empiric antibiotics, stopped by final	3	1-4	Institutional database
Empiric antibiotics, not stopped by final	9	7-13	Institutional database
No empiric antibiotics	0	0-5	Institutional database
Duration of inpatient antibiotics with contaminated culture, days			
Empiric antibiotics, stopped by final	4	3-7	Institutional database
Empiric antibiotics, not stopped by final	10	7-13	Institutional database

No empiric antibiotics, stopped by final	1.5	1-3.5	Institutional database
No empiric antibiotics, not stopped by final	9	7-9	Institutional database
Duration of inpatient antibiotics with true bacteremia, days	10	7-13	Institutional database
Hospital length of stay, days			
Negative blood culture	5	3-9	(1), Institutional database
Contaminated blood culture	7	4-11	(1), Institutional database
True bacteremia	9	7-13	(1), Institutional database
Costs, $			
Blood culture collection and processing	36	20-56	(6, 10, 15-17, 34)
Organism identification and AST with RDT	300	108-488	(19-21), Institutional database
Organism identification and AST without RDT	104	80-200	(6, 16-18), Institutional database
Daily antibiotic therapy (purchasing and labor)	75	50-80	(12, 24)
Serum vancomycin assay (laboratory)	68	63-77	(35)
Serum vancomycin assay (pharmacy)	41	28-55	Institutional database
Non-ICU (floor) day	1,500	1,000-2,500	(29)
Follow-up tests and procedures	1,100	900-1,300	(26-28)
Cost of hospital-acquired infection	5,000	2,500-10,000	(30, 36, 37)
Cost of adverse drug reaction	150	25-600	(31, 32)

411 *AST=antimicrobial susceptibility testing; RDT=rapid diagnostic testing

412 **Table 2**. Distribution of component downstream costs stratified by result of initial blood culture collected in the ED

Blood culture result	Microbiology costs, $		Pharmacy costs, $	Indirect hospital hosts, $					Total costs, $	
	With RDT	Without RDT		LOS	ADRs	HAIs	Additional procedures	Total indirect hospital costs	With RDT	Without RDT
Cost per contaminated blood culture	477	275	423	10,500	47	480	1100	12,126	13,026	12,824
Cost per negative blood culture	119	118	295	7,500	30	343	0	7,873	8,287	8,286
Attributable costs per blood culture contamination	358	158	127	3,000	16	137	1100	4,253	4,739	4,538

413 * ADR=adverse drug reaction; HAI=hospital acquired infection; LOS=length of stay; RDT=rapid diagnostic testing

414

415 **Table 3**. Total estimated net cost-savings per blood culture collection associated with routine Steripath

416 implementation in the ED

Baseline blood culture contamination rate prior to Steripath implementation for routine blood culture collection	Expected microbiology cost-savings per blood culture, $		Expected pharmacy cost-savings per blood culture, $	Expected indirect hospital cost-savings per blood culture, $	Total Expected cost-savings per blood culture, $	
	With RDT	Without RDT			With RDT	Without RDT
2%	6	3	2	74	83	79
3%	10	4	3	117	130	124
4%	13	6	4	160	178	170
6%	21	9	7	244	272	261
8%	28	12	10	330	367	352

417 *RDT=rapid diagnostic testing

418

419

420 **Figure legends**

421

422 **Figure 1**. Tornado diagram for estimated hospital cost per blood culture collection when routinely utilizing
423 Steripath (Figure 1a) vs. conventional methods (Figure 1b) in the ED

424

425 **Figure 2**. Total hospital costs associated with a blood culture collection using Steripath vs. conventional
426 methods over a range of baseline blood culture contamination rates

427

428 **Figure 3**. Two-way sensitivity analyses for direct (microbiology and pharmacy) costs per blood culture
429 collection in the ED associated with two blood culture collection strategies; break even analysis

430

431

432

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Figure 1a

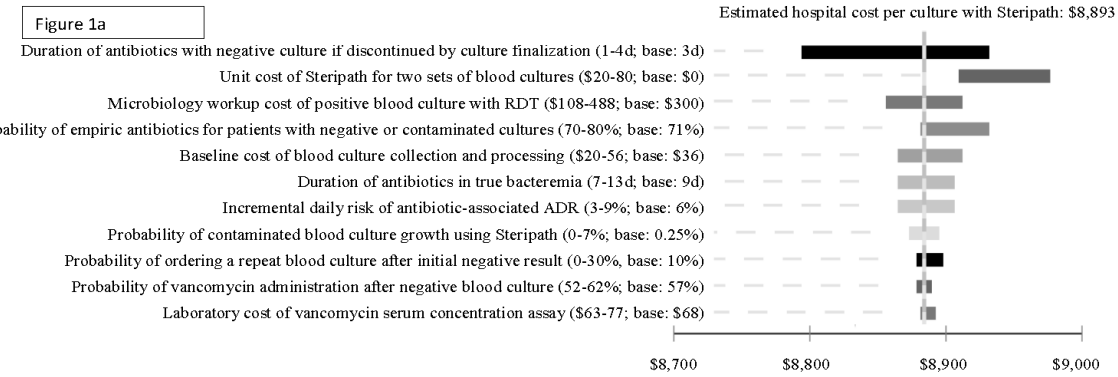
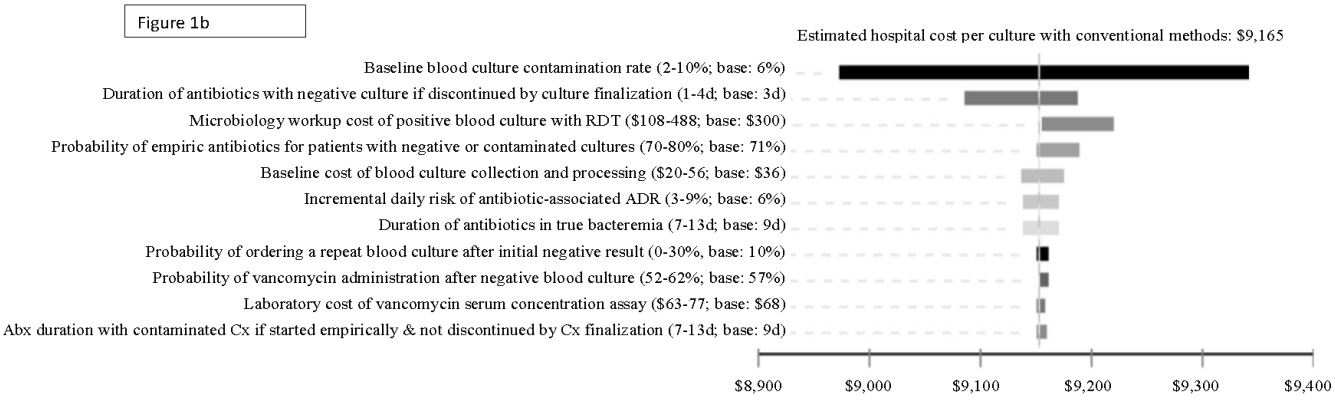


Figure 1b



Data presented for hospitals employing using rapid diagnostic testing for antimicrobial identification and susceptibility testing.

RDT: rapid diagnostic testing; ADR: adverse drug reaction; Abx: antibiotic(s); Cx: culture

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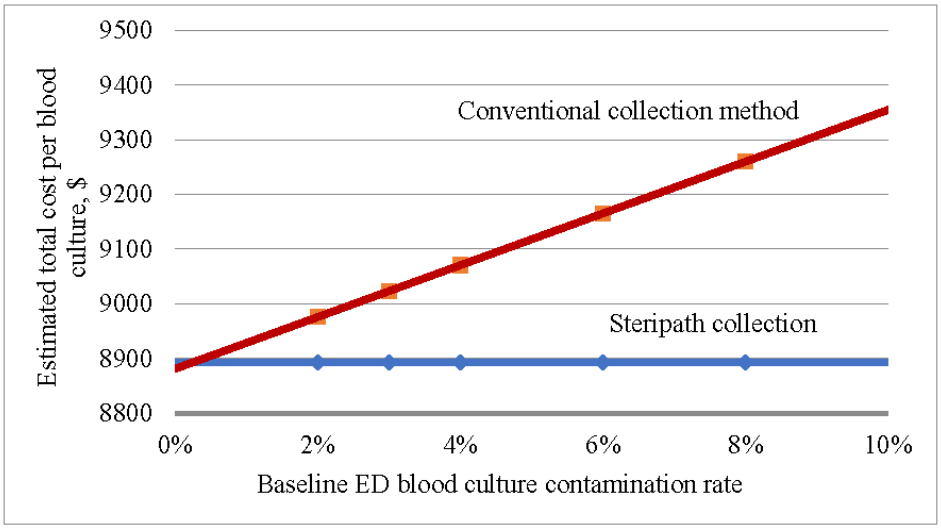
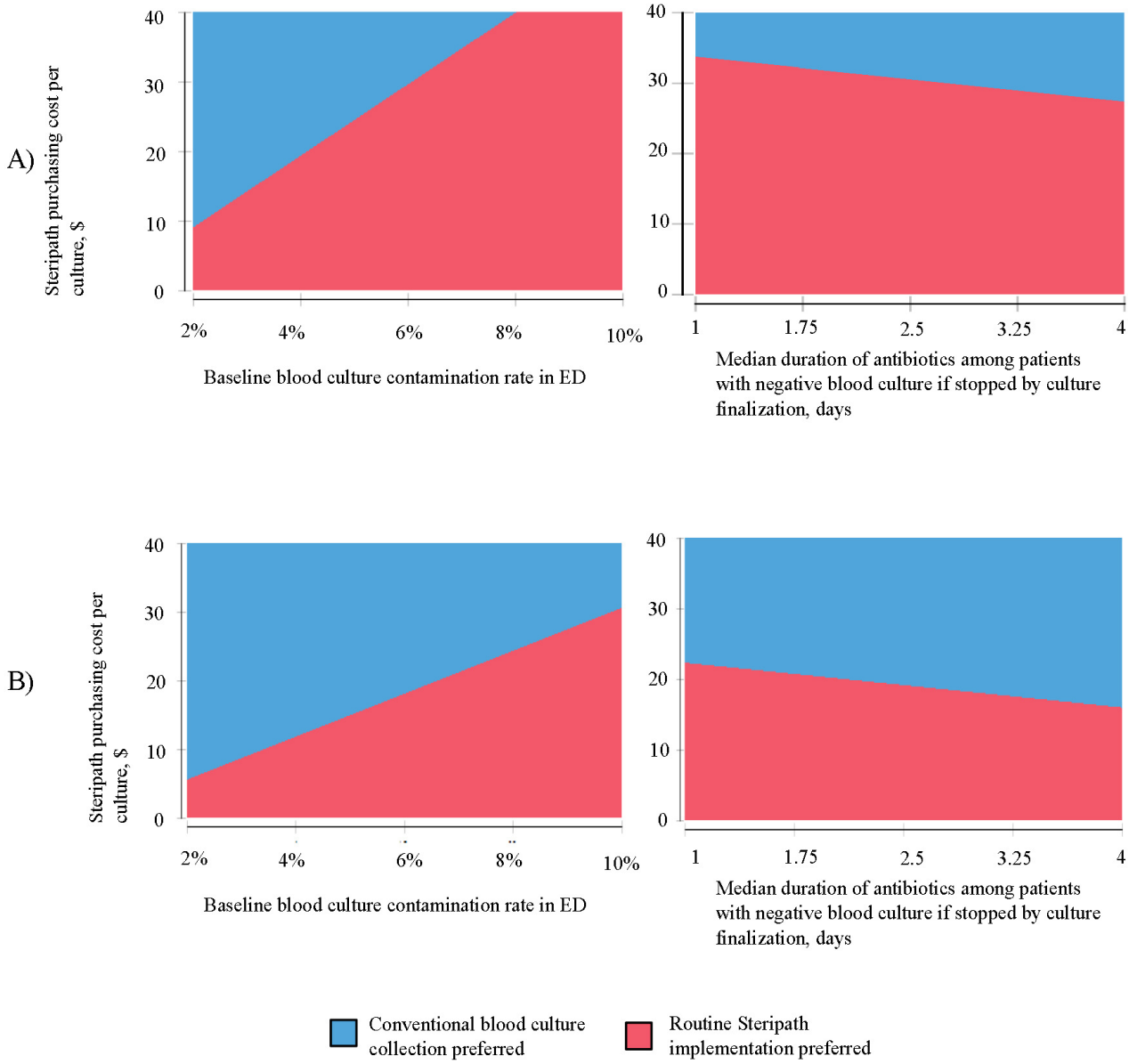


Data presented for hospitals employing using rapid diagnostic testing for antimicrobial identification and susceptibility testing. Estimated cost-differential shown does not include Steripath unit costs.



A: hospitals employing using rapid diagnostic testing; B: hospitals employing traditional microbiology identification and susceptibility techniques.