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Implementation of Telemedicine Infectious Diseases Consultation in a Rural Hospital Using the Active Implementation Framework

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In this pilot study, guided by the Active Implementation Framework, telemedicine infectious diseases consultation was provided to hospitalized inpatients at a rural Missouri hospital. Measured outcomes included the implementation outcomes of feasibility, acceptability, appropriateness, and fidelity, as well as clinical outcomes of readmissions and death.

Keywords. acceptability; active implementation framework; appropriateness; feasibility; telemedicine infectious diseases consultation.

For inpatients with various infections, consultation with an infectious diseases (ID) physician leads to reduced mortality, fewer hospital readmissions, and receipt of guideline-adherent care [1]. Many underserved, economically disadvantaged, and/or rural areas do not have access to ID physicians (~45% of United States [US] hospitals and 80% of US counties) [2, 3]. Providing access to ID expertise could substantially improve patient outcomes in these settings.

Despite telemedicine's usefulness and its surge in use during the severe acute respiratory syndrome coronavirus 2 pandemic, best practices for its implementation are not well studied among inpatients. Small studies evaluating telemedicine antimicrobial stewardship in rural Veterans Affairs hospitals have not involved direct contact between remote physicians and hospitalized patients [4, 5].

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To better understand its implementation, we conducted a pilot study of inpatient telemedicine ID consultation in a rural Missouri hospital for patients with bloodstream infections. This project used the Active Implementation Framework [6], proceeding through the phases of exploration, installation, initial implementation, and full implementation (Figure 1). We assessed feasibility, acceptability, and appropriateness of telemedicine ID consultation.

METHODS

The Active Implementation Framework's exploration phase was initiated in March 2018 (Figure 1) in preparation for a larger telemedicine implementation study. The rural hospital's interest in inpatient telemedicine ID consultation was assessed. Supplementary Figure 1 describes the innovation, implementation drivers, implementation stages, cycles, and relevant project teams.

The installation phase involved contract negotiations, information technology issues, credentialing, and acquiring access to telemedicine software (Figure 1). Additional steps included assignments of priorities/roles at hub and spoke hospitals, establishing telemedicine consent forms, regulatory approvals, and an electronic medical record (EMR) algorithm to alert the principal investigator (PI) to positive blood cultures from the rural hospital.

Contract negotiation between hospitals lasted approximately 6 months. Mock consultation testing began in June 2019 (Figure 1). After troubleshooting and initial implementation, full implementation began in July 2019. Positive blood culture notifications were sent to the PI's EMR inbox. The PI reviewed alerts and determined whether patients were still at the rural hospital at the time of alert firing (ie, not deceased or transferred at time of blood culture positivity; see Results). For patients still admitted, the PI called the inpatient provider and discussed whether the patient could consent for telemedicine ID consultation and whether the provider was interested in a consultation. This was a flexible process—if the rural provider noted the positive blood culture before the PI, the provider could contact the PI to initiate a consult.

Providers (physicians and nurses) completed a survey on feasibility, acceptability, and appropriateness [7], which was adapted for telemedicine ID consultation (Appendix A). Providers could complete this survey more than once during the study.

All telemedicine ID consultations were performed by the PI, which included medical record review, face-to-face video discussion with patients, and documenting findings and recommendations in the EMR. Follow-up consultations could be

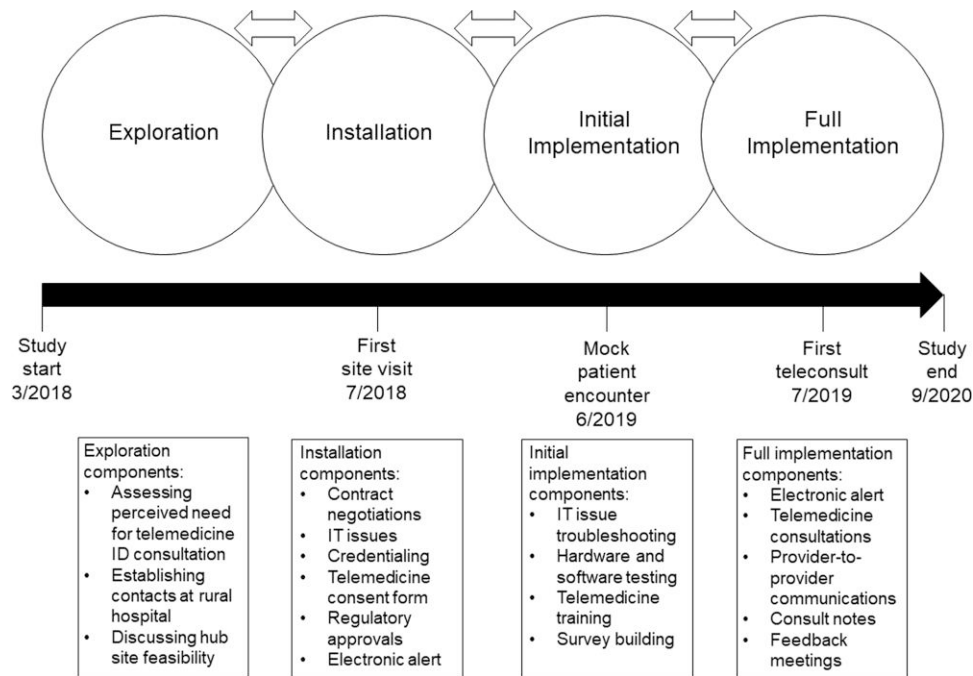


Figure 1. Active Implementation Framework diagram of study procedures and timeline. Abbreviations: ID, infectious diseases; IT, information technology.

face-to-face video, electronic (record review only), or by phone with provider only.

After discharge, readmission or death was tracked for 30 days. Recommendations from the ID provider were documented in the chart. To measure fidelity to relevant treatment guidelines [8–18], whether recommendations from the ID provider were followed by the consulting provider was tracked.

Hospital

The rural facility is a 35-bed hospital with medical and surgical beds and an intensive care unit. There were no on-site ID physicians during the study.

Definitions

We tracked the following implementation outcomes from Proctor [19]: fidelity, acceptability, appropriateness, and feasibility (Supplementary Figure 1). Fidelity was defined as the extent to which practitioners adhere to how the evidence-based intervention is intended to be implemented and thus, maintain the intervention’s effectiveness—that is, the extent to which clinicians adhere to treatment guidelines. We defined acceptability as the perception among stakeholders (rural providers/patients) that a given service (telemedicine ID consultation) was agreeable, palatable, or satisfactory. We defined appropriateness as perceived fit, relevance, or compatibility of telemedicine ID consultation for rural providers/patients. We defined feasibility as the extent to which telemedicine ID consultation was perceived as implementable by rural providers/patients.

Our evidence-based intervention was guidelines for the treatment of bloodstream infections. Our implementation strategy was telemedicine ID consultation. Our innovation was use of an implementation science framework to study this process. Standards for Reporting Implementation Studies (StaRI) is used for checklist reporting (Supplementary Checklist) [20].

Patient Consent Statement

This study was approved by the Washington University in St Louis Institutional Review Board. Patients undergoing telemedicine consultation were consented by rural hospital providers and signed written consent forms.

RESULTS

Over the 15-month study, 155 positive blood cultures were alerted. Of these, 8 (5%) patients died before consultation could occur, 52 (34%) had been transferred, 4 (3%) were unable to consent, 14 (9%) left against medical advice or were discharged from the emergency department, and 31 (20%) had contaminated blood cultures. Of the 46 remaining possible consults, 43 of 155 (28% of total culture alerts) patients underwent telemedicine consultation.

Organisms detected from blood cultures are listed in Supplementary Table 1. A total of 175 organisms were isolated from 155 blood cultures. Among patients receiving

telemedicine ID consultation, 55 organisms were isolated, most commonly Enterobacterales, staphylococci, and streptococci.

Of patients undergoing telemedicine ID consultation, 8 were readmitted and 1 died within 30 days of hospital discharge.

Of 43 telemedicine ID consultations, recommendations from the ID consultant were completely followed in 83.7% of cases. Complete fidelity to treatment guidelines went from 0% (0/14 patients) in the 6 months prior to the first telemedicine ID consult to 83.7% (36/43 patients) during the study.

Regarding the survey, of providers, 27 surveys were completed by nurses, 2 by physicians, and 29 by patients. Among nurses, 1 completed the survey 3 times during the study; 2 completed it twice. Years at current job ranged from 1 to 40 years (total of 19 responses). Survey results are shown in [Table 1](#) and [Supplementary Tables 2–4](#). Overall, acceptability, appropriateness, and feasibility received predominantly positive responses (agree or strongly agree). The summary scores for each measure, for patients and providers, were above 4, indicating strong perceptions of acceptability, appropriateness, and feasibility of telemedicine ID consultation ([Table 1](#)).

DISCUSSION

We observed that telemedicine ID consultation in a rural Missouri hospital was deemed feasible, acceptable, and appropriate by providers and patients. In addition, fidelity to treatment guidelines increased during the study.

A recent systematic review found few studies reporting outcomes from telemedicine ID consultations [21]. However, other disciplines have data regarding telemedicine and important outcomes. In a teledermatology study assessing acceptability and feasibility with the instrument developed by Weiner and used also for our study [7], synchronous audio and video visits with stored digital photos were deemed acceptable to patients and physicians [22]. This study also addressed feasibility; synchronous audio/video visits were also deemed feasible [22].

Table 1. Summary Scores of Acceptability of Intervention Measure, Intervention Appropriateness Measure, and Feasibility of Intervention Measure for Providers and Patients

Measure	Summary Score	% of Participants Rating at Least Agree to Measures
AIM (acceptability)		
Patients	4.43	91%
Providers	4.81	99%
IAM (appropriateness)		
Patients	4.40	94%
Providers	4.83	100%
FIM (feasibility)		
Patients	4.38	93%
Providers	4.83	100%

Abbreviations: Acceptability of Intervention Measure (AIM), Intervention Appropriateness Measure (IAM), and Feasibility of Intervention Measure

A commonly reported outcome for telemedicine is patient and/or provider satisfaction. Inpatient neurology consultations were associated with high patient/provider satisfaction [23]. Patient satisfaction for hospital-based consultation was demonstrated for ophthalmology consultations in emergency departments [24]. Among patients seeing orthopedists via telemedicine, patient satisfaction was high, with a low percentage reporting difficulty understanding/following instructions/recommendations provided via telemedicine [25]. Even in high-acuity, high-emotion situations such as pediatric critical care in emergency departments and palliative care consultation, telemedicine had high satisfaction among patients, families, and/or providers [26, 27]. While this does not directly measure acceptability, appropriateness, and feasibility, it may be a reasonable, temporary surrogate in the absence of widely disseminated knowledge of implementation outcomes by researchers.

One aspect of inpatient telemedicine ID consultation not addressed by the Active Implementation Framework was sustainability. At the time of writing of this manuscript, sustainability of this program is an issue. This work was supported by a career development award of the PI, and when that grant ended, the contract with the rural hospital was ended by the PI's institution. The hub and spoke hospitals are working toward a solution for future telemedicine ID consultation. This work has facilitated initiation of a telemedicine program for intravenous opioid users at the rural hospital. In addition, this pilot study led to telemedicine programs at 2 other hospitals in the region without on-site ID physicians.

Barriers to sustainability include staff turnover and infrastructure. The intervention ended when the PI had to dedicate his time to non-grant duties (ie, coronavirus disease 2019 pandemic). In addition, local champions at the rural hospital moved or had changes in their roles that complicated sustainability. For example, 1 manager who had been leading day-to-day telemedicine activities, including patient consent and moving the telemedicine apparatus, changed job titles and was no longer involved in telemedicine. One of the rural physician champions moved states. The small size of rural hospitals puts programs such as this in jeopardy, and contingency plans should be outlined at the start of work such as this.

One limitation of this study is its size—a single, small rural hospital in Missouri without a comparison group. Our findings may not be applicable to other locations. However, the processes and procedures used (implementation science, Active Implementation Framework) can and should be broadly applied with an eye for sustainability.

In conclusion, telemedicine ID consultation was deemed feasible, acceptable, and appropriate. Sustainability was challenging due to staff turnover and funding issues, which should be accounted for in future projects in small, rural settings.

Supplementary Data

Supplementary materials are available at *Open Forum Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

Notes

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Potential conflicts of interest. The authors: No reported conflicts of interest.

All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

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APPENDIX A

	Completely disagree	Disagree	Neither agree nor disagree	Agree	Completely agree
1. Telemedicine infectious diseases consultation meets my approval.	①	②	③	④	⑤
2. Telemedicine infectious diseases consultation is appealing to me.	①	②	③	④	⑤
3. I like telemedicine infectious diseases consultation.	①	②	③	④	⑤
4. I welcome telemedicine infectious diseases consultation.	①	②	③	④	⑤

	Completely disagree	Disagree	Neither agree nor disagree	Agree	Completely agree
1. Telemedicine infectious diseases consultation seems fitting.	①	②	③	④	⑤
2. Telemedicine infectious diseases consultation seems suitable.	①	②	③	④	⑤
3. Telemedicine infectious diseases consultation seems applicable.	①	②	③	④	⑤
4. Telemedicine infectious diseases consultation seems like a good match.	①	②	③	④	⑤

	Completely disagree	Disagree	Neither agree nor disagree	Agree	Completely agree
1. Telemedicine infectious diseases consultation seems implementable.	①	②	③	④	⑤
2. Telemedicine infectious diseases consultation seems possible.	①	②	③	④	⑤
3. Telemedicine infectious diseases consultation seems doable.	①	②	③	④	⑤
4. Telemedicine infectious diseases consultation seems easy to use.	①	②	③	④	⑤