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Article Title:

Effectiveness of telemedicine in outpatient parenteral antimicrobial therapy (Tele-OPAT): a systematic review

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ABSTRACT

Introduction: Telemedicine is increasingly used to deliver healthcare in many clinical specialities. However, the adoption of telemedicine in delivery of outpatient parenteral antimicrobial therapy (OPAT) has been relatively slow and limited. This study aims to collate current evidence for telemedicine in OPAT regarding clinical efficacy, safety, acceptability and cost-effectiveness.

Methods: We systematically searched the Cochrane Library, CINAHL, EMCARE, EMBASE and MEDLINE databases through 24 July 2022, for relevant studies published in English. Research articles and conference abstracts were included if they involved any form of telephone or video consultation in delivering parenteral antibiotics in the home or outpatient setting. Study findings were synthesised into three main themes: patient outcomes and safety, patient and provider satisfaction, and cost-effectiveness. The mixed methods appraisal tool was used to review the methodological quality of the studies. PROSPERO CRD42022342874

Results: The literature search yielded 311 articles, of which 12 (5 full-length articles and 7 conference abstracts) reporting over 1245 telemedicine interventions were reviewed. The reported outcomes were heterogeneous. Telemedicine was cost-effective, and associated with high patient satisfaction and comparable complication rates compared to conventional OPAT. Considering 6 comparative studies, rehospitalisation risk was lower for telemedicine than conventional OPAT (risk ratio, 0.58; 95% confidence interval, 0.38-0.88; I^2=31%).

Discussion: The results of this review demonstrate that telemedicine has a role in delivering safe and cost-effective OPAT care, especially for patients residing in remote and geographically isolated locations. Nevertheless, high-quality studies and publication of existing data and experiences are needed to further validate this model of care delivery.

KEYWORDS: eHealth; home health monitoring; outpatient parenteral antimicrobial therapy; systematic review; telehealth; telemedicine

Introduction

A wide range of infections are increasingly treated with intravenous (IV) antibiotics in home and outpatient settings rather than inpatient settings. The effectiveness and safety of outpatient parenteral antimicrobial therapy (OPAT) have been well documented.[1-3] Despite its benefits, OPAT is potentially associated with increased clinical risk compared with inpatient care due to reduced level of supervision and monitoring.[4] OPAT practice guidelines emphasise the need for close monitoring of patients during treatment and ongoing communication between patients and their care team to optimise clinical outcomes.[5,6] However, monitoring of patients living in remote and rural locations could be challenging.

The use of telemedicine to support delivery of OPAT, especially in geographically isolated locations, is recognised by OPAT practice guidelines.[5,6] Telemedicine is the use of telecommunication and information technology for the purpose of providing remote health assessments and therapeutic interventions.[7] This could include video or voice messaging services on mobile phones, computers and tablets. With advances in technology, telemedicine has been more widely used to deliver healthcare in many clinical specialities, including infectious diseases and across different healthcare settings with associated significant cost savings and high patient/clinician satisfaction.[8-10] The COVID-19 pandemic has further accelerated the growth of telemedicine, and it is likely to be used increasingly in future.[11]

The adoption of telemedicine in OPAT has been relatively slow and limited.[12] This systematic review aims to collate current evidence for telemedicine in OPAT practice (tele-OPAT) regarding its clinical efficacy, safety, acceptability and cost-effectiveness.

Methods

This systematic review protocol was registered in the PROSPERO international prospective register of systematic reviews (CRD42022342874) and complies with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist (Supplementary Material, Table A.1).[13]

Search strategy and Information sources

The source of evidence and search strategy were developed after an initial review of existing literature. A three-step search strategy was used in this systematic review. An initial limited search of CINAHL and MEDLINE (PubMed) databases was conducted followed by an analysis of the text words contained in the

titles and abstracts of retrieved articles, and of the index terms used to describe the articles. A second search was then performed across the databases of CINAHL, EMBASE (Ovid), Ovid Emcare, MEDLINE (PubMed) and the Cochrane Library, using all identified keywords and index terms. Thereafter, the reference lists of identified articles were searched for additional sources. Supplementary searches of clinical trial registries, Web of Science Conference Proceedings, Google/Google Scholar, WorldCat and the websites of the Infectious Diseases Society of America and British Society for Antimicrobial Chemotherapy were performed to identify relevant grey literature and unpublished studies. The search terms were generated based on the two main key terms (i.e., telemedicine and OPAT) and their corresponding alternative terms. The full search strategy is presented in the Supplementary Material (Table A.2). The search was not limited by years (all articles up to 24 July 2022) but restricted to studies published in English.

Eligibility criteria

Eligibility criteria were assessed using the PICO framework (Population, Intervention, Comparison and Outcome).[14] Studies were eligible if they reported any form of video or telephone consultation (intervention) in the delivery of parenteral antibiotics in home or outpatient settings (population), and measurable outcomes (e.g., readmission rates) evaluating telemedicine (outcome) – with or without conventional OPAT (comparison). Studies of any research design were considered - with the exception of reviews, guidelines, commentaries and editorials. Studies were excluded if they were not specifically related to tele-OPAT (Supplementary Material, Table A.3). Given the sparse research in tele-OPAT, conference abstracts were considered to account for as much existing literature as possible and provide a comprehensive overview of the topic. The authors of the abstracts were contacted to inquire whether the full data were later published in a scientific journal. We included original conference abstracts meeting our eligibility criteria if the full-length articles were not available or no response from the author. The inclusion of conference abstracts follows Scherer et al.[15] recommendations that conference abstracts should be considered for systematic review if available evidence is sparse or conflicting.

Study selection and data extraction

Duplicate records were removed using EndNote reference management software. All identified titles and abstracts were independently reviewed by two reviewers (OCD and IJ). The full texts of potentially eligible studies were then screened independently against the eligibility criteria by both reviewers. Disagreements were resolved by consensus or with a third reviewer (EIK). All reviewers (OCD, IJ, EIK)

independently extracted data from retrieved studies using a standardised pro forma. Extracted data included citation details (author, year of publication and title), location, study aim/purpose, design, sample size/population details, duration, type of telemedicine intervention, study outcome and main findings. Discrepancies in data extraction were resolved by discussion.

Data synthesis

We qualitatively classified different applications of telemedicine in OPAT and reported outcomes. Considering the limited number of full-length articles on tele-OPAT and methodological heterogeneities in study design, intervention and outcome definitions, a meta-analysis was only possible for assessing the average risk of all-cause unplanned readmission, but no other outcome could be meaningfully meta-summarised. We estimated the pooled risk ratio (RR) for readmission and the respective 95% confidence interval (CI) associated with tele-OPAT (as opposed to conventional OPAT) using the random-effects model. The between-study variability parameter (Tau^2) was estimated with the restricted maximum likelihood method. Heterogeneity of intervention effects across the studies was measured using Cochrane's Q statistic and chi-square test, and Higgin's I^2 statistic (I^2 >50% indicates substantial heterogeneity).

Quality assessment

We used the Mixed Methods Appraisal Tool (MMAT) version 2018 to access the methodological quality of the included studies,[16] due to differences in study design. The MMAT tool was designed for the appraisal stage of systematic mixed studies reviews (i.e., qualitative, quantitative and mixed methods studies) and allows assessment of quality over five criteria with rating scales of 'Yes', 'No' and 'Can't tell'. The developers of the tool discourage the calculation of an overall numerical score but advise reviewers to provide a detailed presentation of the ratings of each criterion to better inform the quality of the included studies. They also discourage exclusion of studies with low methodological quality.[17] In our study, quality appraisal was independently performed by all reviewers. Any disagreement was resolved by discussion, and no studies were excluded based on the results of the evaluation.

Results

Selection results and characteristics of the studies

The search yielded 311 non-duplicate publications, of which 12 met the eligibility criteria and were reviewed (Figure 1). Details of the studies (five full-length articles[18-22] and seven conference abstracts[23-

[29]) are presented in the Supplementary Material (Table A.4). The findings of the studies were classified into three main themes: patient outcomes and safety, patient and provider satisfaction, and cost-effectiveness. The studies were published between 2004 and 2022. Most (10/12; 83%) appeared in the last five years,[19,21-29] and were conducted in the United States (*n* = 9)[20,22-29] and Australia (*n* = 3).[18,19,21] Two studies were conducted in paediatric patients.[18,25] Altogether, the studies included 2572 (median, 145) participants, of whom over 1245 (median, 49) had some form of telemedicine intervention, with sample sizes ranging from 2[25] to 636.[26]

Real-time (synchronous) telemedicine was utilised in all but one study. Videoconferencing was most commonly used (8/12; 67%),[18-21,23,25,27,28] followed by telephone calls only (n = 3).[22,26,29] The technology used was not specified in one study.[24] The types of services provided via telemedicine included consultation between healthcare professionals,[18,21,24] remote patient monitoring,[20] home support and care,[18,20] patient/caregivers consultation,[26] and tele-visit.[19,20,22-25,27-29]

Quality appraisal

Eight (67%) studies were categorised as quantitative non-randomised studies,[18,20-24,28,29] and four (33%) studies as quantitative descriptive studies.[19,25-27] There were no qualitative, randomised controlled trials (RCTs) nor mixed method studies. Using the MMAT tool, the weakest studies[25,28,29] had only one 'Yes' answer out of five criteria, while the strongest one[20,21] had five 'Yes' answers. The key quality issue was related to the insufficient information in most of the conference articles to determine if the criterion was met or not (Supplementary Material, Table A.5).

Patient outcomes and safety

Nine studies reported on patient outcomes or safety of telemedicine.[19-24,27-29] Hospital readmission was the most assessed outcome. Tan et al.[19] reported on the use of telemedicine in the management of OPAT patients over a wide geographical area of Australia and recorded low unplanned OPAT-related admission rate which was comparable to published non-telemedicine OPAT literature. Treatment was administered by local nursing staff and supported by a weekly videoconference with an infectious diseases (ID) specialist. Two other studies also showed similar readmission rates between telemedicine and non-telemedicine groups,[21,23] while four studies showed significant reduction in rehospitalisation.[22,24,27,29] Vaz et al.[25] demonstrated the feasibility and functionality of telemedicine to conduct OPAT clinic visits in two paediatric OPAT patients with no reported rehospitalisation. Another

study also reported no readmission (cf. one rehospitalisation in control group) in their cohort of 25 patients treated via telemedicine.[20] No study identified significantly higher readmission rates for OPAT patients treated via telemedicine compared to those treated via conventional OPAT. Pooling data from 6 comparative cohort studies (1051 patients), the risk of readmission was significantly lower for telemedicine group compared to conventional OPAT group (RR, 0.58; 95% CI, 0.38-0.88; p = 0.01) with moderate heterogeneity of effects across the studies (I^2 = 31%) (Figure 2).

One study demonstrated comparable clinical cure or improvement rates using telemedicine compared to conventional OPAT.[19] Another study also reported that patients treated via telemedicine had satisfactory (comparable) clinical outcomes (p = 0.30), shorter length of hospitalisation (p = 0.02) and returned to normal function sooner (p <0.001) than hospitalised patients.[20]

Among the studies assessing rates of adverse events, Felder et al.[26] showed that post-hospital discharge telephone calls resulted in early identification of significant concerns and OPAT-related complications. Two additional studies reported comparable adverse event rates between telemedicine group and historic OPAT programmes.[19,29] One study reported one case of vascular access-related complication in a cohort of 13 patients managed via telemedicine,[27] but lacked a direct comparison with non-telemedicine OPAT group.

Patient and provider satisfaction

Only one study assessed patient satisfaction with telemedicine, but none reported on provider/clinician satisfaction. Eron et al.[20] reported a higher mean satisfaction score for patients with acute infections managed in the home setting via telemedicine compared with a comparable group of patients treated in the hospital. The telemedicine group was more comfortable at home (p = 0.35) but would have felt safer in the hospital (p = 0.09). The authors suggested that patient perception will have to be altered before telemedicine is widely accepted.

Cost-effectiveness

Telemedicine was associated with lower cost when compared with conventional treatment model. A study on telemedicine-supported OPAT reported that over 100,000 km of travel was averted over a four-year period with associated cost savings from travel, accommodation and early return to work.[19] Another study compared the cost of outpatient treatment via telemedicine with the cost of inpatient

treatment and estimated a cost saving of $135,000 to $540,000 over a year.[20] A cost minimisation study compared the costs associated with three different methods of administering IV antibiotic therapy in outpatient settings to paediatric oncology patients and found that service cost in a scenario where antibiotics were prepared in the home setting and checked by a second nurse via a video link was significantly lower than the costs wherein the medications were prepared by an outsourced company or in the hospital (mean costs of a medication episode of $129.91 vs. $312.00 and $355.91, respectively).[18]

Discussion

This study presents a systematic review of the literature to summarise data regarding use of telemedicine in the delivery of OPAT. Based on the available limited evidence, the impact of tele-OPAT on clinical outcomes is comparable to conventional OPAT. In addition, tele-OPAT can be a valid, safe, cost-efficient, and acceptable method of delivering OPAT especially for patients residing in remote and geographically isolated locations. However, we identified a small number of articles reporting on our predefined outcomes, and the majority were conference articles, leading to negative ratings in the quality assessment. It would have been ideal to include RCTs in this review but none of the RCTs identified by the search strategy met the inclusion criteria. Nonetheless, observational studies can provide meaningful insight into 'tele-OPAT' and explore its long-term efficacy, rare complications and clinical outcomes.[30] The lack of RCTs comparing tele-OPAT to conventional OPAT, and of robust high-quality data are significant weakness of the existing literature. Consequently, strong conclusions regarding the clinical efficacy, safety, acceptability, and cost-effectiveness of tele-OPAT cannot be made.

In the reviewed studies, the operationalisation of tele-OPAT varied widely. The most commonly reported type of telemedicine was live (real-time) videoconferencing. Also known as synchronous telemedicine, live videoconferencing allows healthcare providers to communicate with patients in real-time. Other forms of telemedicine that could be adopted in OPAT settings include: (a) asynchronous (store-and-forward) technique, wherein patients' data are collected, stored and later sent to health practitioners for diagnostic and treatment expertise; (b) remote patient monitoring, which involves continuous evaluation of patients remotely; and (c) Mobile health (mHealth), which is the delivery of healthcare services via mobile devices, often incorporating wearable technologies.[31]

The studies within this review demonstrated the effectiveness of telemedicine in OPAT across a range of clinical outcomes. However, only one study reported on and identified high patient satisfaction with tele-OPAT.[20] Whilst the reasons for the high patient satisfaction was not assessed in the study, it could be due to convenience of care, improved communication with OPAT providers, decreased missed workdays, and reduced travel time and costs.[32,33] High patient satisfaction may improve adherence to OPAT treatment and follow-ups,[33] allowing further cost savings. Another study in this review reported that tele-OPAT allowed equitable access to ID specialists in a geographically large area of Australia.[19] This is particularly beneficial for isolated populations including people living in rural communities, nursing home residents and socioeconomically disadvantaged patients. Increased access to OPAT care through telemedicine will allow many more patients to be managed outside of the hospital setting. In addition, direct access to specialist support via telemedicine promotes networks between OPAT and primary care clinicians, which consecutively can enhance delivery of care and stability within healthcare systems.[19]

The studies analysed in this review clearly demonstrate that telemedicine has the potential to prevent rehospitalisation in patients receiving OPAT, even though partially different measures of readmissions were used. Rehospitalisation rates from the studies assessing readmission, when aggregated, show that telemedicine interventions significantly reduced hospital readmissions. Telemedicine provides an ideal opportunity for timely identification and appropriate management of complications and concerns before they become significant enough to warrant hospitalisation.[22] In addition, all the reviewed studies assessing the cost-effectiveness of telemedicine suggest that tele-OPAT may be more cost effective than conventional OPAT. However, the analyses were based on projections that may not be applicable to all settings. Although not rigorously evaluated in the reviewed articles, other potential benefits of tele-OPAT include reduced frequencies of clinic visits and late/missed appointments, and reduction in health disparities.[9,34-36] By reducing in-person visits and travel-related emissions, tele-OPAT also offer a potential opportunity to reduce the carbon footprints of healthcare systems, and thus helps in the fight against climate change.[37]

One key knowledge gap within the reviewed literature relates to patient experience and provider acceptance/perspectives on tele-OPAT. There is limited reflection about the factors which may influence patient experience and satisfaction such as visit-related factors and degree of trust in OPAT clinician.[38]

Patient and healthcare professional perceptions are crucial to the acceptability and success of telemedicine.[20] We also do not know the long-term outcomes of patients managed via tele-OPAT.

The adoption of tele-OPAT has been limited.[12] Regulatory, reimbursement, socioeconomic and technological barriers such as access to high-speed internet connections are potential obstacles to widespread use of telemedicine in OPAT.[9,35,39,40] Although, poor internet access remains an issue in some rural areas, progress has been made and video quality has improved.[9,35] Furthermore, there are concerns regarding the legal and ethical aspects of telemedicine such as data privacy, confidentiality, professional liability risk and medical malpractice.[41,42] As such, medical regulatory authorities around the world have produced practice guidelines to mitigate these risks.[43] Telemedicine in OPAT must meet the same clinical and ethical standards as traditional care in order to deliver quality treatment that safeguards the welfare and best interests of patients.

Our review has several limitations. As suggested by Scherer et al.,[15] we included conference abstracts in this systematic review due to paucity of evidence on tele-OPAT. Most conference abstracts are not peer-reviewed and reported results are often preliminary and/or based on limited analyses. Nevertheless, inclusion of conference abstracts in systemic reviews can provide a more comprehensive overview and potentially reduce the impact of publication bias.[15] We only considered studies published in the English language due to lack of language resources (e.g., professional translators). Relevant articles written in non-English languages could have been omitted; thus, we cannot exclude the possibility of a language bias. Although this review used a robust and iterative methodological approach, its conclusions are limited by heterogeneity in study design and outcome definitions and by lack of high-quality evidence, especially from RCTs comparing telemedicine in OPAT with conventional OPAT. Nevertheless, within its constraints, the findings of this study show that tele-OPAT offers a number of benefits to patients and OPAT service providers.

Conclusion

This study sheds light on the use of telemedicine in OPAT settings. Limited evidence suggests that tele-OPAT can be safe, clinically and cost effective with high patient satisfaction. However, high-quality studies are required to substantiate or further investigate our findings and address gaps in knowledge, especially regarding clinician acceptance and perspectives on tele-OPAT. As telemedicine continues to

grow, new and existing services should consider adopting tele-OPAT to support OPAT delivery, especially for patients residing in remote and geographically isolated locations.

Implications for research

Large-scale and well-designed studies are needed to better evaluate the clinical efficacy, safety and cost-effectiveness of tele-OPAT. In addition, a well-validated measure to assess patient and provider acceptance and satisfaction is required for reliability and comparability of research results. Future studies should also define the type of telemedicine that is most cost-effective and adaptable to different OPAT settings. OPAT services that have already adopted telemedicine should consider publishing their existing data and experiences to further validate this model of care delivery.

References

1. Bryant PA, Katz NT. Inpatient versus outpatient parenteral antibiotic therapy at home for acute infections in children: a systematic review. *Lancet Infect Dis* 2018; 18: e45-e54. https://doi.org/10.1016/S1473-3099(17)30345-6.

2. Durojaiye OC, Bell H, Andrews D, et al. Clinical efficacy, cost analysis and patient acceptability of outpatient parenteral antibiotic therapy (OPAT): a decade of Sheffield (UK) OPAT service. *Int J Antimicrob Agents* 2018; 51: 26-32. https://doi.org/10.1016/j.ijantimicag.2017.03.016.

3. Al Shareef HJ, Al Harbi A, Alatawi Y, et al. Evaluate the effectiveness of outpatient parenteral antimicrobial therapy (OPAT) program in Saudi Arabia: A retrospective study. *Antibiotics (Basel)* 2022; 11: 441. https://doi.org/10.3390/antibiotics11040441.

4. Durojaiye OC, Morgan R, Chelaghma N, et al. External validity and clinical usefulness of a risk prediction model for 30 day unplanned hospitalization in patients receiving outpatient parenteral antimicrobial therapy. *J Antimicrob Chemother* 2021; 76: 2204-2212. https://doi.org/10.1093/jac/dkab127

5. Chapman ALN, Patel S, Horner C, et al. Updated good practice recommendations for outpatient parenteral antimicrobial therapy (OPAT) in adults and children in the UK. *JAC Antimicrob Resist* 2019; 1: dlz026. https://doi.org/10.1093/jacamr/dlz026.

6. Norris AH, Shrestha NK, Allison GM, et al. 2018 Infectious Diseases Society of America Clinical Practice Guideline for the Management of Outpatient Parenteral Antimicrobial Therapy. *Clin Infect Dis* 2019; 68: e1-e35. https://doi.org/10.1093/cid/ciy745.

7. NHS Digital. NHS data model and dictionary – Telemedicine, www.datadictionary.nhs.uk/nhs_business_definitions/telemedicine.html (2022, accessed 20 July 2022).

8. Haider Z, Aweid B, Subramanian P, et al. Telemedicine in orthopaedics during COVID-19 and beyond: A systematic review. *J Telemed Telecare* 2022; 28: 391-403. https://doi.org/10.1177/1357633X20938241.

9. Burnham JP, Fritz SA, Yaeger LH, et al. Telemedicine infectious diseases consultations and clinical outcomes: A systematic review. *Open Forum Infect Dis* 2019; 6: ofz517. https://doi.org/10.1093/ofid/ofz517.

10. Lee JY, Lee SWH. Telemedicine cost-effectiveness for diabetes management: A systematic review. *Diabetes Technol Ther* 2018; 20 :492-500. https://doi.org/10.1089/dia.2018.0098.

11. Thomas EE, Haydon HM, Mehrotra A, et al. Building on the momentum: sustaining telehealth beyond COVID-19. *J Telemed Telecare* 2022; 28: 301-308. https://doi.org/10.1177/1357633X20960638.

12. Young JD, Abdel-Massih R, Herchline T, et al. Infectious Diseases Society of America position statement on telehealth and telemedicine as applied to the practice of infectious diseases. *Clin Infect Dis* 2019; 68: 1437-1443. https://doi.org/10.1093/cid/ciy907.

13. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021; 372: n71. https://doi.org/10.1136/bmj.n71.

14. Tufanaru C, Munn Z, Aromataris E, et al. Chapter 3: Systematic reviews of effectiveness. In: Aromataris E, Munn Z (Editors). *JBI Manual for Evidence Synthesis.* JBI, 2020. Available from https://synthesismanual.jbi.global. https://doi.org/10.46658/JBIMES-20-04.

15. Scherer RW, Saldanha IJ. How should systematic reviewers handle conference abstracts? A view from the trenches. *Syst Rev* 2019; 8: 264. https://doi.org/10.1186/s13643-019-1188-0.

16. Hong QN, Fàbregues S, Bartlett G, et al. The Mixed Methods Appraisal Tool (MMAT) version 2018 for information professionals and researchers. *Educ Inf* 2018; 34: 285 - 291. https://doi.org/10.3233/EFI-180221.

17. Hong QN, Pluye P, Fàbregues S, et al. Mixed Methods Appraisal Tool (MMAT), version 2018. Registration of Copyright (#1148552), Canadian Intellectual Property Office, Industry Canada.

18. Bradford N, Armfield NR, Young J, et al. Internet video to support intravenous medication administration in the home: a cost minimisation study. *J Telemed Telecare* 2013; 19: 367-71. https://doi.org/10.1177/1357633X13506510.

19. Tan SJ, Ingram PR, Rothnie AJ, et al. Successful outpatient parenteral antibiotic therapy delivery via telemedicine. *J Antimicrob Chemother* 2017; 72: 2898-2901. https://doi.org/10.1093/jac/dkx203.

20. Eron L, King P, Marineau M, et al. Treating acute infections by telemedicine in the home. *Clin Infect Dis* 2004; 39: 1175-81. https://doi.org/10.1086/424671.

21. Greenup EP, McCusker M, Potts BA, et al. The efficacy of telemedicine-supported discharge within an in-home model of care. *Telemed J E Health* 2017; 23: 763-765. https://doi.org/10.1089/tmj.2016.0216.

22. Huggins CE, Park TE, Boateng E, et al. The impact of a standardized discharge process on 30-day readmissions for patients on outpatient parenteral antibiotic treatment. *Hosp Pharm* 2022; 57: 107-111. https://doi.org/10.1177/0018578720985434.

23. Swartwood MJ, Boerneke RA, Kinlaw AC, et al. 483. OPAT Delivery during COVID-19. *Open Forum Infect Dis* 2020; 7(Suppl 1): S308. https://doi.org/10.1093/ofid/ofaa439.676.

24. Cortes-Penfield NW, LeMaster M, Alexander B. 606. Implementation of a telehealth-based OPAT early post-discharge clinic may reduce hospital readmission. *Open Forum Infect Dis* 2021; 8(Suppl 1): S405. https://doi.org/10.1093/ofid/ofab466.804.

25. Vaz L, Wagner T, Cochran B, et al. Pilot of a home telehealth platform in a pediatric OPAT program. *Open Forum Infect Dis* 2017; 4(Suppl 1):S333. https://doi.org/10.1093/ofid/ofx163.789.

26. Felder K, Vaz L, Barnes P, et al. Utilizing a post-discharge telephone call in outpatient parenteral antimicrobial therapy (OPAT): findings from a quality improvement project. *Open Forum Infect Dis* 2017; 4(Suppl 1): S333. https://doi.org/10.1093/ofid/ofx163.790.

27. Sheridan KR, Wingfield J, Clouse N. 592. A pilot program to evaluate home telemedicine visits in an OPAT program. *Open Forum Infect Dis* 2020; 7(Suppl 1): S359 – S360. https://doi.org/10.1093/ofid/ofaa439.786.

28. Sheridan KR, Abdel-Massih R, Gupta N, et al. 627. Tele-OPAT outcomes at two community hospitals. *Open Forum Infect Dis* 2020; 7(Suppl 1): S373 – S374. https://doi.org/10.1093/ofid/ofaa439.821.

29. Boerneke RA, Swartwood MJ, Kinlaw AC, et al. 618. Post-discharge care coordination telephone call for patients enrolled in the UNC OPAT Program. *Open Forum Infect Dis* 2020; 7(Suppl 1): S370. https://doi.org/10.1093/ofid/ofaa439.812.

30. Gilmartin-Thomas JF, Liew D, Hopper I (2018). Observational studies and their utility for practice. Aust Prescr. 41:82-85. https://doi.org/10.18773/austprescr.2018.017.

31. Mechanic OJ, Persaud Y, Kimball AB. Telehealth Systems. 2021. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022. Available from: https://www.ncbi.nlm.nih.gov/books/NBK459384.

32. Kruse CS, Krowski N, Rodriguez B, et al. Telehealth and patient satisfaction: a systematic review and narrative analysis. *BMJ Open* 2017; 7: e016242. https://doi.org/10.1136/bmjopen-2017-016242.

33. Barbosa CD, Balp MM, Kulich K, et al. A literature review to explore the link between treatment satisfaction and adherence, compliance, and persistence. *Patient Prefer Adherence* 2012; 6: 39-48. https://doi.org/10.2147/PPA.S24752.

34. Parmar P, Mackie D, Varghese S, et al. Use of telemedicine technologies in the management of infectious diseases: a review. *Clin Infect Dis* 2015; 60: 1084-94. https://doi.org/10.1093/cid/ciu1143.

35. Gajarawala SN, Pelkowski JN. Telehealth Benefits and Barriers. *J Nurse Pract* 2021; 17: 218-221. https://doi.org/10.1016/j.nurpra.2020.09.013.

36. Adams CS, Player MS, Berini CR, et al. A telehealth initiative to overcome health care barriers for people experiencing homelessness. *Telemed J E Health* 2021; 27: 851-858. https://doi.org/10.1089/tmj.2021.0127.

37. Purohit A, Smith J, Hibble A. Does telemedicine reduce the carbon footprint of healthcare? A systematic review. *Future Healthc J* 2021; 8: e85-e91. https://doi.org/10.7861/fhj.2020-0080.

38. Orrange S, Patel A, Mack WJ, et al. Patient satisfaction and trust in telemedicine during the COVID-19 pandemic: retrospective observational study. *JMIR Hum Factors* 2021; 8: e28589. https://doi.org/10.2196/28589.

39. Zhai Y. A Call for Addressing Barriers to Telemedicine: Health Disparities during the COVID-19 Pandemic. *Psychother Psychosom* 2021; 90: 64-66. https://doi.org/10.1159/000509000.

40. Smith AC, Thomas E, Snoswell CL, et al. Telehealth for global emergencies: Implications for coronavirus disease 2019 (COVID-19). *J Telemed Telecare* 2020; 26:309-313. https://doi.org/10.1177/1357633X20916567.

41. Stanberry B. Legal and ethical aspects of telemedicine. *J Telemed Telecare* 2006; 12: 166-75. https://doi.org/10.1258/135763306777488825.

42. Nittari G, Khuman R, Baldoni S, et al. Telemedicine Practice: Review of the current ethical and legal challenges. *Telemed J E Health* 2020; 26: 1427-1437. https://doi.org/10.1089/tmj.2019.0158.

43. Europe Economics. Regulatory approaches to telemedicine. London: Europe Economics. UK, July 2022.

STATEMENTS AND DECLARATIONS

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Declaration of conflicting interests

The authors declare that there is no conflict of interest.

Author contributions

OCD: Conceptualisation, Data Curation, Investigation, Methodology, Writing – original draft, Visualisation. IJ: Investigation, Writing – Review & Editing. EIK: Validation, Formal analysis, Writing – Review & Editing.

Ethics approval

Not applicable

Consent to participate

Not applicable

Consent to publish

Not applicable

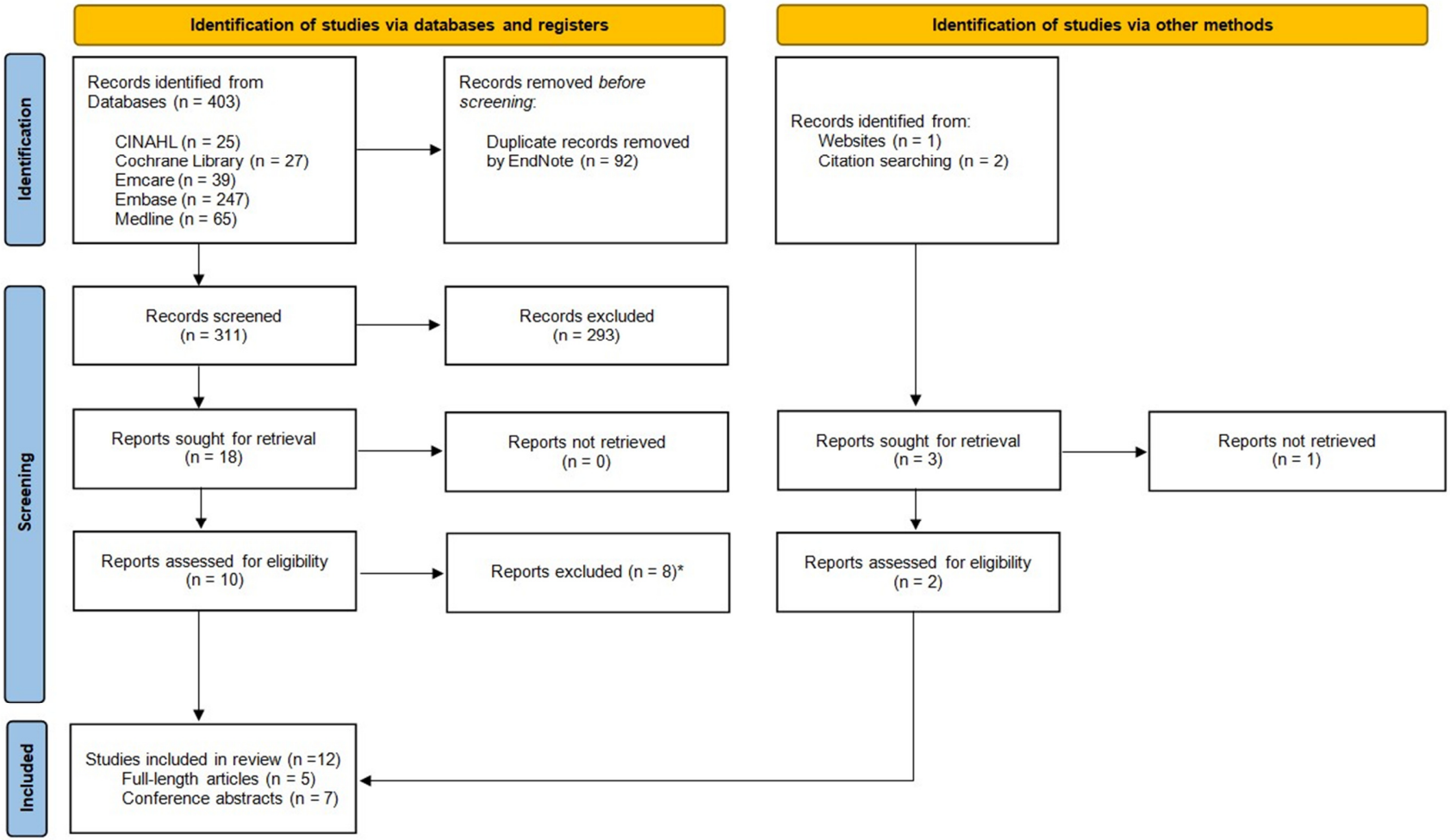
FIGURE CAPTIONS

Fig. 1. Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2020 flow diagram of the systematic review process.[13]

Fig. 2. Results of random-effects meta-analysis for the risk of hospital readmission in telemedicine versus conventional OPAT

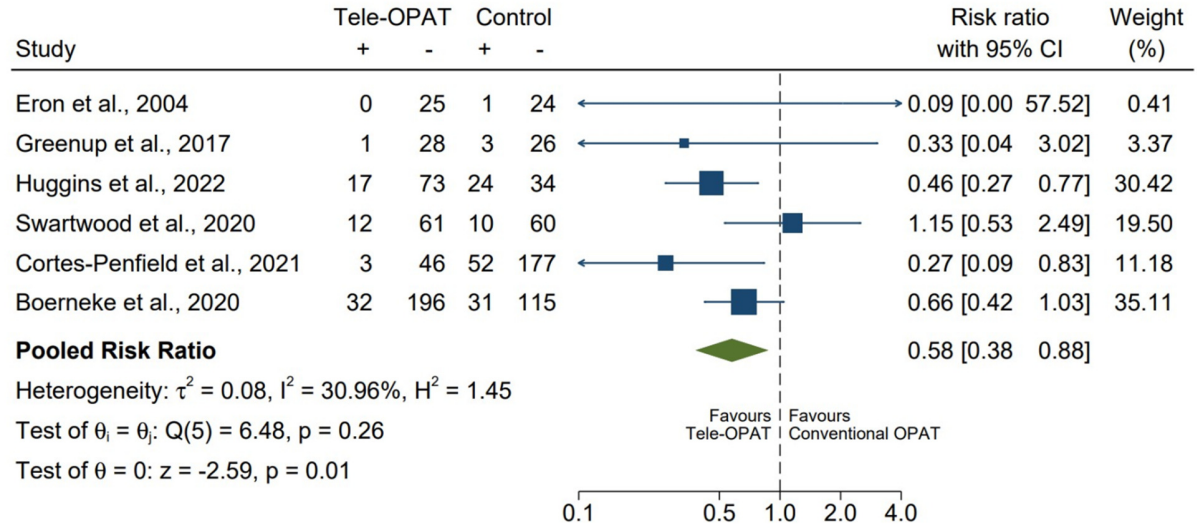
FIGURES

Figure 1



*Reasons stated in Supplementary Material A.3.

Figure 2



+ = readmission event

SUPPLEMENTARY MATERIAL

Effectiveness of telemedicine in outpatient parenteral antimicrobial therapy (Tele-OPAT): a systematic review

Content

Table A.1. Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Page 1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	Page 2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Page 3
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Page 3
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Page 4
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Page 3-4. Supplementary Table A.2
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Page 3-4. Supplementary Table A.2
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	Page 4-5
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	Page 4-5
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Page 4-5
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Page 4-5
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Page 5
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	Page 5
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	Page 4-5
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	Page 4-5
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Page 4-5
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Page 4-5
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	Page 5
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	Page 5
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	Page 4
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	N/A

RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Figure 1 Page 6
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Supplementary Table A.3
Study characteristics	17	Cite each included study and present its characteristics.	Supplementary Table A.4 Page 6
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Supplementary Table A.5 Page 6
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Page 6-7
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Page 6-7
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	Page 7 Figure 2
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	Page 6-7
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	Page 7
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	Page 6-7
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	Page 6-7
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Page 8-10
	23b	Discuss any limitations of the evidence included in the review.	Page 9-10
	23c	Discuss any limitations of the review processes used.	Page 10
	23d	Discuss implications of the results for practice, policy, and future research.	Page 11
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Page 3
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Page 3
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	N/A
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	N/A
Competing interests	26	Declare any competing interests of review authors.	N/A
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	Page 4

Table A.2. Search Strategy

Databases Searched

Database	Date
Be Part of Research website https://bepartofresearch.nihr.ac.uk/	Accessed 20 July 2022
British Society for Antimicrobial Chemotherapy (BSAC) website https://bsac.org.uk/	Accessed 24 July 2022
CINAHL (EBSCOHost)	Accessed 19 July 2022
ClinicalTrials.gov Registry https://clinicaltrials.gov/	Accessed 19 July 2022
Embase (Ovid)	Accessed 21 July 2022
European Union Clinical Trials Registry https://www.clinicaltrialsregister.eu/	Accessed 19 July 2022
Google/Google Scholar https://scholar.google.com/	Accessed 20 July 2022
Infectious Diseases Society of America (IDSA) website https://www.idsociety.org	Accessed 24 July 2022
Ovid Emcare	Accessed 21 July 2022
PubMed MEDLINE	Accessed 20 July 2022
The Cochrane Library	Accessed 22 July 2022
Web of Science Conference Proceedings Citation Index	Accessed 23 July 2022
WorldCat https://www.worldcat.org/	Accessed 23 July 2022

MEDLINE (PubMed) – search conducted on 20 July 2022

#1 Anti-infective Agents[Mesh:NoExp] (59789)

#2 Anti-Infective Agents, Urinary (2722)

#3 Anti-Bacterial Agents[Mesh:NoExp] (379782)

#4 Antifungal Agents (64609)

#5 Antiviral Agents[Mesh:NoExp] (94377)

#6 #1 OR #2 OR #3 OR 4 OR #5 (580282)

#7 Administration, Intravenous (148091)

#8 Infusions, Intravenous (56731)

#9 Infusions, Parenteral (94923)

#10 Infusion Pumps (15045)

#11 Injections, Intravenous (82426)

#12 Home Infusion Therapy (710)

#13 #7 OR #8 OR #9 OR #10 OR #11 OR #12 (197567)

#14 (IV[tw]OR intravenous[tw] OR inject*[tw] OR infusion[tw] OR parenteral[tw]) AND (antimicrobial*[tw] OR anti-microbial*[tw] OR antiinfective*[tw] OR anti-infective*[tw] OR antibiotic*[tw] OR anti-biotic*[tw] OR antifungal*[tw] OR anti-fungal*[tw] OR antiviral* [tw] OR anti-viral*[tw] OR antibiotherap*[tw] OR anti-biotherap*[tw]) (74718)

#15 (#6 AND #13) OR #14 (78018)

#16 Outpatients (19826)

#17 Outpatient Clinics, Hospital (17406)

#18 Ambulatory Care (55826)

#19 Ambulatory Care Facilities (58249)

#20 Day Care, Medical (5223)

#21 Community Health Services (325194)

#22 Community Health Nursing (20266)

#23 Home Care Services, Hospital-Based (1978)

#24 Home Nursing (9521)

#25 Home Care Services (50102)

#26 #16 OR #17 OR #18 OR #19 OR #20 OR 21 OR #22 OR #23 OR #24 OR #25 (443880)

#27 #15 AND #26 (1843)

#28 Outpatient*[tw] (222280)

#29 Home[tw] OR homes[tw] (332204)

#30 (self[tw] OR carer[tw]) AND (treat*[tw] OR admin*[tw] OR care OR regime*[tw]) (428037)

#31 (clinic[tw] OR clinics[tw]) AND (treat*[tw] OR admin*[tw] OR care[tw] OR regime*[tw]) (244717)

#32 (community[tw]) AND (treat*[tw] OR admin*[tw] OR care[tw] OR regime*[tw]) (330175)

#33 (ambulatory[tw]) AND (treat*[tw] OR admin*[tw] OR care[tw] OR regime*[tw]) (125674)

#34 ‘‘district nurs’’*[tw] OR ‘‘community nurs’’*[tw] OR ‘’specialist nurs’’*[tw] OR ‘‘nurse specialist’’*[tw] (11893)

#35 #28 OR #29 OR #30 OR #31 OR #32 OR #33 OR #34 (1402531)

#36 #15 AND #35 (7685)

#37 ‘‘outpatient parenteral antimicrobial* therapy’’[tw] OR ‘‘outpatient parenteral antibiotic* therapy’’[tw] (959)

#38 ‘‘outpatient antibiotic* therapy’’[tw] OR ‘‘outpatient antimicrobial* therapy’’[tw] (6684)

#39 OHPAT[tw] OR OPAT[tw] (523)

#40 #36 OR #37 OR #38 OR #39 (12562)

#41 #27 OR #40 (12697)

#42 Telemedicine (41052)

#43 Remote Consultation (5633)

#44 Telecommunications (117574)

#45 Telemetry (14680)

#46 Videoconferencing (2654)

#47 Mobile Health Units (3850)

#48 #42 OR #43 OR #44 OR #45 OR #46 OR #47 (121282)

#49 tele-medicine[tw] OR tele-OPAT[tw] OR telecare [tw] OR tele-care[tw] OR telehealth[tw] OR tele-health[tw] (11922)

#50 videoconferenc*[tw] OR video-conferenc*[tw] OR ‘‘video consult’’*[tw] OR videoconsult*[tw] OR ‘‘video care’’[tw] OR videomonitor*[tw] OR ''video monitor''*[tw] (7527)

#51 teleconferenc*[tw] OR tele-conferenc*[tw] OR ‘‘telephone conferenc’’*[tw] OR teleconsult*[tw] OR ‘‘tele-consult’’*[tw] OR ‘‘telephone consult’’*[tw] OR ‘’telephone care’’[tw] OR telemonitor*[tw] OR ''tele monitor''*[tw] OR ''telephone monitor''*[tw] (7126)

#52 ‘‘mobile health’’[tw] OR mHealth[tw] OR m-health[tw] (15601)

#53 ‘‘remote care’’[tw] OR ‘‘remote monitor’’*[tw] OR ''remote consult''*[tw] OR ''remote patient monitoring''[tw] OR store-and-forward[tw] (10721)

#54 #49 OR #50 OR #51 OR #52 OR #53 (46172)

#55 #48 OR #54 (140164)

#56 #41 AND #55 **(65)**

The Cochrane Library search conducted on 22 July 2022

#1 MeSH descriptor: [Anti-Infective Agents] (31426)

#2 MeSH descriptor: [Anti-Infective Agents, Urinary] (257)

#3 MeSH descriptor: [Anti-Bacterial Agents] (13046)

#4 MeSH descriptor: [Antifungal Agents] (1808)

#5 MeSH descriptor: [Antiviral Agents] (8989)

#6 #1 OR #2 OR #3 OR #4 OR #5 (31426)

#7 MeSH descriptor: [Administration, Intravenous] (19228)

#8 MeSH descriptor: [Infusions, Intravenous] (10562)

#9 MeSH descriptor: [Infusions, Parenteral] (12739)

#10 MeSH descriptor: [Infusion Pumps] (1322)

#11 MeSH descriptor: [Injections, Intravenous] (7741)

#12 MeSH descriptor: [Home Infusion Therapy] (19)

#13 #7 OR #8 OR #9 OR #10 OR #11 OR #12 (22359)

#14 ((IV OR intravenous OR inject* OR infusion OR parenteral) AND (antimicrobial* OR anti-microbial* OR antiinfective* OR anti-infective* OR antibiotic* OR anti-biotic* OR antifungal* OR anti-fungal* OR antiviral* OR anti-viral* OR antibiotherap* OR anti-biotherap*)):ti,ab,kw (11644)

#15 (#6 AND #13) OR #14 (11962)

#16 MeSH descriptor: [Outpatients] (1388)

#17 MeSH descriptor: [Outpatient Clinics, Hospital] (660)

#18 MeSH descriptor: [Ambulatory Care] (3755)

#19 MeSH descriptor: [Ambulatory Care Facilities] (1956)

#20 MeSH descriptor: [Day Care, Medical] (255)

#21 MeSH descriptor: [Community Health Services] (15109)

#22 MeSH descriptor: [Community Health Nursing] (352)

#23 MeSH descriptor: [Home Care Services, Hospital-Based] (247)

#24 MeSH descriptor: [Home Nursing] (300)

#25 MeSH descriptor: [Home Care Services] (2568)

#26 #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25 (21398)

#27 #15 AND #26 (109)

#28 (outpatient):ti,ab,kw (45099)

#29 (home OR homes):ti,ab,kw (52923)

#30 ((self OR carer) NEAR/6 (treat* OR admin* OR care OR regime*)):ti,ab,kw (31936)

#31 ((clinic OR clinics) NEAR/6 (treat* OR admin* OR care OR regime*)):ti,ab,kw (129605)

#32 (community NEAR/6 (treat* OR admin* OR care OR regime*)):ti,ab,kw (10716)

#33 (ambulatory NEAR/6 (treat* OR admin* OR care OR regime*)):ti,ab,kw (6772)

#34 ((district NEXT nurs*) OR (community NEXT nurs*) OR (specialist NEXT nurs*) OR (nurse NEXT specialist*)):ti,ab,kw (1327)

#35 #28 OR #29 OR #30 OR #31 OR #32 OR #33 OR #34 (242295)

#36 #15 AND #35 (3157)

#37 ((outpatient NEXT parenteral NEXT antimicrobial* NEXT therapy) OR (outpatient NEXT parenteral NEXT antibiotic* NEXT therapy)):ti,ab,kw (28)

#38 ((outpatient NEXT antibiotic* NEXT therapy)):ti,ab,kw (23)

#39 (OHPAT OR OPAT):ti,ab,kw (42)

#40 #36 OR #37 OR #38 OR #39 (3183)

#41 #27 OR #40 (3195)

#42 MeSH descriptor: [Telemedicine] (3253)

#43 MeSH descriptor: [Remote Consultation] (410)

#44 MeSH descriptor: [Telecommunications] (8170)

#45 MeSH descriptor: [Telemetry] (308)

#46 MeSH descriptor: [Videoconferencing] (247)

#47 MeSH descriptor: [Mobile Health Units] (68)

#48 #42 OR #43 OR #44 OR #45 OR #46 OR #47 (8248)

#49 (telecare OR telehealth OR (tele* NEAR/6 (medicine OR OPAT OR care OR health))):ti,ab,kw (7581)

#50 (videoconferenc* OR videoconsult* OR videomonitor* OR (video NEAR/6 (conferenc* OR consult* OR care OR monitor*))): ti,ab,kw (2807)

#51 (teleconferenc* OR teleconsult* OR telemonitor* OR (tele* NEAR/6 (conferenc* OR consult* OR monitor*))):ti,ab,kw (4414)

#52 (mHealth OR (mobile NEAR/6 health) OR (m NEAR/6 health)):ti,ab,kw (4541)

#53 ((remote NEAR/6 (care OR monitor* OR consult*)) OR (store NEAR/3 forward)):ti,ab,kw (2128)

#54 #49 OR #50 OR #51 OR #52 OR #53 (17858)

#55 #48 OR #54 (22685)

#56 #41 AND #55 **(27)**

CINAHL (EBSCOHost) – search conducted on 19 July 2022

#	Searches	Results
S1	(IV OR intravenous OR inject* OR infusion OR parenteral) N6 (antimicrobial* OR anti-microbial* OR antiinfective* OR anti-infective* OR antibiotic* OR anti-biotic* OR antifungal* OR anti-fungal* OR antiviral* OR anti-viral* OR antibiotherap* OR anti-biotherap*)	14411
S2	Outpatient* OR (home or homes) OR ((self OR carer) N6 (treat* OR admin* OR care OR regime*)) OR ((clinic OR clinics) N6 (treat* OR admin* OR care OR regime*)) OR (community N6 (treat* OR admin* OR care OR regime*)) OR (ambulatory N6 (treat* OR admin* OR care OR regime*)) OR (‘‘district nurs*’’ OR ‘‘community nurs*’’ OR ‘‘specialist nurs*’’ OR ‘‘nurse specialist*’’)	603665
S3	‘‘outpatient parenteral antimicrobial* therapy’’ OR ‘‘outpatient parenteral antibiotic* therapy’’ OR ‘‘outpatient antibiotic* therapy’’ OR OHPAT OR OPAT	368
S4	telemedicine OR telecommunicat* OR telemetr* OR telecare OR telehealth OR (tele* N6 (medicine OR OPAT OR care OR health)) OR videoconferenc* OR videoconsult* OR videomonitor* OR (video N6 (conferenc* OR consult* OR care OR monitor*)) OR teleconferenc* OR teleconsult* OR telemonitor* OR (tele* N6 (conferenc* OR consult* OR monitor*)) OR mHealth OR (mobile N6 health) OR (m N6 health) OR (remote N6 (care OR monitor* OR consult*)) OR (store N3 forward)	60259
S5	((S1 AND S2) OR S3) AND S4	**25**

Embase (Ovid) – search conducted on 21 July 2022

#	Searches	Results
1	Anti-infective Agent.mp. or exp antiinfective agent/	4180431
2	anti-infective agents, urinary.mp. or exp urinary tract antiinfective agent/	203445
3	antibiotic.mp. or exp antibiotic agent/	1806401
4	antifungal agent.mp. or exp antifungal agent/	398320
5	antiviral agent.mp. or exp antivirus agent/	1294307
6	antimicrobial*.mp.	296680
7	antibiotherap*.mp.	4229
8	1 or 2 or 3 or 4 or 5 or 6 or 7	4336611
9	intravenous drug administration.mp. or exp intravenous drug administration/	943335
10	home infusion therapy.mp. or exp home infusion therapy/	296
11	(IV or intravenous or inject* or infusion or parenteral).mp.	2945457
12	9 or 10 or 11	2945471
13	8 and 12	678073
14	outpatient.mp. or exp outpatient/	354779
15	outpatient care.mp. or exp outpatient care/	46885
16	outpatient department.mp. or exp outpatient department/	81481
17	community health nursing.mp. or exp community health nursing/	24340
18	community care.mp. or exp community care/	128151
19	home care.mp. or exp home care/	90020
20	((self or carer) adj3 (treat* or admin* or care or regime*)).mp.	166738
21	((clinic or clinics) adj3 (treat* or admin* or care or regime*)).mp.	43126
22	(community adj3 (treat* or admin* or care or regime*)).mp.	95013
23	(ambulatory adj3 (treat* or admin* or care or regime*)).mp.	53735
24	(district nurs* or community nurs* or specialist nurs* or nurse specialist*).mp.	17958
25	14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24	813620
26	13 and 25	18828
27	(outpatient parenteral antimicrobial* therapy or outpatient parenteral antibiotic* therapy).mp.	922
28	home intravenous therapy.mp. or home intravenous therapy/	119
29	(outpatient antibiotic* therapy or outpatient antimicrobial* therapy).mp.	230
30	(OPAT or OHPAT).mp.	897
31	26 or 27 or 28 or 29 or 30	19076
32	exp telemedicine/ or telemedicine.mp.	66794
33	exp telecommunication/ or telecommunication.mp.	101770
34	exp telemetry/ or telemetry.mp.	37865
35	exp videoconferencing/ or videoconferencing.mp.	8255
36	(telecare or telehealth or (tele* adj6 (medicine or OPAT or care or health))).mp.	46885
37	(videoconferenc* or videoconsult* or videomonitor* or (video adj6 (conferenc* or consult* or care or monitor*))).mp.	21294
38	(teleconferenc* or teleconsult* or telemonitor* or (tele* adj6 (conferenc* or consult* or monitor*))).mp.	36500
39	(mHealth or (mobile adj6 health) or (m adj6 health)).mp.	19403
40	((remote adj6 (care or monitor* or consult*)) or (store adj3 forward)).mp.	15255
41	32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40	190790
42	31 and 41	**247**

Ovid Emcare – search conducted on 21 July 2022

#	Searches	Results
1	Anti-infective Agent.mp. or exp antiinfective agent/	619458
2	anti-infective agents, urinary.mp. or exp urinary tract antiinfective agent/	33691
3	antibiotic.mp. or exp antibiotic agent/	282305
4	antifungal agent.mp. or exp antifungal agent/	55079
5	antiviral agent.mp. or exp antivirus agent/	165025
6	antimicrobial*.mp.	48884
7	antibiotherap*.mp.	576
8	1 or 2 or 3 or 4 or 5 or 6 or 7	647545
9	intravenous drug administration.mp. or exp intravenous drug administration/	27968
10	home infusion therapy.mp. or exp home infusion therapy/	106
11	(IV or intravenous or inject* or infusion or parenteral).mp.	392874
12	9 or 10 or 11	392878
13	8 and 12	66387
14	outpatient.mp. or exp outpatient/	121579
15	outpatient care.mp. or exp outpatient care/	19261
16	outpatient department.mp. or exp outpatient department/	43681
17	community health nursing.mp. or exp community health nursing/	5384
18	community care.mp. or exp community care/	50561
19	home care.mp. or exp home care/	40008
20	((self or carer) adj3 (treat* or admin* or care or regime*)).mp.	70424
21	((clinic or clinics) adj3 (treat* or admin* or care or regime*)).mp.	14314
22	(community adj3 (treat* or admin* or care or regime*)).mp.	40239
23	(ambulatory adj3 (treat* or admin* or care or regime*)).mp.	15659
24	(district nurs* or community nurs* or specialist nurs* or nurse specialist*).mp.	8661
25	14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24	305694
26	13 and 25	3349
27	(outpatient parenteral antimicrobial* therapy or outpatient parenteral antibiotic* therapy).mp.	224
28	home intravenous therapy.mp. or home intravenous therapy/	48
29	(outpatient antibiotic* therapy or outpatient antimicrobial* therapy).mp.	59
30	(OPAT or OHPAT).mp.	209
31	26 or 27 or 28 or 29 or 30	3430
32	exp telemedicine/ or telemedicine.mp.	24909
33	exp telecommunication/ or telecommunication.mp.	42057
34	exp telemetry/ or telemetry.mp.	7443
35	exp videoconferencing/ or videoconferencing.mp.	3593
36	(telecare or telehealth or (tele* adj6 (medicine or OPAT or care or health))).mp.	24255
37	(videoconferenc* or videoconsult* or videomonitor* or (video adj6 (conferenc* or consult* or care or monitor*))).mp.	6883
38	(teleconferenc* or teleconsult* or telemonitor* or (tele* adj6 (conferenc* or consult* or monitor*))).mp.	12568
39	(mHealth or (mobile adj6 health) or (m adj6 health)).mp.	9867
40	((remote adj6 (care or monitor* or consult*)) or (store adj3 forward)).mp.	5317
41	32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40	71943
42	31 and 41	**39**

Table A.3. Excluded Studies with Reasons

Study identification	Title	DOI	Reason for exclusion
Appiah-Kubi G et al., 2012	Telemedicine to improve access to specialized care for patients with cystic fibrosis	10.1002/ppul.22682	Conference abstract. No IV antimicrobial therapy was administered
Breaux K et al., 2021	Outpatient parenteral antibiotic therapy and follow-up during the COVID-19 pandemic	10.1097/01.JAA.0000800608.04046.79	Conference abstract. Effectiveness of telemedicine was not reported
Eron L. 2010	Telemedicine: the future of outpatient therapy?	10.1086/653524	Commentary article
Evans C et al., 2017	Development of a virtual ward model of care for adults with cystic fibrosis (CF) requiring home intravenous (IV) antibiotics	N/A	Conference abstract. Effectiveness of telemedicine was not reported
Koziatek C, et al., 2021	Use of a telehealth follow-up system to facilitate treatment and discharge of emergency department patients with severe cellulitis	10.1016/j.ajem.2020.01.061	Telemedicine utilised in an ED (non-OPAT) setting
Miyatake H, et al., 2021.	Videoconferencing for home care delivery in Japan: observational study	10.2196/23539	No IV antimicrobial therapy was administered
Patel M et al., 2019	Dalbavancin Use in the Emergency Department Setting	10.1177/1060028019855159	Telemedicine utilised in an ED (non-OPAT) setting
Schneider N et al., 2003	Telemedicine success story	10.1089/153056203763317738	Commentary article

ED, emergency department; IV, intravenous; N/A, not applicable; OPAT, outpatient parenteral antimicrobial therapy

Table A.4. Summary of studies included in the review

Study	Publication type	Study design	Purpose	Sample size/ population and duration of intervention	Telemedicine setting	Intervention type	Outcome assessed	Key findings	Noted authors' comments/ recommendations
Bradford et al., 2013 Australia [18]	Journal article	Quantitative non-randomised (cross-sectional) study	To compare the costs associated with three different methods of administering antibiotics to paediatric oncology patients (cost minimisation analysis)	11 paediatric patients (231 medication episodes) 4 months	Internet video (video conferencing) to support antibiotic administration at home	Real-time	Cost-effectiveness *(medication cost)*	Mean costs of a medication episode in a scenario where antibiotics were prepared and checked in the home using a video link to a second nurse ($129.91) was lower than the costs in scenarios where medications were prepared by an outsourced commercial organisation ($312.00) or in the hospital ($355.91).	Use of internet-based video appears to produce savings compared to other methods of administering antibiotics and the technique may have wider application in supporting complex interventions in the home.
Tan et al., 2017 Australia [19]	Journal article	Quantitative descriptive (retrospective single-group cohort) study	To evaluate the clinical outcomes and complication rates for patients living in geographically isolated locations managed by telemedicine-supported OPAT	83 adult patients (88 OPAT episodes) 47 months	Weekly videoconferencing with an ID specialist	Real-time	Patient outcomes and safety *(cure/improvement, readmission, and adverse event rates)*	Favourable clinical outcomes were achieved in 87% of patients; 8% unplanned OPAT-related readmission. Clinical outcomes, adverse event and readmission rates were comparable to other published non-telemedicine OPAT literature 102,748 km of travel was	High rates of favourable clinical outcomes and likely cost benefits suggest that telemedicine-supported OPAT is an efficacious and safe substitute for inpatient care in our setting.

								avoided.	
Eron et al., 2004 United Sates [20]	Journal article	Quantitative non-randomised (matched cohort) study	To evaluate use of TM in the home to monitor moderately to severely ill patients with acute infections who would normally be hospitalised.	50 adult patients: TM group: 25 Control group: 25 26 weeks	AV outpatient follow-up visits with remote home monitoring of vital signs	Remote patient monitoring	Cost-effectiveness Patient satisfaction Patient outcomes and safety *(length of hospital stay, time to return to ADL, recurrence, and readmission)*	Projected savings of $135,000 - $540,000 over one year TM group had comparable frequency of recurrence or readmission (12% vs. 16%; $p = 0.30$), shorter mean length of hospital stays (2.6 vs. 8.0 days; $p = 0.02$) and returned to normal function sooner (8 vs. 21 days; $p < 0.001$) than hospitalised patients TM patients were more comfortable at home (mean rating 4.9 vs. 3.0 on 5-point scale; $p = 0.35$) but felt safer in the hospital (mean rating 3.8 vs. 4.7) $p = 0.09$) than hospitalised patients.	Patients treated with telemedicine have satisfactory clinical outcomes, and their recovery appears to be more rapid than comparable hospitalised patients. Telemedicine in the home results in considerable savings by averting or shortening hospital stays.
Greenup et al., 2017 Australia [21]	Journal article	Quantitative non-randomised (matched cohort) study	To determine if mobile videoconferencing technology can facilitate the discharge of low-acuity patients receiving in-home care without	345 adult patients: TM group: 35 Control group: 310 Matched sample: TM group: 29	Mobile videoconferencing between nurses and hospital-based physicians to facilitate discharge of	Real-time/ mHealth	Patient outcomes and safety *(readmission rates)*	No significant differences in 28-day readmission rates between TM group and control group (3.4% vs. 10.3%; OR, 0.34; 95% CI, 0.01 – 4.51).	The results of evaluating TM support for nurses providing low-acuity in-home care indicate that patients

			compromising short-term health outcomes.	patients Control group: 29 patients 6 months	patients considered unsuited to criteria led discharge receiving in-home care.				may be discharged remotely while maintaining the existing clinical standards of the service.
Huggins et al., 2022 United States [22]	Journal article	Quantitative non-randomised (unmatched cohort) study	To examine the impact of post-hospital discharge automated voice calls on 30-day readmissions of OPAT patients	148 adult patients (429 voice calls): TM group: 90 patients (297 calls) Control group: 58 patients (132 calls) 28 months	Automated telephone calls provided at 2, 9, 16, 28 and 40 days post-hospital discharge (depending on duration of therapy).	Real-time	Patient outcomes and safety *(readmission rates)*	Patients who were contacted were significantly less likely to be readmitted (18.9% vs. 41.4%; RR, 0.46; 95% CI, 0.27 - 0.77; p = 0.003 than those not reached by the automated telephone calls).	The live phone calls serve as a vehicle through which concerns that may affect readmission and patient satisfaction are both expressed and subsequently addressed.
Swartwood et al., 2020 United States [23]	Conference abstract	Quantitative non-randomised (pre-post intervention) study	To compare OPAT delivery pre-COVID-19 (pre-introduction of TM) with delivery during COVID-19 (via TM)	143 patients TM group: 73 patients Non-TM group: 70 patients 2.5 months	ID follow-up visits by phone and video TM	Real-time	Patient outcomes and safety *(readmission rates)*	Readmission rates were similar between the two time periods/groups (14% vs. 16%; p = 0.72)	Readmission rates for OPAT patients during COVID-19 were comparable to historical baseline data.
Cortes-Penfield et al., 2021 United States [24]	Conference abstract	Quantitative non-randomised (unmatched cohort) study	To report experience of implementing a telehealth-based clinic to facilitate early follow-up for selected OPAT patients perceived to be at high risk for	278 patients Early TM group: 49 patients Control group: 229 patients	Early (1-2 week) post-hospital discharge TM follow-up visits	Real-time	Patient outcomes and safety (*readmission rates*)	30-day all-cause and infection-related readmission rates were significantly lower in the early TM group (6.1% vs. 22.7%; p = 0.008) and (0% vs. 7.4%; p = 0.049) respectively.	Telehealth-based encounters appear comparable in effectiveness to those previously reported utilising in-person visits, introducing

			readmission.	7 months				An intervention was made in 27% (13/49) TM patients - mostly to mitigate adverse event or vascular access-related complications.	efficiencies that may allow for broader implementation of this intervention.
Vaz et al., 2017 United States [25]	Conference abstract	Quantitative descriptive (pilot case series) study	To demonstrate the feasibility and functionality of home telehealth platform in a paediatric OPAT Programme	2 paediatric patients Duration: not specified	A virtual (AV) clinic between OPAT provider and family with a parent-driven physical exam	Real-time	Patient outcomes and safety	Three visits between the OPAT ID provider (located in her office) and the patients (located at home) were successfully piloted. The platform also allowed for multidisciplinary visits with a hospitalist and home health nurse to address a central line related issue	The use of TM in OPAT may serve as a new platform for improving provider efficiency, lowering health system costs, and achieving greater patient satisfaction.
Felder et al., 2017 United States [26]	Conference abstract	Quantitative descriptive (single-group cohort) study	To assess the utility of post-discharge TC as an OPAT program quality improvement process	636 adult patients 14 months	Post-hospital discharge telephone calls	Real-time	Patient outcomes and safety *(complication rates)*	302 patients (47%) reported 319 issues, including 293 (92%) relevant to OPAT	Adding a post-discharge TC to an OPAT program was feasible and resulted in frequent and early identification of significant OPAT patient and caregiver concerns.

Sheridan et al., 2020 United States [27]	Conference abstract	Quantitative descriptive (retrospective case series) study	To evaluate readmission rates and outcomes of OPAT patients that had home AV TM follow-up appointments	13 adult patients 8 months	Home AV TM visits	Real-time	Patient outcomes and safety *(readmission and complication rates)*	30-day all-cause readmission rate 30.8% (4/13) Vascular access complication 7.7% (1/13)	Home TM video visits could be an alternative to in-office appointments for OPAT patients.
Sheridan et al., 2020 United States [28]	Conference abstract	Quantitative non-randomised (unmatched cohort) study	To investigate outcomes from telemedicine OPAT services	489 adult patients (536 encounters) TM & Control group sizes and study duration: not specified	AV outpatient follow-up visits	Real-time	Patient outcomes and safety (readmission rates)	30-day readmission rate was lower in TM group (7.4%) vs. no follow-up (62%) vs. PCP follow up (22%) vs. follow up with other non-ID physicians (12.8%)	Tele-OPAT is an important option for patients residing in rural areas who are discharged on parenteral antibiotics
Boerneke et al., 2020 United States [29]	Conference abstract	Quantitative non-randomised (unmatched cohort) study	To evaluate dissemination and impact of a structured telephone outreach OPAT programme	374 adult patients: TM group: 228 (61%) Control group: 146 (39%) 14 months	Structured telephone outreach programme to enhance care coordination at discharge.	Real-time	Patient outcomes and safety (readmission and adverse event rates)	Unplanned readmission rate was lower in contacted (TM) group (14% vs. 21%; RD -7%; 95% CI -15% to 1%). Risk of adverse events was similar between both groups (58% vs. 54%; RD 4%; 95%CI -6%, 15%).	This intervention may be a simple, low-cost way to reduce readmissions for OPAT patient.

ADL, activities of daily living; AV, audio-visual; ID, infectious diseases; CI, confidence interval; COVID-19, coronavirus disease 2019; mHealth, mobile health; OPAT, outpatient parenteral antimicrobial therapy; OR, odds ratio; RD, risk difference; RR, relative risk; PCP, primary care physician; TC, telephone call; TM, telemedicine.

Table A.5. Quality assessment using Mixed Methods Appraisal Tool (MMAT), version 2018

		Quantitative non-randomised								Quantitative descriptive			
Category of Study designs	**Methodological quality criteria**	**Boerneke *et al*** [29]	**Bradford *et al*** [18]	**Cortes-Penfield *et al*** [24]	**Eron *et al*** [20]	**Greenup *et al*** [21]	**Huggins *et al*** [22]	**Sheridan *et al*** [28]	**Swartwood *et al*** [23]	**Felder *et al*** [26]	**Sheridan *et al*** [27]	**Tan *et al*** [19]	**Vaz *et al*** [25]
Quantitative non-randomised	Are the participants representative of the target population?	C	C	Y	Y	Y	Y	C	Y	-	-	-	-
	Are measurements appropriate regarding both the outcome and intervention (or exposure)?	Y	Y	Y	Y	Y	Y	Y	Y	-	-	-	-
	Are there complete outcome data?	C	Y	Y	Y	Y	Y	C	C	-	-	-	-
	Are the confounders accounted for in the design and analysis?	N	N	N	Y	Y	N	N	C	-	-	-	-
	During the study period, is the intervention administered (or exposure occurred) as intended?	C	Y	C	Y	Y	Y	C	C	-	-	-	-
Quantitative descriptive	Is the sampling strategy relevant to address the research question?	-	-	-	-	-	-	-	-	N	N	Y	N
	Is the sample representative of the target population?	-	-	-	-	-	-	-	-	C	C	C	C
	Are the measurements appropriate?	-	-	-	-	-	-	-	-	Y	Y	Y	N
	Is the risk of nonresponse bias low?	-	-	-	-	-	-	-	-	C	C	Y	Y
	Is the statistical analysis appropriate to answer the research question?	-	-	-	-	-	-	-	-	Y	Y	Y	N

C, can't tell; N, no; Y, yes