



The Emerging Role of Telehealth in Antimicrobial Stewardship: A Systematic Review and Perspective

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Abstract

Purpose of Review The purpose of this article is to critically evaluate the available literature on telehealth and antimicrobial stewardship.

Recent Findings There is limited evidence regarding the role of telehealth within the discipline of antimicrobial stewardship. A review of the available literature suggests remote antimicrobial stewardship programs conducted via telehealth can decrease antimicrobial consumption. A direct comparison between traditional antimicrobial stewardship programs and remote antimicrobial stewardship programs is lacking.

Summary Telehealth is a promising tool for expanding antimicrobial stewardship, especially in small rural or community hospitals. Trust, team, and technology, the three Ts of remote antimicrobial stewardship derived from themes within the available literature, can serve as a framework for developing a remote antimicrobial stewardship program.

Introduction

Telehealth is an emerging field that has a potential role in expanding antimicrobial stewardship to small and critical access hospitals. This review seeks to summarize the available literature on the utilization of telehealth for providing antimicrobial stewardship.

The 2019 United States Centers for Disease Control and Prevention (CDC) core elements for hospital antibiotic stewardship suggest the use of off-site or remote Infectious Diseases (ID)-trained providers when local resources are not available [1••]. A recent report published in the *Annals of Internal Medicine* found that in 2017 roughly 80% of counties in the USA did not have an ID physician [2]. A 2012 survey showed that 40% of Veteran's Affairs Medical Centers with inpatient care did not have full-time ID physicians on staff [3]. Also in 2019, the Centers for Medicare and Medicaid Services (CMS) set a requirement for all acute-care hospitals that utilize Medicare or Medicaid to include antimicrobial stewardship by March 30, 2020 [4••]. The COVID-19 pandemic has highlighted the disparity in access to ID physicians, and novel strategies are needed to meet the demand for ID expertise. Telehealth is a potential solution to increasing ID physician access.

Additionally, the pandemic has brought telemedicine to the forefront for medical providers around the world. As of quarter three of 2020, venture capital funding in telehealth had reached \$9.4 billion USD—already surpassing the previous annual record of \$8.2 billion in 2018 [5].

The Infectious Diseases Society of America (IDSA) published a position statement in 2019 on the role of telehealth in the field of Infectious Diseases [6•].

They note the Health Resources Services Administration defines telehealth as “the use of electronic information and telecommunications technologies to support long-distance clinical healthcare, patient and professional health-related education, public health and health administration.” According to definitions put forth by the IDSA, telehealth with antimicrobial stewardship would primarily involve asynchronous telemedicine without direct patient communication. The IDSA supports the use of telehealth in antimicrobial stewardship to expand access to antimicrobial stewardship to community hospitals [6•].

A recent systematic review examined the effectiveness of telehealth with ID consultation demonstrating comparable efficacy to in-person consultation based on limited available evidence [7]. A separate review focused more broadly on the application of telehealth in ID practice. They demonstrated similar outcomes in the outpatient setting for patients with HCV, HIV, and tuberculosis, whether clinic visits were conducted in-person or through telehealth services [8]. In 2018 Pottinger et al. provided an overview of the literature and potential value of antimicrobial stewardship conducted via telehealth. They highlighted the need for telehealth in antimicrobial stewardship given the vast disparity between available ID specialists and the number of hospitals. They purported that the fundamentals of a successful stewardship program include building trust with a remote institution through periodic face-to-face communication [9]. To our knowledge, there has been no comprehensive systematic review on the role of telehealth in antimicrobial stewardship.

Methods

A systematic literature review was performed using PubMed on September 14, 2020. Search terms utilized were “Antimicrobial Stewardship” and “Telehealth” along with “Antibiotic Stewardship” and “Telehealth” and finally “Telestewardship.” Only English language articles were included if no translation was available. There was no date range limitation, but all articles were published between 2012 and 2020. Articles were included if they described an antimicrobial stewardship intervention performed by an off-site team utilizing telehealth capabilities such as phone calls, video conferencing, email,

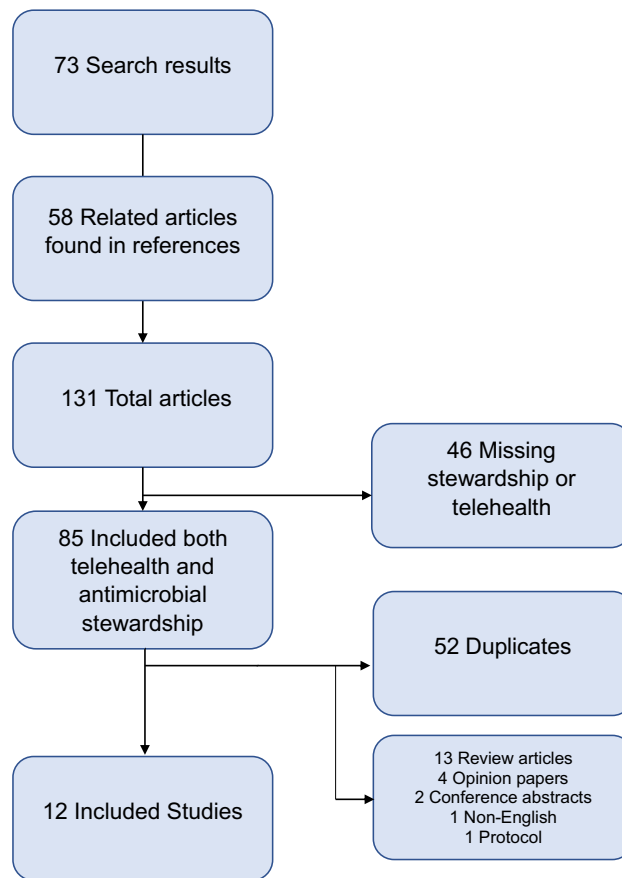


Fig. 1 Literature search results. Seventy-three initial search results were found and an additional 58 related articles were located within the references of these initial references. Studies with horizontal arrows indicate excluded studies. Twelve studies were included in the final analysis

electronic medical record documentation, or other methods of remote communication. All references of included articles were reviewed for the relevant search terms. Conference abstracts were excluded if outcome data could not be determined. See Fig. 1 for the search process. Primary outcomes were included as specified in the article or if not specified (or if multiple primary outcomes were listed) the first listed measurable outcome was labeled as the primary outcome,¹ and all other outcomes were labeled as secondary. Study quality was determined utilizing previously published methodology [10].

Outcomes were sorted based on antimicrobial stewardship intervention. Examples included prospective audit and feedback (PAF), antimicrobial restriction, IV to PO conversion, etc.

¹ In one study, “main topic discussed” was inferred to mean primary outcome [18].

Results

A total of 131 articles were reviewed, and 12 met inclusion criteria (Table 1). The quality of included studies was generally low consisting, primarily of observational and quasi-experimental studies with only one randomized controlled trial.

Eight studies were conducted in the USA, two in Brazil, and two in Europe. Primary study sites were community hospitals, three included long-term acute care hospitals, and one study was in the outpatient primary care setting. One study examined a pediatric inpatient population [18], the remainder focused on adults.

The most common ASP intervention was prospective audit and feedback (PAF) included in 58% (7/12) studies.

The most common primary outcome was antimicrobial consumption reported in 5 of the included studies [11, 13, 14, 16, 20]. Four of the five studies demonstrated a statistically significant decrease in antimicrobial consumption with the implementation of telehealth antimicrobial stewardship [11, 13, 14, 16].

One study demonstrated a statistically significant decrease in antimicrobial prescriptions for upper respiratory tract infections in the outpatient setting [17]. A separate study examined effects on compliance with local guidelines with a statistically significant increase in the rate of adherence [15]. One study demonstrated a significant decrease in isolation of multi-drug resistant organisms [18]. One study found a statistically significant decrease in hospital-acquired *Clostridioides difficile* infection as a secondary outcome [14].

A single study expressed concern the local private practice ID physician would experience decreased financial compensation from lower consult volume with the implementation of telestewardship and evaluated the effect on ID consultations. They found a 40% increase in consultation following telehealth antimicrobial stewardship implementation [13]. Another study examined the time commitment required to perform telestewardship and found an average of 3.6 h per week of time from a remote ID pharmacy resident [22].

Personnel

Of the examined studies, 83% (10/12) of telehealth antimicrobial stewardship programs consisted of a remote ID physician (one study utilized an internal medicine trained associated medical director [19], and another consisted of pharmacists [22]) and 25% (3/12) included a remote pharmacist [14, 20, 22]. One-third (4/12) of local sites created a local ASP team consisting of local providers, infection prevention nurses, and pharmacists [12, 16, 17, 23]. The other two-thirds only utilized local providers communicating with the remote ASP team.

Table 1 Summary of studies reviewed

Author	Year	Study design	Primary outcome	Secondary outcomes	Population	Intervention	Statistical significance (primary)	Statistical significance (secondary)	N	Quality	Acceptance rate
dos Santos [11]	2019	Quasi-experimental	Antimicrobial consumption	"Appropriateness," antimicrobial resistance, hand rub use, cost	55-bed community hospital in Brazil	PAF ¹	Significant reductions in the consumption of fluoroquinolones, first-generation cephalosporins, and ceftriaxone	"Appropriateness" and cost. Decrease in the rate of carbapenem-resistant Acinetobacter spp. isolation	11,088 prescriptions for 6163 patients	***	Not reported
Stevenson [12]	2018	Prospective quasi-experimental pilot study	Provider perceptions	Recommendation acceptance rate	Two rural VAMCs ² 342 total acute-care and long-term care beds	Weekly meetings to discuss cases	N/A	N/A	259 cases over 78 sessions between both sites	*	73%
Shively [13]	2020	Prospective observational, semi-structured interviews	Antimicrobial consumption	ID consultation, cost	Two community hospitals with 461 total beds	PAF, Restriction, guideline development, provider education	Broad spectrum antimicrobial utilization decreased by 24.2% (341.1 vs. 258.7 DOT/1000 PDs – $p < 0.001$)	ID consultation increased from 15.4 consults per 1000 PDs compared to 21.5 consults per 1000 PDs ($p = 0.001$). Estimated annualized savings \$142,629.83	78,339 PDs ³ prior to intervention; 37,639 PDs after intervention	***	88.9%

Table 1 (continued)

Author	Year	Study design	Primary outcome	Secondary outcomes	Population	Intervention	Statistical significance (primary)	Statistical significance (secondary)	N	Quality	Acceptance rate
Beaulac[14]	2016	Uninterrupted time series analysis	Antimicrobial consumption	HA-CDI ⁴ , antimicrobial consumption by group	212 bed LTACH ⁵	Daily audits of EMR ⁶ with PAF via e-mail	Non-significant decrease in absolute consumption 32.8 DDD ⁷ /1000 PD (95% CI, -77.0 to 11.4) ($p=0.14$); significant change in slope from before to after the program (-6.58 DDD/1000 PD per month [95% CI, -11.48 to -1.67]; $p=0.01$)	Decrease HA-CDI (incidence rate ratio, 0.57 [95% CI, 0.35-0.92]; $p=0.02$). Decrease anti-MRSA antibiotic use, decrease CDI therapy, increased antipseudomonal agents	885 recommendations about 734 patients	**	48%

Table 1 (continued)

Author	Year	Study design	Primary outcome	Secondary outcomes	Population	Intervention	Statistical significance (primary)	Statistical significance (secondary)	N	Quality	Acceptance rate
dos Santos ^[15]	2013	Prospective observational	Appropriateness of empiric therapy	Appropriateness of empiric pneumonia therapy	50-bed community hospital in Brazil	Web-based consultation portal for providers	Significant increase in local guideline appropriate empiric therapy. 60% of prescriptions after interventions compared to 40% before. ($p < 0.01$)	Guideline appropriate empiric pneumonia therapy increased from 41 to 63% after intervention ($p = 0.01$)	81 consult requests	**	100%

Table 1 (continued)

Author	Year	Study design	Primary outcome	Secondary outcomes	Population	Intervention	Statistical significance (primary)	Statistical significance (secondary)	N	Quality	Acceptance rate
Wilson[16]	2019	Prospective observational	Antimicrobial consumption	Duration of therapy, Mean ASI ⁸ , DOT ⁹ per antibiotic class, ratio of DOT to antibiotic exposure, mean LOS, mortality	Two rural VAMCs 342 total acute care and long-term care beds	Weekly meetings to discuss cases	Significant decrease, in overall anti-biotic DOT in acute and long-term care at both sites ranging from 8 to 22% all $p < 0.001$	ASI decreased in acute/long-term care at site A ($p < 0.001$), but unchanged to increase at site B. Only site A acute care had decreased length of therapy ($p < 0.001$). At site A fluoroquinolone and broad-spectrum beta-lactams usage decreased in acute+LTC. No change in LOS ¹⁰ or mortality	259 cases over 78 sites between both sites	**	not reported

Table 1 (continued)

Author	Year	Study design	Primary outcome	Secondary outcomes	Population	Intervention	Statistical significance (primary)	Statistical significance (secondary)	N	Quality	Acceptance rate
Yam [17]	2012	Observational	Number of ASP interventions	Rate of narrowing therapy to culture results, agreement between local ASP and remote ID physician, CDI cost, HAI infections, LOS, cost, satisfaction, consumption	141-bed rural community hospital	Develop local ASP with remote ID physician support. PAF, Cascade reporting	N/A	N/A	311 cases	*	86–100%
Ceradini [18]	2017	Observational “before and after”	Incidence of multidrug-resistant Enterobacteriaceae	HAI infections, LOS, cost, satisfaction, consumption	220-bed pediatric hospital “suburban”	Case discussion	Rate of multidrug-resistant organism isolation decreased from 104/1000 PDs to 79/1000 PDs. ($p < 0.01$)	No for LOS, HAI. N/A for others	683 patients to establish baseline: 531 patients post-intervention	**	not reported

Table 1 (continued)

Author	Year	Study design	Primary outcome	Secondary outcomes	Population	Intervention	Statistical significance (primary)	Statistical significance (secondary)	N	Quality	Acceptance rate
Yan[19]	2020	Randomized control trial	Antimicrobial prescribing rate	Diagnostic shifting to mask inappropriate prescribing	Physicians practicing primary care via telemedicine (outpatient)	Education compared to individualized feedback on prescribing patterns	For URT ¹¹ and bronchitis, there was a greater decrease in antibiotic prescribing in the intervention group compared with the control group (decrease from 15 to 7.8% of prescriptions for URI diagnosis and 64 to 32.1% for bronchitis compared to control groups $p < 0.001$)	OR of visits with sinusitis or pharyngitis increased in the post-period compared with that in the pre-intervention period (aOR 1.36, 95% CI [1.29, 1.44], $p < 0.001$). However, a larger diagnostic shift was seen in the control group	31,473 visits in education arm and 25,519 visits in intervention arm met enrollment criteria	****	N/A

Table 1 (continued)

Author	Year	Study design	Primary outcome	Secondary outcomes	Population	Intervention	Statistical significance (primary)	Statistical significance (secondary)	N	Quality	Acceptance rate
Wood[20]	2015	Observational	Antimicrobial consumption	Cost, consumption by class, antimicrobial resistance	6 community hospitals within one health system -413 total beds	PAF	No significant decrease in total antimicrobial consumption	Quinolone use decreased 57.4% in hospital B ($p=0.001$), 65.9% in hospital D ($p<0.001$), and 67.3% in hospital E ($p<0.001$). Hospitals B, D, and E also had statistically significant decreases in antipseudomonal prescribing Average cost savings of \$20,860.25 over 18 months	12,904 charts reviewed between the 6 sites	**	81–95%
Morquin[21]	2018	Prospective observational	Adherence to recommendations	Provider perceptions of program	2000-bed academic hospital system	PAF	N/A; 79% of diagnostic and 87% of therapeutic recommendations were accepted	N/A; most approved of the program	6994 chart reviews for 4173 inpatients	*	79–87%

Table 1 (continued)

Author	Year	Study design	Primary outcome	Secondary outcomes	Population	Intervention	Statistical significance (primary)	Statistical significance (secondary)	N	Quality	Acceptance rate
Howell[22]	2019	Prospective observational	Time commitment	Barriers, cost	110-bed small community hospital	PAF	N/A, 3039 min over 3.5 months. 218 min per week or 3.6 h/week. 41.1% time spent on data analysis, 20.5% reporting, 18.4% preparing for meetings, 14.6% on education, and 5.4% spent on regulatory protocols and policies	N/A, barriers—work-flow, communication, consistency. Average cost savings of \$17,411.02 for patients with accepted ASP interventions compared to those rejected	724 alerts on 553 patients	*	11%

¹PAF, prospective audit and feedback

²VAMC, Veterans Affairs Medical Center

³PD, patient days

⁴HA-CDI, hospital-acquired Clostridioideis difficile infection

⁵LTACH, long-term acute care hospital

⁶EMR, electronic medical record

⁷DDD, defined daily doses

⁸AST, antibiotic spectrum index

⁹DOT, days of therapy

¹⁰LOS, length of stay

¹¹URI, upper respiratory tract infection

Studies included between 1 and 4 remote ID physicians, 2 studies employed ID-trained pharmacists [14, 22], with one study included pharmacists with unspecified levels of training [20].

The size of hospitals examined ranged from 50 beds up to 2000. The average number of remote ASP providers to hospital beds was one provider for every 234 beds. The number of full-time-equivalents dedicated to remote antimicrobial stewardship was not routinely reported. The exact ratio of remote ASP providers to hospital bed size is unknown although it should be noted that only three of the eleven (27%) inpatient studies met the goal for traditional ASP programs of 1.0–1.5 FTEs per 100 hospital beds that has been described [24, 25]. CMS proposes a minimum of 0.10 physician FTEs along with 0.25 pharmacy FTEs for a “moderate size hospital” (defined as 124 beds), although acknowledges that 1.0 physician FTEs and 0.5 pharmacies FTEs may be more effective [4••].

On average, 64.6 interventions were performed per remote provider per month for the 9 studies where this could be determined. It should be noted that the reporting of interventions was not standardized among publications.

Equipment

The primary modalities of communication were telephone or videoconferencing along with electronic medical record documentation. Two studies from the same author developed web-based platforms [11, 15], three communicated via secure email [11, 14, 15], and one via secure SMS messaging [15].

Acceptance Rate of Recommendations

There was a wide variance in the provider acceptance rate of remote ASP recommendations ranging from 11 to 100%. The studies with the lowest reported compliance rates lacked face-to-face communication with the local facility—one study relied on e-mail only communication providing a 48% acceptance rate [14]. An 11% acceptance rate was seen when the remote ASP personnel communicated via TheraDoc with a local pharmacist and had no direct communication with frontline providers [22]. The remaining studies that reported on acceptance rates included some form of face-to-face communication with local providers and had acceptance rates ranging from 73 to 100%. Among the three studies that developed a local antimicrobial stewardship team and provided acceptance rates, the average acceptance rate was 86.6%. Among the 5 studies that did not create a local ASP, the average was 66.5%. It is notable that the studies not employing local ASP representatives had significantly more variance of acceptance rates and included the two lowest acceptance rates of 11 and 48%.

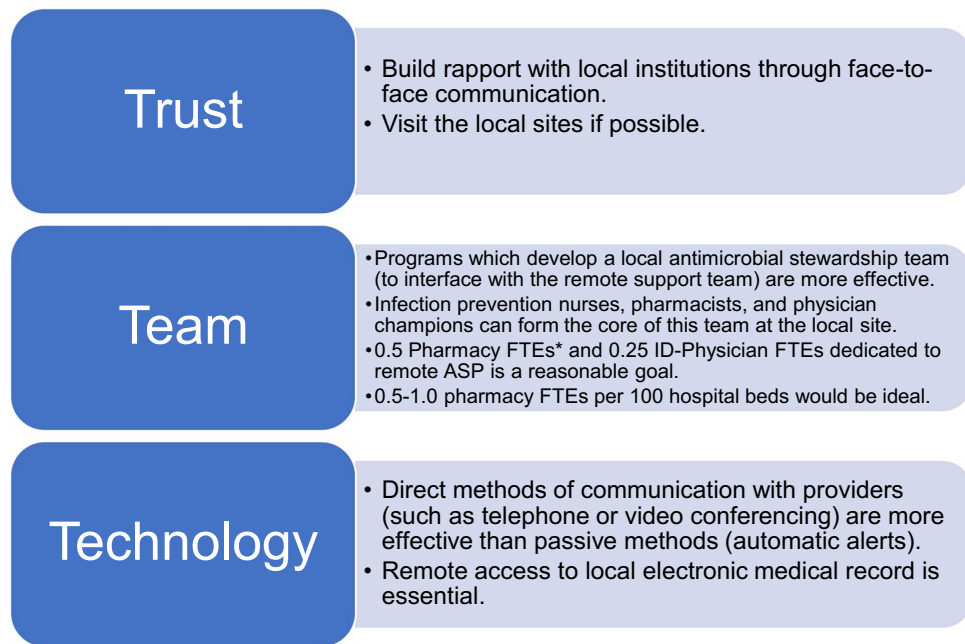


Fig. 2 The three Ts of remote antimicrobial stewardship: trust, team, and technology. *FTE, fulltime equivalent

Financial Impact

A potential concern regarding telehealth intervention would be decreased financial compensation related to a decrease in local ID consultation. The one study that examined this demonstrated an increase in local consultation. No study reported a financial loss. Three studies reported on annual antimicrobial purchasing cost savings ranging from \$13,907 to \$142,630. One study reported a \$17,411 savings in total hospital charges including, \$10,073 in pharmacy charges over 4 months. No study directly addressed the cost of establishing or maintaining a telehealth ASP.

Discussion

Three primary themes which emerged from the review of the available literature are described in Fig. 2. Establishing relationships and building trust with the local institution are frequently cited as vital to success in the examined articles. Examples included visiting with the local facility on a periodic basis, hosting grand rounds on topics regarding antimicrobial stewardship, or monthly teleconference meetings with local stewardship champions.

Another key element in the formation of remote antimicrobial stewardship is the components of the team. Infectious diseases expertise is critical

to successful antimicrobial stewardship. Recommending infectious diseases consultation is a common ASP intervention. The one study article that mentioned the presence of a local ID provider prior to the implementation noted an increase in consultation [13], while in the remaining studies the remote ASP served as the primary medium of ID expertise.

According to data from the National Residency Matching Program for 2021, there were 365 applicants for 416 open positions in infectious diseases. Although this was an increase from the year prior, a quarter of programs reported an unfilled position [26]. This suggests an increase in the ID workforce is not on the immediate horizon and novel strategies are needed to meet ID expertise for stewardship staffing requirements. Telestewardship is well positioned to meet these needs by extending available ID expertise. When on-site ID consultation is not available, access to remote ID-trained physicians in conjunction with local antimicrobial stewardship champions would greatly facilitate the work of a telestewardship program.

Although additional data are required to establish with certainty, there is a signal suggesting the formation of a local ASP team is associated with a greater acceptance rate of remote ASP team recommendations. According to the National Antimicrobial Stewardship Task Force, a study of the time required to complete various ASP activities within 12 VAMCs suggested a minimum of 0.25 ID physician full-time equivalents (FTEs) and 0.5 pharmacy FTEs dedicated to an ASP regardless of hospital size with a goal of 1.0 ID-trained pharmacy FTEs per 100 patient beds for a robust ASP. It should be noted that only 21% of their facilities had more than one pharmacy FTE dedicated to ASP despite 8 of the facilities having 200 or more beds [24]. A separate study examining a survey of 244 US institutions found that institutions employing less than 0.5 dedicated FTEs to antimicrobial stewardship were less likely to be able to perform the most effective ASP activities such as prospective audit and feedback. They also demonstrated a 1.5-fold increase in achieving primary outcomes measures such as cost savings, decreased antimicrobial consumption, or decreased multi-drug resistant organisms per each 0.5 pharmacy FTEs dedicated to ASP. They proposed a minimum of 1.0 pharmacy FTEs with 0.5 physician FTEs with roughly 1 additional pharmacy FTE per 500 beds [25]. Although there is no specific guidance for telestewardship, these FTE targets are reasonable goals for a remote ASP.

Certain technological capabilities are required to conduct antimicrobial stewardship via telehealth. According to publicly released statements from the CMS, telehealth encounters have increased by 2600% in 2020 compared to 2019 [27]. This suggests a potential increase in telehealth capabilities developed during the COVID-19 pandemic that could be utilized for telestewardship activities post-pandemic.

Several limitations were noted in the included studies. For the study with the lowest acceptance rate [22], it is conceivable that this may have been related to the reluctance of the local clinical pharmacist to accept recommendations from a pharmacy resident. Robust telestewardship models ideally would include services provided by ID-trained pharmacists and physicians; any learners involved ideally would be precepted by staff clinicians. Although several studies commented on cost savings, the direct cost of establishing the remote antimicrobial stewardship programs was not discussed.

The lack of direct comparison between remote antimicrobial stewardship and traditional antimicrobial stewardship programs is notable and is a key target for future research.

Conclusion

Telehealth is a rapidly expanding field and antimicrobial stewardship programs are well-positioned to take advantage of this growing technology. Data in the existing literature are not robust but suggest facilitators include local antimicrobial stewardship champions as well as access to infectious diseases consultants (either locally or via telehealth services). More research is needed to fully characterize the role of telehealth in antimicrobial stewardship, but existing data suggest this may be a promising mechanism to support hospitals that cannot create robust local programs.

Declarations

Conflict of Interest

The authors declare no competing interests.

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Papers of particular interest, published recently, have been highlighted as:

- Of importance
- Of major importance

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