11-1-2022

Implementation of telemedicine infectious diseases consultation in a rural hospital using the Active Implementation Framework

Jason P Burnham

Stephanie A Fritz

Graham A Colditz

Open Forum Infectious Diseases

BRIEF REPORT

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

Jason P. Burnham,[1] Stephanie A. Fritz,[2] and Graham A. Colditz[3]

[1]Division of Infectious Diseases, Washington University School of Medicine, St Louis, Missouri, USA, [2]Department of Pediatrics, Washington University in St Louis, St Louis, Missouri, USA, and [3]Division of Public Health Sciences, Washington University School of Medicine, St Louis, Missouri, USA

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].

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

Received 26 August 2022; editorial decision 29 September 2022; accepted 04 October 2022; published online 6 October 2022

Correspondence: Jason P. Burnham, MD, Division of Infectious Diseases, Washington University School of Medicine, 4523 Clayton Ave, Campus Box 8051, St Louis, MO 63110 (burnham@wustl.edu).

Open Forum Infectious Diseases®

https://doi.org/10.1093/ofid/ofac523

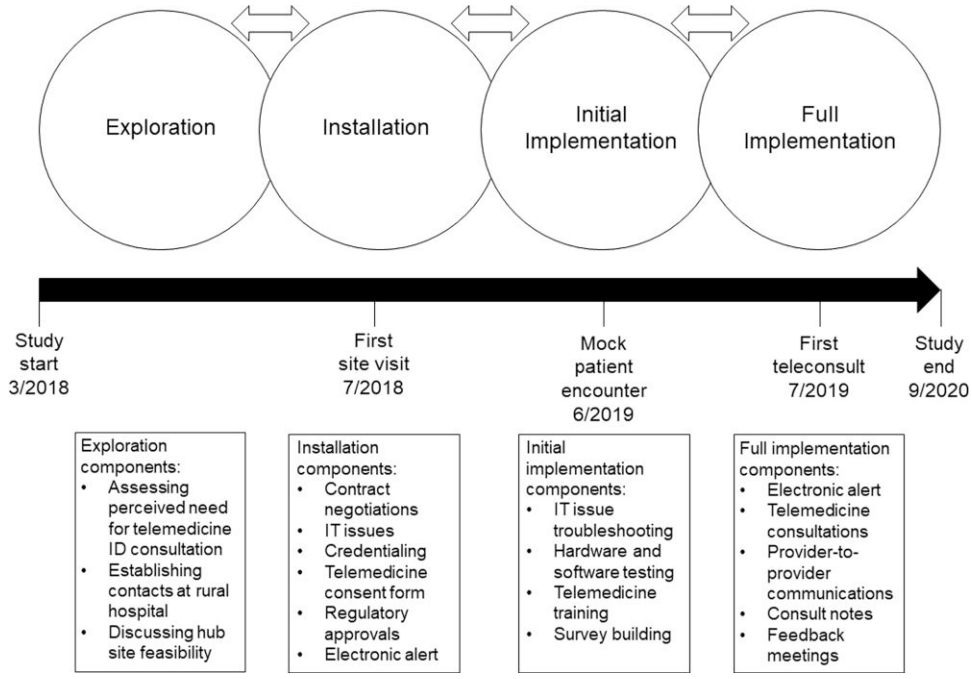

Figure 1. Active Implementation Framework diagram of study procedures and timeline. Abbreviations: ID, infectious diseases; IT, information technology.

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

Financial support. This work was supported by the National Institutes of Health (NIH), National Center for Advancing Translational Sciences (NCATS) (grant number UL1 TR002345, subaward KL2 TR002346 to J. P. B.), components of the NIH, and the NIH Roadmap for Medical Research. This publication was also supported by The Foundation for Barnes-Jewish Hospital and their generous donors and the Washington University Institute of Clinical and Translational Sciences, which is, in part, supported by the NIH/NCATS, Clinical and Translational Science Award (number UL1TR002345).

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.

References

1. Burnham JP, Olsen MA, Stwalley D, Kwon JH, Babcock HM, Kollef MH. Infectious diseases consultation reduces 30-day and 1-year all-cause mortality for multidrug-resistant organism infections. Open Forum Infect Dis **2018**; 5: ofy026.
2. McQuillen DP, MacIntyre AT. The value that infectious diseases physicians bring to the healthcare system. J Infect Dis **2017**; 216(Suppl 5):S588–93.
3. Walensky RP, McQuillen DP, Shahbazi S, Goodson JD. Where is the ID in COVID-19? Ann Intern Med **2020**; 173:587–9.
4. Wilson BM, Banks RE, Crnich CJ, et al. Changes in antibiotic use following implementation of a telehealth stewardship pilot program. Infect Control Hosp Epidemiol **2019**; 40:810–4.
5. Stevenson LD, Banks RE, Stryczek KC, et al. A pilot study using telehealth to implement antimicrobial stewardship at two rural Veterans Affairs medical centers. Infect Control Hosp Epidemiol **2018**; 39:1163–9.
6. Fixsen DL, Naoom SF, Blase KA, Friedman RM, Wallace F. Implementation research: a synthesis of the literature, FMHI. Tampa: University of South Florida; **2005**.
7. Weiner BJ, Lewis CC, Stanick C, et al. Psychometric assessment of three newly developed implementation outcome measures. Implement Sci **2017**; 12:108.
8. Liu C, Bayer A, Cosgrove SE, et al. Clinical practice guidelines by the Infectious Diseases Society of America for the treatment of methicillin-resistant *Staphylococcus aureus* infections in adults and children: executive summary. Clin Infect Dis **2011**; 52:285–92.
9. Kusumoto FM, Schoenfeld MH, Wilkoff BL, et al. 2017 HRS expert consensus statement on cardiovascular implantable electronic device lead management and extraction. Heart Rhythm **2017**; 14:e503–51.
10. Mermel LA, Allon M, Bouza E, et al. Clinical practice guidelines for the diagnosis and management of intravascular catheter-related infection: 2009 update by the Infectious Diseases Society of America. Clin Infect Dis **2009**; 49:1–45.
11. Osmon DR, Berbari EF, Berendt AR, et al. Diagnosis and management of prosthetic joint infection: clinical practice guidelines by the Infectious Diseases Society of America. Clin Infect Dis **2013**; 56:e1–25.
12. Berbari EF, Kanj SS, Kowalski TJ, et al. 2015 Infectious Diseases Society of America (IDSA) clinical practice guidelines for the diagnosis and treatment of native vertebral osteomyelitis in adults. Clin Infect Dis **2015**; 61:e26–46.
13. Kalil AC, Metersky ML, Klompas M, et al. Management of adults with hospital-acquired and ventilator-associated pneumonia: 2016 clinical practice guidelines by the Infectious Diseases Society of America and the American Thoracic Society. Clin Infect Dis **2016**; 63:e61–111.
14. Taplitz RA, Kennedy EB, Bow EJ, et al. Outpatient management of fever and neutropenia in adults treated for malignancy: American Society of Clinical Oncology and Infectious Diseases Society of America clinical practice guideline update. J Clin Oncol **2018**; 36:1443–53.
15. Hooton TM, Bradley SF, Cardenas DD, et al. Diagnosis, prevention, and treatment of catheter-associated urinary tract infection in adults: 2009 international clinical practice guidelines from the Infectious Diseases Society of America. Clin Infect Dis **2010**; 50:625–63.
16. Baddour LM, Wilson WR, Bayer AS, et al. Infective endocarditis in adults: diagnosis, antimicrobial therapy, and management of complications: a scientific statement for healthcare professionals from the American Heart Association. Circulation **2015**; 132:1435–86.
17. Rybak M, Lomaestro B, Rotschafer JC, et al. Therapeutic monitoring of vancomycin in adult patients: a consensus review of the American Society of Health-System Pharmacists, the Infectious Diseases Society of America, and the Society of Infectious Diseases Pharmacists. Am J Health Syst Pharm **2009**; 66: 82–98.
18. Goto M, Schweizer ML, Vaughan-Sarrazin MS, et al. Association of evidence-based care processes with mortality in *Staphylococcus aureus* bacteremia at Veterans Health Administration hospitals, 2003–2014. JAMA Intern Med **2017**; 177:1489–97.
19. Proctor E, Silmere H, Raghavan R, et al. Outcomes for implementation research: conceptual distinctions, measurement challenges, and research agenda. Adm Policy Ment Health **2011**; 38:65–76.
20. Pinnock H, Barwick M, Carpenter CR, et al. Standards for Reporting Implementation Studies (StaRI) statement. BMJ **2017**; 356:i6795.
21. Burnham JP, Fritz SA, Yaeger LH, Colditz GA. Telemedicine infectious diseases consultations and clinical outcomes: a systematic review. Open Forum Infect Dis **2019**; 6:ofz517.
22. Briggs SM, Lipoff JB, Collier SM. Using implementation science to understand teledermatology implementation early in the COVID-19 pandemic: cross-sectional study. JMIR Dermatol **2022**; 5:e33833.
23. Pj J, Am T, Re S, et al. Inpatient telemedicine for neurology consultation at satellite hospitals: patient and provider perspectives. Neurohospitalist **2022**; 12: 476–83.
24. Kalra G, Commiskey PW, Schempf T, et al. Initial results and patient survey of virtual inpatient ophthalmology consultations during the COVID-19 pandemic. Semin Ophthalmol **2021**; 36:461–8.
25. Kumar S, Kumar A, Kumar M, Kumar A, Arora R, Sehrawat R. Feasibility of telemedicine in maintaining follow-up of orthopaedic patients and their satisfaction: a preliminary study. J Clin Orthop Trauma **2020**; 11:S704–S10.
26. Kuntz JG, Kavalieratos D, Esper GJ, et al. Feasibility and acceptability of inpatient palliative care E-family meetings during COVID-19 pandemic. J Pain Symptom Manage **2020**; 60:e28–32.
27. Heath B, Salerno R, Hopkins A, Hertzig J, Caputo M. Pediatric critical care telemedicine in rural underserved emergency departments. Pediatr Crit Care Med **2009**; 10:588–91.

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