A fully integrated infectious diseases and antimicrobial stewardship telehealth service improves \textit{Staphylococcus aureus} bacteremia bundle adherence and outcomes in 16 small community hospitals

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\textbf{Running Title:} IDt plus Tele-AS Improves SAB Outcomes

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BACKGROUND
Infectious diseases (ID) and antimicrobial stewardship (AS) improve *Staphylococcus aureus* bacteremia (SAB) outcomes. However, many small community hospitals (SCHs) lack on-site access to these services, and it is not known if ID telehealth (IDt) offers the same benefit for SAB. We evaluated the impact of an integrated IDt service on SAB outcomes in 16 SCHs.

METHODS
An IDt service offering IDt physician consultation plus IDt pharmacist surveillance was implemented 10/2016. Patients treated for SAB in 16 SCHs between 1/2009–8/2019 were identified for review. We compared SAB bundle adherence and outcomes between patients with and without an IDt consult (IDt group and control group, respectively).

RESULTS
423 patients met inclusion criteria: 157 in the IDt group and 266 in the control group. Baseline characteristics were similar between groups. Among patients completing their admission at a SCH, IDt consultation increased SAB bundle adherence [79% versus 23%; OR (95% CI), 16.9 (9.2–31.0)]. 30-day mortality and 90-day SAB recurrence favored the IDt group, but the differences were not statistically significant [5% versus 9% (p=0.2), and 2% versus 6% (p=0.09), respectively]. IDt consultation significantly decreased 30-day SAB-related readmissions (9% versus 17%, p=0.045) and increased length of stay [median days (IQR), 5 (5–8) versus 5 (3–7), p=0.04]. In a subgroup of SAB patients with controllable source, IDt appeared to have a mortality benefit [2% versus 9%; OR 0.12 (0.01–0.98)].

CONCLUSIONS
An integrated ID/AS telehealth service improved SAB management and outcomes at 16 SCHs. These findings provide important insight for other IDt programs.
BACKGROUND

Infectious diseases (ID) consultation improves outcomes for patients with *Staphylococcus aureus* bacteremia (SAB) including mortality, readmissions, and adherence to best-practice care bundles. These benefits have primarily been demonstrated with in-person ID consultation, yet many small community hospitals (SCHs) < 200 beds lack access to on-site ID physicians. These facilities may also lack access to ID-trained pharmacists for antimicrobial stewardship (AS) surveillance of positive blood cultures, which is key for early identification, intervention, and referral of SAB patients for ID consultation. Indeed, studies have increasingly described the complementary role of AS surveillance and ID consultation in optimizing SAB management and outcomes.  

Telehealth can improve access to both ID consultation and AS services, but best practices for remote SAB management have not been defined. Two retrospective SAB studies found that telephone-only consultation led to higher mortality than in-person consultation, whereas one study found that live audio-visual telemedicine consultation (when paired with an AS care bundle) resulted in similar outcomes. One randomized trial found that ID telephone consultation improved quality of care but had no impact on mortality. Further studies are needed to define the impact of different telehealth modalities [e.g. asynchronous electronic consults (eConsults) versus synchronous 2-way audiovisual (telemedicine) visits] on SAB outcomes and to describe ID telehealth (IDt) and Tele-AS interventions for SAB in resource-limited settings. Herein, we describe the impact of an IDt consultation service with integrated Tele-AS surveillance on SAB management and outcomes at 16 SCHs in the Intermountain Healthcare system.

METHODS

Setting, Patients, and Study Design
This multicenter, retrospective, quasi-experimental study was approved by the Intermountain Healthcare Institutional Review Board. Intermountain Healthcare is an integrated regional healthcare system consisting of 24 hospitals, >200 clinics, and 75 telehealth services providing care to >1.5 million patients each year in the Intermountain West region (i.e. Utah, Idaho, and Nevada; Western Colorado/Wyoming/Montana; Eastern Oregon/Washington; and Northern Arizona/New Mexico).

Sixteen Intermountain SCHs [median (range) bed size: 25 (14-146) beds] in Utah and Idaho provide inpatient medical and surgical services for the surrounding communities and generally lack on-site access to sub-specialty services. Ten (63%) of these SCHs are rural (six with Critical Access Hospital designation), and eight (50%) have intensive care units (ICUs) although critically ill patients are often transferred to a higher-level care facility.

The Intermountain Enterprise Data Warehouse (EDW) was used to identify the first positive *S. aureus* blood culture for patients ≥ 18 years of age admitted to one of these 16 SCHs between January 2009 and August 2019. Patients were excluded if, within 48 hours of the index blood culture, or prior to blood culture identification as methicillin-susceptible versus methicillin-resistant *Staphylococcus aureus* (MSSA vs MRSA) they either transferred, died, or were discharged to hospice care. Those with polymicrobial growth on blood cultures were also excluded unless the concomitant organism was judged to be a contaminant (e.g. single positive blood culture for Coagulase-negative *Staphylococcus* species).

To capture any SAB-related care in the SCH setting, we evaluated patients admitted to a SCH for > 48 hours (SCH admission population – Figure 1). Patients discharged from the hospital or emergency department (ED) prior to 48 hours were still included in this population if the blood culture results were acknowledged in the chart, the treatment plan was stated, and the patient was not lost to follow-up. To best describe SCH outcomes for SAB, we then focused on a subgroup of SCH inpatients who completed their entire admission and received definitive SAB management at a SCH omitting those who...
transferred, left against medical advice, or were discharged with hospice (SCH management population – Figure 1).

4 ID Telehealth Intervention

The SCHs did not have access to ID consultation or AS services from January 2009 through June 2014. A dedicated ID advice line was implemented from July 2014 through September 2016 as part of a cluster randomized AS intervention trial (the SCORE study). SAB cases during this time period were excluded from the current study because no ID notes were written in the chart when telephone-only advice was given, and we were unable to determine which cases might have received telephonic ID physician input.

A formal integrated IDt program was established in October 2016 to provide IDt consultation and Tele-AS support to all 16 SCHs. IDt services included a 24-hour advice line staffed by an attending ID physician who could choose to offer phone advice only, chart review with electronic medical record (EMR) documentation (eConsult), or synchronous 2-way audio-visual telemedicine consultation (TC) with EMR documentation. TCs and eConsults were offered weekdays 7:30 am – 4:30 pm, while telephone-only advice was offered after-hours, weekends, and holidays (with follow-up eConsult or TC the next business day). EMR note templates were created to differentiate eConsults from TCs, whereas telephone-only advice was not captured for SAB patients. No access to in-person ID consultation was available during the study period. For outpatient follow-up, patients could either be seen by their local primary care provider (who could contact the IDt service for outpatient telephonic advice) or by an IDt physician in-person (if the patient lived in close proximity to the central ID clinic).

The IDt pharmacist conducted daily blood culture surveillance on weekdays from 8:00 am – 4:30 pm and participated in daily rounds with the IDt physician to provide recommendations for SAB patients. Upon discovery of SAB, the IDt pharmacist contacted the SCH care team with
recommendations to optimize antibiotics, draw repeat blood cultures, and obtain an IDt consult to facilitate workup for SAB source and complications. IDt consultation was strongly encouraged (not mandatory) for all SAB patients, although the pharmacist did not recommend a consult if the IDt service was already following, or if the SCH team planned to withdraw care or transfer the patient to a higher level of care. All recommendations were logged prospectively in REDCap (Research Electronic Data Capture; copyright 2021 Vanderbilt University). The IDt physicians and pharmacist also undertook extensive education efforts related to SAB including in-depth staffing of cases with frontline SCH clinicians, interactive tele-mentoring webinars, in-person SAB-focused Grand Rounds at selected SCH sites, and highlighting clinical pearls during local stewardship and medical staff meetings. No formal Intermountain guidelines for SAB management were available during the study period.

Data and Outcomes

Data pertaining to patient demographics, comorbidities, microbiology, imaging, hospital course, antibiotic treatment, and IDt consultation were captured electronically from the EDW, whereas severity of illness, source and complications of SAB, source control procedures, readmissions, and follow-up ID clinic visits were captured via manual chart review. 30-day mortality was assessed using Utah and Idaho Department of Health Vital Records.

The primary outcome of interest was adherence to best-practice recommendations in a SAB bundle (Table 1). Adherence to bundle components 1-3 (both individually and combined) was evaluated for the full SCH admission and SCH management populations. Source control within 72 hours (bundle element 4) was evaluated only for a subgroup of patients with a controllable source of SAB (i.e. source could be drained, removed, or debrided), and appropriateness of discharge antibiotics (bundle elements 5 and 6) was evaluated only for SCH management patients who survived to discharge. Criteria for complicated versus uncomplicated SAB were determined from national guidelines, and sources of
bacteremia were classified as high, intermediate, or low risk for mortality based on established definitions (mortality rate >20%, 10-20%, and <10%, respectively). Secondary outcomes included: in-hospital and 30-day mortality; 30-day all-cause and SAB-related readmissions; 90-day SAB recurrence; length of stay (LOS); and transfers. SAB-related readmission was defined as repeat hospitalization due to the same source as the initial infection, metastatic or disseminated complications of SAB, recurrent SAB, or adverse reaction from the antibiotic regimen. LOS was evaluated only among SCH management patients who survived to discharge, and transfers were only evaluated for SCH admission patients. Primary and secondary outcomes were compared in patients with a formal IDt consultation (eConsult or TC with EMR note) and those without an IDt consultation (control group). Outcomes were also compared in control group patients admitted before versus after IDt program implementation in 2016 to identify potential trends.

**Statistical Analysis**

Categorical data were compared using Fisher’s exact test, and continuous data were compared using the Mann-Whitney U test. Multivariate regression analyses were used to determine independent predictors of primary and secondary outcomes using odds ratios with 95% confidence intervals. Covariate adjustors were selected based on previous SAB studies or if the P-value was ≤ 0.1 on univariate analysis. To avoid overfitting, we limited the number of covariates to those with the strongest associations and we assessed goodness of fit using likelihood ratio tests. Logistic regression models were used for all outcomes except LOS, which used a linear regression model. P-values less than 0.05 were considered significant, and all statistical analyses were performed using Stata (version 15.1).

**RESULTS**

**Patients**
A total of 916 patients with SAB were identified between January 2009 and August 2019, and 423 met inclusion criteria: 157 in the IDt group and 266 in the control group (Figure 1). Baseline characteristics were similar between the two groups, with a few key exceptions. Fewer IDt patients were admitted to the smallest rural hospitals (≤ 25 beds) compared to control group patients (6 versus 16%, p = 0.005). The incidence of high, intermediate, and low-risk source of SAB was similar between groups, but the IDt group had more patients with an endovascular source (17 versus 10%, p = 0.049) and fewer patients with an unknown source (10 versus 18%, p = 0.026) compared to the control group. IDt patients also had a higher prevalence of indwelling hardware (39% versus 29%, p = 0.032) (Table 2).

**ID Telehealth Intervention**

IDt physicians completed 309 consult notes for the 157 IDt patients (198 TCs and 111 eConsults). The median number of IDt consult notes per patient was 2 (range 1 – 5). Eighty-one patients (52%) received TCs only, 30 (19%) received eConsults only, and 46 (29%) received a combination of TCs and eConsults. The percentage of eConsults increased over time (15% in 2016-17 to 59% in 2019, p<0.001) while TCs decreased (85% in 2016-17 to 41% in 2019, p<0.001). Notably, there were no significant differences in baseline characteristics, SAB bundle adherence, or clinical outcomes among TC-only versus eConsult-only patients although the small number in each group prevented robust comparisons [e.g. 30-day mortality was 6% (5/81) for TC-only versus 7% (2/30) for eConsult-only, p = 1.000].

Significantly more IDt patients received ID outpatient follow-up visits within 30 and 60 days [28% versus 10% (p<0.001) and 35% versus 11% (p<0.001), respectively].

The IDt pharmacist made 168 recommendations for the 157 IDt patients, of which 164 (98%) were accepted. The most common recommendations were for IDt physician consult (42%), stopping unnecessary antibiotics (23%), and renal dose adjustment (15%). Referral by the IDt pharmacist was the primary reason for IDt physician consult in 70 of the 157 IDt patients (45%). Of the 54 control group
patients admitted after IDt program implementation in 2016, the pharmacist recommended IDt consult for 32 (59%), none of which were accepted. However, acceptance of pharmacist recommendations for IDt consult did increase over time [3/8 (38%) in 2016 versus 25/28 (89%) in 2019, \(p = 0.006\)].

**SAB Bundle Adherence and Outcomes**

Adherence to every SAB bundle component and adherence to bundle components 1-3 combined was significantly higher in the IDt group than the control group for both the SCH admission and SCH management populations (Table 3). In the SCH admission population, the most common reason for bundle non-adherence was lack of negative repeat blood cultures, although 37 patients (12 IDt, 25 control group) received clearance blood cultures after transfer to another facility. The most common reason for non-adherence among SCH management patients was the antibiotic duration prescribed at discharge. In the SCH management population, patients admitted to SCHs ≤ 25 beds had significantly lower adherence to bundle components 1-3 combined than patients admitted to larger hospitals [4/35 (11%) versus 136/287 (47%), respectively, \(p<0.001\)]. However, of the 35 patients admitted to SCHs ≤ 25 beds, IDt intervention significantly improved adherence compared to the control group [3/5 (60%) versus 1/30 (3%), \(p=0.006\)].

Unadjusted in-hospital mortality was similar between groups for both the SCH admission and SCH management populations. 30-day mortality, all-cause readmission, and SAB recurrence all favored the IDt group; however, none of these differences were statistically significant. SAB-related readmissions were significantly lower, and length of stay was significantly longer in the IDt group for the SCH management population (Table 3). Outcomes were not significantly different for control group patients admitted before (2009-2014) versus after (2016-2019) IDt program implementation [SAB bundle adherence 25 vs 22% (\(p = 0.726\)); 30-day mortality 12 versus 7% (\(p = 0.469\)); SAB-related readmission 17 versus 15% (\(p = 0.838\)); and SAB recurrence 6 versus 4% (\(p = 0.743\)), respectively].
Transfer rates were similar between groups. Of the 34 IDt patients who transferred, 27 transfers (79%) were recommended by the IDt physician for procedures that were unavailable at the SCH such as TEE or surgical intervention by a sub-specialty service (e.g. orthopedics or neurosurgery).

In multivariable regression analyses adjusting for age, comorbidities, SCH size, SAB source, and complicated SAB, IDt consultation was an independent predictor of SAB bundle adherence. Odds ratios for mortality and SAB-related readmission favored the IDt group but were not statistically significant (Table 4). These results were robust to sensitivity analyses in which substance use disorder, MRSA, receipt of vasopressors, chronic kidney disease, *Staphylococcus aureus* bacteriuria, and year of admission for the control group were included in the model. IDt consultation was associated with lower 30-day mortality in a subgroup of SCH management patients who had SAB from a controllable source [1/65 (2%) versus 10/117 (9%), OR (95% CI), 0.12 (0.01 – 0.98)], although two variables (Charlson comorbidity index and complicated SAB) had to be excluded from the model due to perfect prediction.

Endocarditis and receipt of vasopressors were predictors of transfer on multivariate analysis, but IDt consultation was not significantly associated with transfers.

**DISCUSSION**

Patients receiving IDt consultation at 16 SCHs had significantly better SAB bundle adherence and reduced SAB-related readmissions compared to the control group. Mortality and SAB recurrence rates also favored the IDt group, although these differences were not statistically significant. No differences in outcomes were found based on IDt consult type (i.e. eConsults versus TCs), and tele-AS surveillance played a key role in antibiotic optimization and referral of SAB patients for IDt consult. These findings provide important insight into the management of SAB in resource-limited settings.

Adherence to best practice recommendations for SAB has been known to improve outcomes for over two decades yet bundle adherence to elements 1-3 was lower than 25% in the control group. Even
lower adherence (3-11%) was noted at the smallest rural hospitals, which might have been impacted by
difficult access to services such as echocardiography. However, the strikingly low adherence rates
suggest that control group patients were often discharged without appropriate workup for SAB source
and complications, which likely explains the higher incidence of SAB from “unknown” source, shorter
length of stay, and higher SAB-related readmissions. Lack of ID clinic follow-up likely also contributed to
higher readmissions in the control group, which has prompted expansion of outpatient video visit
capabilities for our service so patients can access ID follow-up regardless of where they reside. The
overall rates of 30-day mortality (10%) and 90-day SAB recurrence (4%) were lower in our study than in
previous studies. While this prevented a robust comparison to find significant differences, the
mortality and recurrence rates in the IDt group were still favorable compared to the control group.

Determining the optimal type of IDt consult is an important clinical and logistical consideration
for telehealth programs. While telephone-only consultation is inferior for SAB due to lack of valid
information for the consultant and poor adherence to advice, it is possible that eConsults and TCs
(which both involve detailed chart review and EMR documentation) could be feasible alternatives to
bedside consultation in facilities with limited resources, particularly SCHs. We found no difference in
outcomes between eConsults and TCs, although the evaluation was limited by small sample size. Our
ratio of eConsults-to-TCs increased over time for two key reasons: IDt physicians chose eConsults for
efficiency as the service got busier, and they built strong relationships with many local providers
through extensive SAB-related education. This empowered local clinicians to implement best practices
for SAB, which allowed IDt physicians to opt for eConsults when feeling comfortable with management
after conducting in-depth EMR review and communicating with the local provider. While our findings
related to eConsults and TCs for SAB are encouraging, further study is needed to define optimal IDt
consultation types for various ID conditions.
The integration of Tele-AS with the IDt service optimized clinical outcomes. Nearly half of IDt
consults were referred by the IDt pharmacist, which highlights the importance of blood culture
surveillance and early AS intervention when ID consults for SAB are not mandatory. Education efforts
were also key for improving local SAB management and emphasizing the value of IDt consultation to
frontline clinicians, which was reflected in increased acceptance of IDt pharmacist recommendations for
IDt consult over time. While the optimal telehealth model remains to be defined, we continue to
observe the importance and complementary nature of the Tele-AS and IDt components of our program.

There are several noteworthy limitations to our study. First, we did not capture telephone-only
advice in either group. This may have especially influenced the management of control group patients
and biased the study toward finding no difference in several outcomes between groups. Second, we did
not capture concomitant infections, which may have influenced antibiotic prescribing and adherence
rates. Third, the EMR-documented discharge plan may have been subject to change (e.g. change in
antibiotic or duration, or follow-up visits outside our system). Fourth, we did not conduct a cost savings
or cost effectiveness analysis, which is an important area of future study for IDt programs. Lastly, our IDt
interventions occurred within one healthcare system, and the findings may not be applicable to other
healthcare systems or IDt services supporting outreach facilities. While this study also has limitations
inherent to a retrospective evaluation, our findings are consistent with Meredith et al\textsuperscript{11} that IDt plus
Tele-AS intervention can improve SAB outcomes at SCHs.

CONCLUSIONS

An integrated IDt service with Tele-AS surveillance improved management and outcomes of SAB
patients at 16 SCHs within the Intermountain Healthcare system. Our findings support the feasibility and
impact of IDt intervention for SAB in resource-limited settings and provide important insights for other
IDt programs. Additional study is needed regarding the impact of Tele-AS intervention, IDt consultation, and consult modality on outcomes for SAB and other ID conditions.

**FUNDING**

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**POTENTIAL CONFLICTS OF INTEREST**

All authors have no conflicts of interest to report. All conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

**PATIENT CONSENT STATEMENT**

This study was approved by the Intermountain Healthcare Institutional Review Board and was granted a waiver of patient consent due to its design and less than minimal risk to subjects.

**ACKNOWLEDGEMENTS**

We thank the SCH frontline clinicians and team members throughout the Intermountain Healthcare system for their partnership and dedicated leadership efforts in patient care. Countless SCH clinicians and stewardship champions were essential to the success of the IDt service and optimization of patient outcomes. We also thank the Intermountain leadership teams at each SCH, as well as our system Telehealth and Pharmacy Service leaders for their valuable support. Lastly, we thank all of the SCH patients whose clinical experiences contributed to this study and allowed us to learn and improve our SAB-focused care efforts for subsequent patients and providers.
REFERENCES


Figure 1. Flowchart of included patients.

SCH Admission Population – patients with SAB admitted to one of 16 small community hospitals (SCHs).

SCH Management Population – patients with SAB who completed their entire hospital course and received definitive management at the SCH.
Table 1. *Staphylococcus aureus* bacteremia (SAB) bundle components

<table>
<thead>
<tr>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Echocardiogram obtained [either transthoracic (TTE), transesophageal (TEE), or both]</td>
</tr>
<tr>
<td>2. Negative repeat blood cultures obtained prior to SCH discharge to demonstrate SAB clearance</td>
</tr>
<tr>
<td>3. Optimal IV antibiotic administered within 72 hours of index blood culture</td>
</tr>
<tr>
<td>4. Source control procedure (if applicable) performed within 72 hours of index blood culture</td>
</tr>
<tr>
<td>5. Optimal IV antibiotic prescribed at discharge</td>
</tr>
<tr>
<td>6. Optimal IV antibiotic duration prescribed at discharge</td>
</tr>
</tbody>
</table>

Note:

- Cefazolin or nafcillin for MSSA; or vancomycin, daptomycin, linezolid, or ceftaroline for MRSA
- Ideally cefazolin or nafcillin for MSSA, but credit was given for any IV β-lactam with MSSA activity (e.g. ceftriaxone) to allow for dosing convenience and coverage of concomitant organisms if needed; vancomycin, daptomycin, linezolid, or ceftaroline for MRSA
- The final two bundle components were only assessed in patients receiving definitive SCH management who survived to discharge
- ≥ 2 weeks for uncomplicated SAB, ≥ 4 weeks for complicated SAB

SCH – Small community hospital
Table 2. Baseline Characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>IDt Group (n=157)</th>
<th>Control Group (n=266)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year of hospital admission</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>January 2009 – December 2014 (pre IDt)</td>
<td>0 (0)</td>
<td>212 (80)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>October 2016 – August 2019 (post IDt)</td>
<td>157 (100)</td>
<td>54 (20)</td>
<td></td>
</tr>
<tr>
<td><strong>Age in years – median (IQR)</strong></td>
<td>66 (49,75)</td>
<td>64 (51,75)</td>
<td>0.667</td>
</tr>
<tr>
<td><strong>Male</strong></td>
<td>95 (61)</td>
<td>155 (58)</td>
<td>0.683</td>
</tr>
<tr>
<td><strong>Charlson Comorbidity Index – median (IQR)</strong></td>
<td>6 (3,10)</td>
<td>6 (3,10)</td>
<td>0.810</td>
</tr>
<tr>
<td><strong>End-stage renal disease (ESRD)</strong></td>
<td>7 (4)</td>
<td>18 (7)</td>
<td>0.398</td>
</tr>
<tr>
<td><strong>Substance use disorder</strong></td>
<td>23 (15)</td>
<td>24 (9)</td>
<td>0.080</td>
</tr>
<tr>
<td><strong>Admitting hospital size and location:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 25 beds (n = 8 hospitals; all rural)</td>
<td>10 (6)</td>
<td>42 (16)</td>
<td>0.005</td>
</tr>
<tr>
<td>26 – 75 beds (n = 5 hospitals; 1 rural, 4 urban)</td>
<td>44 (28)</td>
<td>113 (42)</td>
<td>0.004</td>
</tr>
<tr>
<td>76 – 150 beds (n = 3 hospitals; all urban)</td>
<td>103 (66)</td>
<td>111 (42)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Source of bacteremia:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>High risk source</strong></td>
<td>48 (31)</td>
<td>77 (29)</td>
<td>0.742</td>
</tr>
<tr>
<td><strong>Endovascular</strong></td>
<td>27 (17)</td>
<td>27 (10)</td>
<td>0.049</td>
</tr>
<tr>
<td>Central nervous system</td>
<td>11 (7)</td>
<td>15 (6)</td>
<td>0.676</td>
</tr>
<tr>
<td>Respiratory</td>
<td>10 (6)</td>
<td>33 (12)</td>
<td>0.066</td>
</tr>
<tr>
<td>Intra-abdominal</td>
<td>0 (0)</td>
<td>2 (1)</td>
<td>0.532</td>
</tr>
<tr>
<td><strong>Intermediate risk source</strong></td>
<td>97 (62)</td>
<td>167 (63)</td>
<td>0.836</td>
</tr>
<tr>
<td>Bone and joint</td>
<td>45 (29)</td>
<td>62 (23)</td>
<td>0.247</td>
</tr>
<tr>
<td>Skin and soft tissue</td>
<td>36 (23)</td>
<td>56 (21)</td>
<td>0.715</td>
</tr>
<tr>
<td>Unknown</td>
<td>16 (10)</td>
<td>49 (18)</td>
<td>0.026</td>
</tr>
<tr>
<td><strong>Low risk source</strong></td>
<td>12 (8)</td>
<td>22 (8)</td>
<td>0.856</td>
</tr>
<tr>
<td>Genitourinary</td>
<td>5 (3)</td>
<td>5 (2)</td>
<td>0.510</td>
</tr>
<tr>
<td>Intravenous catheter</td>
<td>7 (4)</td>
<td>17 (6)</td>
<td>0.395</td>
</tr>
<tr>
<td>MRSA bacteremia</td>
<td>37 (24)</td>
<td>55 (21)</td>
<td>0.542</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em> in urine</td>
<td>18 (11)</td>
<td>22 (8)</td>
<td>0.304</td>
</tr>
<tr>
<td>Presence of hardware</td>
<td>62 (39)</td>
<td>77 (29)</td>
<td>0.032</td>
</tr>
<tr>
<td>Complicated SAB</td>
<td>143 (91)</td>
<td>246 (92)</td>
<td>0.712</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td>------</td>
<td>------</td>
<td>-------</td>
</tr>
<tr>
<td>Intensive Care Unit (ICU) admission</td>
<td>59 (38)</td>
<td>109 (41)</td>
<td>0.538</td>
</tr>
<tr>
<td>Vasopressors</td>
<td>13 (8)</td>
<td>10 (4)</td>
<td>0.073</td>
</tr>
<tr>
<td>Mechanical ventilation</td>
<td>2 (1)</td>
<td>10 (4)</td>
<td>0.224</td>
</tr>
</tbody>
</table>

*Values are presented as number (%) unless otherwise noted.

IDt – Infectious Diseases telehealth; IQR – interquartile range; MRSA – methicillin-resistant

*Staphylococcus aureus*
Table 3. *Staphylococcus aureus* bacteremia (SAB) Bundle Adherence and Clinical Outcomes

<table>
<thead>
<tr>
<th></th>
<th>IDt Group (n = 157)</th>
<th>Control Group (n = 266)</th>
<th>p-value</th>
<th>IDt Group (n = 117)</th>
<th>Control Group (n = 205)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAB bundle adherence (Primary Outcome)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adherence to bundle elements 1-3</td>
<td>115 (73)</td>
<td>65 (24)</td>
<td>&lt;0.001</td>
<td>93 (79)</td>
<td>47 (23)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>1. Echocardiogram (TTE, TEE, or both)</td>
<td>140 (89)</td>
<td>131 (49)</td>
<td>&lt;0.001</td>
<td>105 (90)</td>
<td>87 (42)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>2. Negative repeat blood cultures obtained</td>
<td>142 (90)</td>
<td>116 (44)</td>
<td>&lt;0.001</td>
<td>115 (98)</td>
<td>88 (43)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>3. Optimal IV antibiotics within 72 hours</td>
<td>137 (87)</td>
<td>131 (49)</td>
<td>&lt;0.001</td>
<td>101 (86)</td>
<td>91 (44)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>4. Source control within 72 hours</td>
<td>67/96 (70)</td>
<td>83/155 (54)</td>
<td>0.012</td>
<td>53/65 (82)</td>
<td>67/117 (57)</td>
<td>0.001</td>
</tr>
<tr>
<td>5. Optimal IV antibiotic prescribed at dischargec</td>
<td>113/114 (99)</td>
<td>112/198 (57)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Optimal duration prescribed at dischargec</td>
<td>100/114 (88)</td>
<td>63/198 (32)</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Secondary Outcomes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In-hospital mortality</td>
<td>5 (3)</td>
<td>9 (3)</td>
<td>1.000</td>
<td>3 (3)</td>
<td>7 (3)</td>
<td>0.752</td>
</tr>
<tr>
<td>30-day mortality</td>
<td>12 (8)</td>
<td>30 (11)</td>
<td>0.244</td>
<td>6 (5)</td>
<td>19 (9)</td>
<td>0.202</td>
</tr>
<tr>
<td>30-day all-cause readmission</td>
<td>23 (15)</td>
<td>56 (21)</td>
<td>0.121</td>
<td>15 (13)</td>
<td>41 (20)</td>
<td>0.126</td>
</tr>
<tr>
<td>30-day SAB-related readmission</td>
<td>15 (10)</td>
<td>44 (17)</td>
<td>0.058</td>
<td>10 (9)</td>
<td>34 (17)</td>
<td>0.045</td>
</tr>
<tr>
<td>90-day SAB recurrence</td>
<td>4 (3)</td>
<td>15 (6)</td>
<td>0.154</td>
<td>2 (2)</td>
<td>12 (6)</td>
<td>0.094</td>
</tr>
<tr>
<td>Length of stay – median (IQR)d</td>
<td>-</td>
<td>-</td>
<td></td>
<td>-</td>
<td>-</td>
<td>0.043</td>
</tr>
<tr>
<td>Transfers</td>
<td>34 (22)</td>
<td>47 (18)</td>
<td>0.371</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

a Values are presented as number (%) unless otherwise noted
b Denominators represent only those patients who were eligible for source control in each group
c Denominators represent only SCH management patients who survived to discharge
d Length of stay was calculated only for SCH management patients who survived to discharge

TTE – transthoracic echocardiogram, TEE – transesophageal echocardiogram, IV – intravenous, IQR – interquartile range
Table 4. Multivariate analysis models for predictors of Staphylococcus aureus bacteremia (SAB) bundle adherence, SAB-related readmission, and 30-day mortality in the SCH management population

<table>
<thead>
<tr>
<th>Variable</th>
<th>SAB bundle adherence&lt;sup&gt;a,b&lt;/sup&gt;</th>
<th>p-value</th>
<th>SAB-related readmission&lt;sup&gt;b&lt;/sup&gt;</th>
<th>p-value</th>
<th>30-day mortality&lt;sup&gt;b&lt;/sup&gt;</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDt group (versus control)</td>
<td>16.9 (9.2–31.0)</td>
<td>&lt;0.001</td>
<td>0.5 (0.2–1.0)</td>
<td>0.057</td>
<td>0.5 (0.2–1.4)</td>
<td>0.170</td>
</tr>
<tr>
<td>Admission to SCH ≤ 25 beds</td>
<td>0.2 (0.08–0.7)</td>
<td>&lt;0.001</td>
<td>0.9 (0.3–2.4)</td>
<td>0.828</td>
<td>0.7 (0.1–3.8)</td>
<td>0.699</td>
</tr>
<tr>
<td>Age</td>
<td>1.0 (0.9–1.1)</td>
<td>0.431</td>
<td>0.9 (0.9–1.1)</td>
<td>0.309</td>
<td>1.2 (0.9–1.5)</td>
<td>0.193</td>
</tr>
<tr>
<td>Age&lt;sup&gt;^2&lt;/sup&gt;</td>
<td>1.0 (0.9–1.0)</td>
<td>0.426</td>
<td>1.0 (0.9–1.0)</td>
<td>0.806</td>
<td>1.0 (0.9–1.0)</td>
<td>0.482</td>
</tr>
<tr>
<td>Charlson comorbidity index &gt; 4</td>
<td>1.2 (0.5–2.9)</td>
<td>0.653</td>
<td>2.0 (0.8–4.9)</td>
<td>0.147</td>
<td>1.2 (0.3–5.4)</td>
<td>0.846</td>
</tr>
<tr>
<td>Endocarditis</td>
<td>7.3 (2.6–20.5)</td>
<td>&lt;0.001</td>
<td>1.1 (0.3–4.2)</td>
<td>0.939</td>
<td>2.3 (0.4–12.3)</td>
<td>0.314</td>
</tr>
<tr>
<td>Complicated SAB</td>
<td>0.08 (0.03–0.2)</td>
<td>&lt;0.001</td>
<td>–&lt;sup&gt;c&lt;/sup&gt;</td>
<td>–</td>
<td>1.9 (0.3–13.3)</td>
<td>0.537</td>
</tr>
</tbody>
</table>

<sup>a</sup>Adherence to SAB bundle elements 1-3 combined

<sup>b</sup>Multivariate analysis results were not meaningfully different when adding substance use disorder, MRSA, receipt of vasopressors, chronic kidney disease, and Staphylococcus aureus in urine to any of the three models. Furthermore, results were not meaningfully different when adding control group year of admission (2009-2014 versus 2016-2019) to any of the three models.

<sup>c</sup>Complicated SAB was excluded from this multivariate analysis (SAB-related readmission in the SCH management population) due to perfect prediction but was found to be a predictor of SAB-related readmission in the SCH admission population [OR (95% CI), 7.7 (1.1–55.3), p=0.044]

OR – odds ratio, 95% CI – 95% confidence interval, SCH – small community hospital