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Economic Impact of Telehealth on Maternal and Child Health in Regional, Rural and Remote Australia: A Systematic Review

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Abstract

Background

Telehealth has the potential to mitigate maternal and child health access challenges, reduce health system dependency and healthcare expenditures, and facilitate the delivery of healthcare to women and children remotely.

Methods

Exhaustive searches of the literature were performed across multiple databases, including PubMed, Scopus, PDQ-Evidence for Informed Health Policymaking, CINAHL, EconLit, International Health Technology Assessment (HTA), Google Scholar, and the UniSQ RISE Research Repository. These searches targeted peer-reviewed, English-language articles published from inception to February 2024. The quality of the reports was assessed via CHEERS 2022.

Results

In this review, 20 studies comparing telehealth to usual care for maternal and child healthcare in remote, rural, and regional (RRR) Australia were included. Of these, 18 found telehealth to be a cost-saving option, while two reported comparable costs and outcomes. These findings were assessed from a range of perspectives, including those of the health system, society, family, providers, and third-party payers. The review findings indicate that telehealth has potential for addressing health disparities among women and children in remote, rural, and regional Australia. Health disparities are reduced by overcoming access barriers, reducing expenses, fostering healthy behaviors, increasing service utilization, shortening hospital stays, and enhancing care coordination.

Conclusions

This review highlights that telehealth is a predominantly cost-saving alternative to usual care for maternal and child health services in remote, rural, and regional Australia. It has the potential to reduce health inequality among women and children residing in remote, rural, and regional Australia. A broader evaluation incorporating societal costs and benefits, along with a long-term view of the clinical and economic impacts of telehealth, is essential for its wider implementation.

Systematic Review Registration

The study protocol was recorded in the International Prospective Register of Systematic Reviews (PROSPERO) with the protocol identifier CRD42024518089.

Keywords: economic impact; telehealth; maternal and child health; regional, rural, and remote Australia

Introduction

Australia, as a high-income nation with a universal healthcare system, is recognized for its exceptional standards of health and welfare for mothers and children, ranking among the highest globally(1). Nonetheless, approximately seven million individuals, constituting 28% of Australia's population, reside in rural and remote regions, encountering distinct obstacles attributable to their geographic remoteness, which frequently leads to poorer health outcomes than those of urban dwellers. This problem is particularly pronounced among women and children (2). The evidence has underscored the influence of factors such as isolation, indigenous identity, and socioeconomic status (SES) in determining the distribution and standards of healthcare facilities (3).

Enhancing maternal health outcomes requires not only improving the socioeconomic conditions in which women live (4) but also designing healthcare services that are responsive to these conditions, ensuring that care is both acceptable and accessible for women and children (5). The ongoing challenge of providing healthcare services in rural areas persists (6). One potential solution to mitigate these challenges is the utilization of telehealth, which facilitates the remote delivery of healthcare. Telehealth is defined as "the delivery of health care services, where distance is a critical factor, by health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment, and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interest of advancing the health of individuals and their communities" (7).

An expanding body of evidence increasingly demonstrates the effectiveness of telehealth for both patients and service providers. This evidence points to a range of positive outcomes, including shorter hospital stays, reduced pressure on emergency services, improved healthcare accessibility, enhanced quality of care, better clinical outcomes, lower costs, decreased inconvenience for patients, and more effective management of chronic and complex conditions. It also highlights additional benefits such as opportunities for peer support, social connection, and learning (6, 8-15).

The assessment of telehealth in the maternal and child health (MCH) universal program identified both benefits and barriers linked to shifts in service delivery and practice. Nevertheless, it recommended that telehealth continue as a service option beyond the COVID-19 recovery phase, highlighting the need to strengthen workforce capacity for telehealth (16).

Currently, eligible patients across Australia have access to telehealth services offered by GPs, specialists, nurses, midwives, and allied health professionals. However, adjustments have been made to the number of telehealth items introduced during the COVID-19 pandemic. For example, the GP Level C (20+ minute) 'hotspot' telephone consultations, which do not necessitate an existing clinical relationship, have been discontinued. An extended GP telephone consultation

service has recently been implemented for people in remote Australia, highlighting the need to understand the effects of its growing uptake in these communities (17, 18).

Economic evaluation is central to telehealth, given its aims of lowering service delivery costs, improving workforce efficiency, and expanding timely and equitable access to care. With healthcare spending continuing to rise, telehealth is now widely regarded as a cost-saving strategy for healthcare systems (19).

The examined cost evaluations revealed that telehealth led to cost savings by preventing health system-funded travel and by substituting costly procedures or specialist appointments with lower-cost yet clinically appropriate telehealth consultations that were able to meet patients' care needs effectively. Researchers observed that telehealth use resulted in reduced healthcare system costs in 53% of studies focused on cost minimization, 50% of those focused on cost effectiveness, and 32% of studies examining cost utility. The primary factor contributing to cost reductions was the avoidance or minimization of health system-funded travel by both patients and clinicians (20, 21).

The lack of comprehensive, robust economic evaluation studies could pose a significant barrier to the widespread acceptance, expansion, and financial support of telehealth initiatives targeting maternal and child health interventions in rural and remote communities (22, 23). The economic impact of maternal and child healthcare services provided through telehealth in remote, rural, and regional Australia is still unknown. To assist health systems in their endeavors to incorporate telehealth to address care discrepancies in maternal and child health services in remote, rural, and regional areas, it is crucial to fully understand the expenses linked with these telehealth initiatives. Hence, this study sought to compile evidence and evaluate the economic impact of telehealth for maternal and child health in remote, rural, and regional Australia, exploring its potential to address gaps in maternal and child health care delivery.

Methods

Study design

This systematic review followed the guidelines specified in the Preferred Reporting Items for Systematic Reviews (PRISMA) (24). The study protocol was recorded in the International Prospective Register of Systematic Reviews (PROSPERO) with the protocol identifier CRD42024518089.

Search strategy

Exhaustive searches of the literature were performed across multiple databases, including PubMed, Scopus, PDQ-Evidence for Informed Health Policymaking, EconLit, CINAHL (which includes CINAHL Ultimate, Academic Search Ultimate, PA PsycArticles, APA PsycInfo, APA PsycTests, Australia/New Zealand Reference Centre Plus, E-Journals, Health Business Elite, Health Source: Consumer Edition, and Health Source: Nursing/Academic Edition), International

Health Technology Assessment (HTA), Google Scholar, and UniSQ RISE Research Repository. Furthermore, reference lists from original articles and relevant literature reviews were manually searched. The search was undertaken to identify articles that were written in English and released from inception until February 2024, with no restrictions on the year of publication. The goal was to include all economic assessments carried out for telehealth in maternal and child health services in remote, rural, and regional Australia. The search terms used were customized for PubMed via Medical Subject Headings (MeSH) and modified as needed for other databases. The approach integrated Boolean terms linked to telehealth, economic evaluation, maternal health, child health, and rural and regional populations (Supplementary Table 1).

Eligibility criteria

Included were original studies published in English that compared telehealth interventions with usual maternal and childcare interventions in remote, rural, and regional areas of Australia outside major metropolitan cities, irrespective of study design. The final inclusion of studies was contingent upon meeting the predetermined inclusion criteria framed by the population, intervention, comparison, and outcome (PICO) framework.

Population

This study focused on maternal health, “the health of women during pregnancy, childbirth, and the postnatal period (25), as well as child health, “the extent to which individual children or a group of children are able or enabled to (a) develop and realize their potential, (b) satisfy their needs, and (c) develop the capacities that allow them to interact successfully with their biological, physical, and social environments,” (26)who are living in remote, rural and regional Australia (out of major cities) (27).

Intervention

The included studies involved the delivery of maternal health (25), as well as child health (26), through telehealth either exclusively (as a telehealth-exclusive intervention) or in conjunction with standard care, utilizing synchronous or asynchronous information communication technology in any format.

Comparator

Studies met the inclusion criteria if they involved a comparison between telehealth and a group not utilizing telehealth over a certain duration, commonly termed "usual" or "standard" care. Analysis without a comparative group receiving non-telehealth treatment was omitted from inclusion.

Outcome

The main outcome was the cost and effect of telehealth for maternal and child health interventions. This was framed as the cost-effectiveness of telehealth compared with standard care. Studies that did not present costs or outcomes were not included in our study.

Study selection

Duplicates were eliminated via EndNote software and manually. Two authors (GA and ZH) independently reviewed titles and abstracts to determine inclusion criteria on the basis of the predefined criteria. Any differences were handled by a third author (RK). Two authors (GA and ZH) then completed full-text screening to establish consistency with the predefined criteria, and any differences were handled by the reviewing author (RK).

Data Extraction and Data Synthesis

Data extraction was conducted by one author (GA) from the studies selected for inclusion, with a second author (ZH) verifying the accuracy of the extracted data. The extracted data, which encompassed study attributes such as study design, authors, and publication year, population, settings, conditions and diseases, type and duration of intervention, sample size, outcome of measures, and key findings, were recorded in an Excel spreadsheet.

The health economic findings encompassed the type of economic analysis, perspectives on cost effectiveness, costed items, outcomes, and the authors' conclusions. The health and economic results were synthesized through narrative synthesis, depicted in tables, and organized on the basis of the study population and diseases or conditions. The completion of the Criteria for Cost-Effectiveness Review Outcomes checklist is also documented (Supplementary Table 2). Due to the lack of suitability of merging economic results across various populations and healthcare systems, a meta-analysis was not conducted.

Quality assessment

The quality of this review was assessed via the updated Consolidated Health Economic Evaluation Reporting Standards of 2022 (CHEERS 2022) (28), which includes a 28-point quality assessment tool. Notable revisions were made in CHEERS 2022 compared with CHEERS 2013. These changes encompassed aspects such as community or stakeholder involvement, the inclusion of a health economic analysis plan, the consideration of distributional effects, and the elimination of distinctions between model-based and study-based measures. Additionally, there were

expansions in language and a requirement to report the availability of publicly accessible models. One author (GA) assigned scores to all the articles, whereas another author (RK) randomly reviewed a selection of articles to ensure the consistency of the quality assessment.

Results

Study Selection

A total of 2542 articles were found across six main databases (Scopus, PubMed, CINAHL, PDQ Evidence-Informed Policymaking, EconLit, and HTA) and two additional sources (Google Scholar and UniSQ RISE Research Repository) on the economic impact of telehealth on maternal and child health in regional, rural, and remote Australia. Of these articles, 654 duplicates were removed through manual checking and EndNote software checks. Another 1740 articles were excluded after screening their abstracts and titles. Therefore, the search initially targeted 148 articles for retrieval, but four were discarded because of incomplete texts. Of the 144 remaining articles reviewed for eligibility, 124 were excluded for various reasons (such as not being based in Australia; not focusing on maternal and child health; not being based on remote, rural, or regional Australia; not being original articles; relating to Cloud or AI technologies; or the absence of controls). In the end, 20 studies were considered (Figure 1).

Study characteristics

In this systematic review, a total of 20 health economic studies involving 2,713,990 participants were included (14, 22, 23, 29-45). All these studies were conducted in regional, rural, and remote Australia. Telehealth was used in two maternal health services (22, 44) and 18 child health services (14, 29-43, 45). With respect to maternal health, telehealth is used for gestational diabetes mellitus management and for enhancing the physical activity of women (22, 44). On the other hand, telehealth in children has been used for neonatal care (23, 34), fractures (14, 35), mental health (31, 45), ear, nose throat (ENT) services (32, 41, 42), dental care (36, 37, 40), palliative care (38), early behavioral signs of autism (39), nutrition (43), and general child health services (29, 30, 33) (Table 1). The economic evaluation included seven cost minimization analyses (CMA) (30-34, 36, 38), four cost effectiveness analyses (CEA) (37, 39, 43, 44), three cost utility analyses (CUA) (40, 42, 45), one cost benefit analysis (CBA) (14), two cost comparison analyses (22, 35), two cost analyses (23, 29), and one cost evaluation approach (41). The majority of health economic analyses were conducted from a health service/system perspective. The cost components ranged from solely health service provider costs to encompass all fixed and variable expenses associated with the telehealth intervention (Table 2).

Study Quality Assessment

Based on CHEERS 2022 criteria, quality scores ranged from 16.5 (59%) to 27 (96%) out of 28. Table 2 presents the scores for each included study, and Supplementary Table 3 provides the complete scoring breakdown.

Economic impact of telehealth

In this review, 20 studies comparing telehealth to usual care for maternal and child healthcare in remote, rural, and regional (RRR) Australia were included. Of these, 18 found telehealth to be a cost-saving option, while two reported comparable costs and outcomes. These findings were assessed from a range of perspectives, including health system, societal, family, provider, and third-party payer viewpoints.

Maternal health

This review investigated the application of telehealth to manage gestational diabetes mellitus (GDM) and to promote physical activity among women (22, 44). The TeleGDM intervention was designed to assess its impact on healthcare use, clinical effects for both mothers and fetuses, and costs (22). Although this study found that telemedicine support for GDM care did not significantly affect overall service utilization or total costs, some meaningful cost patterns emerged. Planned appointment costs were lower in the telemedicine group (AU$1,735.08) compared to the control group (AU$1,869.41), suggesting that telemedicine may contribute to reducing scheduled care costs. In contrast, unplanned appointment costs were higher among participants receiving telemedicine support (AU$968.52) than among controls (AU$675.29). Any net cost savings, however, would likely depend on achieving high clinic throughput—either a larger number of women with GDM or a greater volume of appointments—if the intervention's scalability challenges can be resolved. These findings should be interpreted with caution, as the study's small sample size and the inability to blind clinicians to the intervention may limit generalizability. Furthermore, clinicians relied on access to self-tracking data to inform treatment decisions, whereas women in the telemedicine group used varied methods of data sharing (e.g., pen-and-paper logs), which may have influenced outcomes(22).

Another intervention, the MobileMums program, spanned 12 weeks and aimed to increase exercise engagement among mothers with young children (44). Projection indicated that for every additional 1.1 million Australian dollars (AUD) to the health system, the program could yield an increase of 131 quality-adjusted life years (QALYs). The anticipated cost-effectiveness ratio per additional unit of benefit gained for the program is A$8,608 per QALY gained, with a 98%

likelihood of cost-effectiveness at an acceptable value of A$64,000 (44). However, it is vital to realize that the duration of the intervention is restricted to 12 weeks and that prolonged changes in activity levels increase the likelihood of developing future chronic health disorders.

Child health

In this review, the vast majority, comprising 90% of the telehealth interventions, were specifically designed for pediatric healthcare. These interventions address various aspects of child health, including neonatal care, fractures, mental health, ENT services, dental care, palliative care, nutrition, and assessment for early signs of autism-related behaviors.

General childcare

A study conducted among children living in remote and rural Queensland demonstrated the effectiveness of telephone services in coordinating and delivering healthcare (33). The study's results indicated a minimum estimated cost savings of A$18,000 and prevented 12 patient transfers through the provision of direct and accessible telereferral services (33). Telehealth also demonstrated a reduction in the family cost of attending hospital outpatient appointments among families living in regional Queensland. Approximately 96% of families attending appointments in person reported incurring various costs, such as travel, childcare, meals, fuel, and parking, whereas telehealth provided more convenient and economical choices (29). Another study revealed that during a five-year period, the total cost of providing 1499 consultations through the telepaediatric service was A$955,996. The estimated potential cost of providing an outpatient service to the same number of patients at the Royal Children's Hospital in Brisbane was A$1,553,264; thus, telepaediatric services resulted in a net saving of approximately A$600,000 to the health service provider(30).

Neonatal care

The actual incurred expenses for telemedicine consultations in acute neonatal care contrasted with the confirmed savings from averting the costs associated with transporting infants and nursery care, resulting in a net savings of A$54,400 to the health system (23). The projected net savings using teleconsultation amounted to A$206,073. However, this estimation relied on an assumed 26% reduction in the need for infant retrieval, indicating potential bias in the avoidance rate (23). Another study explored the utilization of telemedicine for screening retinopathy of prematurity (ROP). ROP screening is crucial for preventing blindness in high-risk preterm infants (34). The study assessed the cost of current screening practices (standard care) against two alternative models: 1) a local specialist nurse in a regional special care nursery that captures retinal images

with digital retinal photography and sends them to a tertiary center for review or 2) a specialist nurse visiting a regional special care nursery that captures retinal images with digital retinal photography and transmits them to a tertiary center for review without transporting the patient. The most cost-effective model was determined to be the specialist nurse traveling to each special care nursery with portable digital retinal photography, costing A$363 per infant (34).

Orthopedics

Videoconferencing was utilized in an orthopedic clinic to compare the costs of three scenarios: patient travel, telehealth, and virtual health workers (14). During a span of three years, only the virtual health practitioner approach resulted in a beneficial cost–benefit ratio for the remote site. Telehealth involves the ongoing deployment of advanced-practice orthopedic physiotherapists to regional and rural healthcare facilities, as demonstrated by a study in Queensland that compared the cost of orthopedic physiotherapy with that of telehealth to outreach fly-in, fly-out (FIFO) specialist services (35). The findings demonstrated that the telehealth approach resulted in 13% estimated cost savings compared with the FIFO strategy (35).

Mental health

Telemental health services were provided by videoconferencing at nine rural and remote sites in Queensland, with an evaluation undertaken to compare the cost of telehealth to that of usual care. The use of videoconferencing resulted in net savings of approximately A$420,000 for health services and was demonstrated to be the cheapest way to provide child mental health services (31). In another study, moodGYM was employed to mitigate anxiety among adolescent students aged 11–17 years. The resulting dominant incremental cost-effectiveness ratio (ICER) suggests that the intervention not only yielded favorable health outcomes but also resulted in cost savings (45).

Dental care

Routine dental screenings and oral health education hold significant promise for enhancing oral health and conserving substantial resources (36). In Australian schoolchildren, the cost of teledentistry (TD) was compared with that of traditional dental screening methods, revealing annual savings of A$85 million through teledentistry (36). Another study evaluated the cost-effectiveness of three approaches: home visits, telehealth, and standard care. Compared with the standard care group, teledentistry was associated with an estimated cost reduction of A$224,298.95, while home visits resulted in a larger reduction of A$258,899.60 (40). An economic assessment was carried out by another study to compare teledentistry with routine care, and teledentistry was revealed to be the superior choice, with cost savings of A$3,160.81 for each extratemporal consultation (37).

ENT service

In regional areas, pediatric ear, nose, and throat (ENT) services are offered through either telemedicine (tele-ENT) with videoconferencing or the usual outpatient department (OPD-ENT), with tele-ENT consultations costing A$108 compared with A$155 for OPD-ENT, as shown by a cost minimization study, potentially saving A$7,621 if all consultations are conducted via tele-ENT (32). In comparing the cost of community-based mobile telemedicine-enabled screening and surveillance (MTESS) services to that of the Deadly Ears Program among indigenous children, the MTESS service exhibited a 98% likelihood of reaching a favorable cost–utility ratio at a willingness–to–pay threshold of A$50,000 per Quality-Adjusted Life Year (QALY) in contrast to the Deadly Ears Program (42). A separate study compared the costs of three alternative care models: 1) surgery provided by a private hospital with an ENT coordinator, 2) telehealth-supported ENT surgery, and 3) standard care, revealing that telehealth-supported ENT surgery has the potential to save A$3,626 to A$5,067 per patient compared with patients traveling to a regional public hospital (41).

Palliative care

Video consultations for children receiving palliative care at home enable equal service access while minimizing interference with palliative care teams based in hospitals (38). A study conducted on pediatric palliative care in Queensland compared the costs of three alternative models: telehealth, home visits, and standard outpatient department (OPD) care. The results revealed that the costs of telehealth, OPD, and home visits were A$294, $748, and A$1,214, respectively (38).

Child development

With the increasing prevalence of autism spectrum disorder (ASD) globally, leading to increased spending on support services, the iBASIS-VIPP intervention has emerged as an approach for supporting infant development, employing video feedback techniques to aid caregivers in comprehending their infant's social communication and offering guidance for fostering social engagement and interaction (39). The cost of the intervention, encompassing all child development-related services compared with standard treatment, revealed an estimated average cost difference of A$5,131 (US$3,607) per child for iBASIS-VIPP, with an 88.9% probability of cost savings as per the study's findings (39).

Nutrition

A comprehensive mobile health (m-health) intervention designed to improve the dietary quality of school lunch kits was rolled out in primary schools throughout New South Wales. The evaluation of the intervention's cost and cost-effectiveness resulted in an incremental cost-effectiveness ratio (ICER) of A$0.24 for reducing the energy intake from discretionary foods in the lunchbox,

suggesting the possibility of cost-effectively lowering kilojoules derived from discretionary foods included in school lunchboxes (43).

Discussion

Key Findings

This systematic review presents an inaugural investigation into the economic impact of telehealth on maternal and child health. On the basis of the findings of this study, 20 studies were included, with 18 articles indicating that telehealth is a cost-effective choice for maternal and child healthcare (23, 29-45), whereas the remaining two present comparable findings (14, 22). Most investigations have focused on comparing the costs and effectiveness of telehealth interventions in child health conditions (14, 23, 29-43, 45). More economic evaluations of the effects of telehealth interventions on maternal health are needed in the future.

The studies analyzed various telehealth interventions, encompassing different populations, diseases, and areas of interest. However, generalizing the findings across different contexts is challenging owing to inconsistencies in clinical procedures, cost structures, healthcare delivery systems, and analytical perspectives, among other factors. A notable finding from these studies is the paucity of information on the viability of adopting such technologies in light of economic and organizational considerations. It is recommended that standardized cost-effectiveness analyses be utilized to compare different interventions in terms of their outcomes and costs, so that it is crucial for helping decision-makers and funders assess whether digital health interventions and innovations effectively improve QALYs or DALYs while keeping costs manageable (46).

The CHEERS 2022 statement (28) facilitated the evaluation of reporting quality in these studies. To effectively apply findings across economic evaluations, comprehensive data collection, consistent methodology, and clear descriptions of the target population, study design, and sample size are essential (47). In this review, the sample sizes varied considerably, spanning from 16 participants in a study exploring the utilization of telehealth in ear, nose, and throat (ENT) surgeries as an alternative access method (41) to 2.7 million participants in a study comparing the costs of teledental screening versus traditional visual examinations (36). Most studies lacked thorough descriptions of unit costs, data origins, and cost computation methods. The methodology employed for cost calculations can significantly impact overall cost estimations.

The majority of health economic assessments focus on the health service or system perspective (22, 23, 30-36, 38, 41, 44). The incorporation of a societal perspective could offer a broader view

of the economic impact, taking into account factors such as patient travel costs, time savings, and productivity gains (48).

Most of the studies employed a time frame of under two years (14, 23, 29, 32, 33, 35-37, 39, 41-45) and did not evaluate long-term expenditures or QALYs. Additionally, these studies failed to elucidate the rationale behind their selection of the time frame for analysis. The decision regarding the time frame could impact the results of the study. A longer time frame would be preferable for fully capturing the long-term impact of healthcare service consumption, costs, and QALYs.

Implications of addressing health inequality among women and children living in regional, rural, and remote Australia

Health disparities, also sometimes called health inequalities, are differences and/or gaps in the quality of health and healthcare across racial, ethnic, and socioeconomic groups. It can also be understood as population-specific differences in the presence of diseases, health outcomes, or access to healthcare (49). Australia's population resides in rural and remote regions, encountering distinct obstacles attributable to their geographic remoteness, often resulting in inferior health outcomes compared with those residing in urban centers (2). The evidence has underscored the influence of factors such as access, indigenous identity, and socioeconomic status (SES) in determining the distribution and standards of healthcare facilities (3). Telehealth holds promise in tackling numerous significant challenges associated with delivering healthcare in Australia's rural and remote communities (7). Research on telehealth indicates various positive outcomes, including shorter hospital stays, decreased strain on emergency services, enhanced healthcare accessibility, improved service quality, better clinical results, lower expenses, reduced inconvenience, and enhanced management of chronic and intricate diseases, along with offering peer assistance, building connections, and learning opportunities (6, 8).

In this review, we identified the greatest potential for telehealth to decrease health disparities in regional, rural, and remote Australia. Telehealth can overcome barriers to accessing care, reduce costs, promote healthy behavior, enhance service utilization, reduce the length of hospital stays, and improve the coordination of care for women and children (14, 22, 23, 29-45).

Telehealth has the potential to mitigate health inequalities by decreasing costs from various angles. Typically, rural and remote areas in Australia display lower socioeconomic status than urban areas do (50). Out-of-pocket expenses, also known as OOP expenses, can pose a barrier to accessing specialist services, particularly for individuals with lower incomes (51). Despite several

limitations, among the 20 studies assessed, 18 provide evidence suggesting that, compared with standard care for maternal and child healthcare, telehealth can effectively lower costs (23, 29-45).

Telehealth shows promise in reducing health inequalities by expanding access to care for a range of maternal and child health conditions, both clinical and nonclinical, and overcoming geographical barriers. Cost-effectiveness research conducted among children in remote and regional Australia revealed that telehealth could eliminate the need for families and children to travel to metropolitan areas for services (23, 29-32, 34, 35, 37, 38, 40-42). Additionally, telehealth has been utilized to connect with specialists in palliative care (38); mental health (31); orthopedics (14, 35); pediatric ophthalmology (34); ear, nose, and throat (32, 41, 42); and dental care (37, 40).

Telehealth plays a role in diminishing health disparities through the encouragement of healthy behaviors. One study examining the cost-effectiveness of a telehealth intervention aimed at enhancing physical activity among mothers with young children reported that the intervention could result in cost savings. The projection suggests that for every additional A$1.1 million allocated to the health system, the program could result in an increase of 131 QALYs, with an anticipated cost-effectiveness ratio of A$8,608 per additional QALY gained, demonstrating a 98% likelihood of cost-effectiveness at an acceptable value of A$64,000 (44).

Another study conducted among caregivers of school-aged children aimed to enhance caregivers' understanding of the nutritional quality of their children's packed lunchbox meals. The evaluation of the intervention's cost and cost-effectiveness resulted in an incremental cost-effectiveness ratio (ICER) of A$0.24 for reducing the energy intake from discretionary foods in the lunch kits, suggesting the possibility of cost-effectively lowering kilojoules derived from discretionary foods included in school lunch kits (43).

Telehealth further addresses health inequalities by increasing service utilization (22, 23, 31-38), decreasing hospital stays (23), and improving care coordination (33) for women and children residing in regional and rural areas of Australia. Generally, cost-effective telehealth interventions have the potential to reduce health inequality among women and children who are living in remote, rural, and regional Australia.

Limitations

The conclusions drawn from this study are limited by the findings of the studies considered. Additionally, our study is limited to only articles written in English and studies conducted in remote, rural, and regional Australia. There is a lack of consistency in the methodologies used, clinical contexts, and telehealth interventions across studies, making it challenging to compare

outcomes and costs directly and conduct meta-analyses. Standardizing cost-effectiveness analyses could help provide more reliable comparisons between different telehealth interventions. Most of the studies' cost-effectiveness came from health service or system perspectives with a short time horizon. Incorporating a societal perspective with a longer time horizon could adequately capture the long-term effect of telehealth intervention and a broader view of the economic impact, considering factors such as patient travel costs, time savings, and productivity gains. There is a paucity of information on the viability of adopting such technologies in light of economic and organizational considerations. Understanding these aspects could aid in the broader implementation of effective telehealth solutions.

Conclusions

This review positions telehealth as an effective, cost-saving option for maternal and child health, especially in remote Australian areas. This underscores the ability of telehealth to bridge health service gaps, reduce costs, and improve healthcare delivery. Future research should focus on standardized analyses for clearer telehealth intervention comparisons and investigate the practicality of telehealth adoption from economic and organizational standpoints. A broader evaluation incorporating societal costs and benefits, along with a long-term view of the clinical and economic impacts of telehealth, is essential for its wider implementation.

List of abbreviations

ASD: Autism Spectrum Disorder, AUD: Australian Dollar, CBA: Cost Benefit Analysis, CEA: Cost Effectiveness Analyses, CHEERS 2022: Consolidated Health Economic Evaluation Reporting Standards of 2022, CMA: Cost Minimization Analyses, CUA: Cost Utility Analyses, DALYs: Disability-Adjusted Life Years, ENT: Ear, Nose, Throat, FIFO: Fly in, Fly out, GDM: Gestational Diabetes Mellitus, GP: General Practitioner, ICER: Incremental Cost-Effectiveness Ratio, iBASIS: Infant Behavioral Assessment and Intervention Sequence, MCH: Maternal and Child Health, MTESS: Mobile Telemedicine-Enabled Screening and Surveillance, OPD: Outpatient Department, QALYs: Quality-Adjusted Life Years, ROP: Retinopathy of Prematurity, VIPP: Video Interaction for Positive Parenting

Declarations

- **Ethics approval and consent to participate**

  N/A

- **Consent for publication**

N/A

- **Availability of data and materials**

  All available data are included in this manuscript.

- **Competing interests**

  The authors declare that they have no competing interests.

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  N/A

- **Authors' contributions**

  RK contributed to the study concept and design. GA, ZH, and RK formulated the methodology, search strategy, data extraction, data analysis and interpretation, quality assessment of all included studies, and writing of the original draft. All the authors read and approved the final manuscript.

Additional materials

Supplementary Table 1: search strategy

Supplementary Table 2. ISPOR CiCERO Checklist: Criteria for Cost (-Effectiveness) Review Outcomes for systematic literature reviews that summarize cost and cost-effectiveness outcomes.

Supplementary Table 3: updated Consolidated Health Economic Evaluation Reporting Standards of 2022 (CHEERS 2022) checklist

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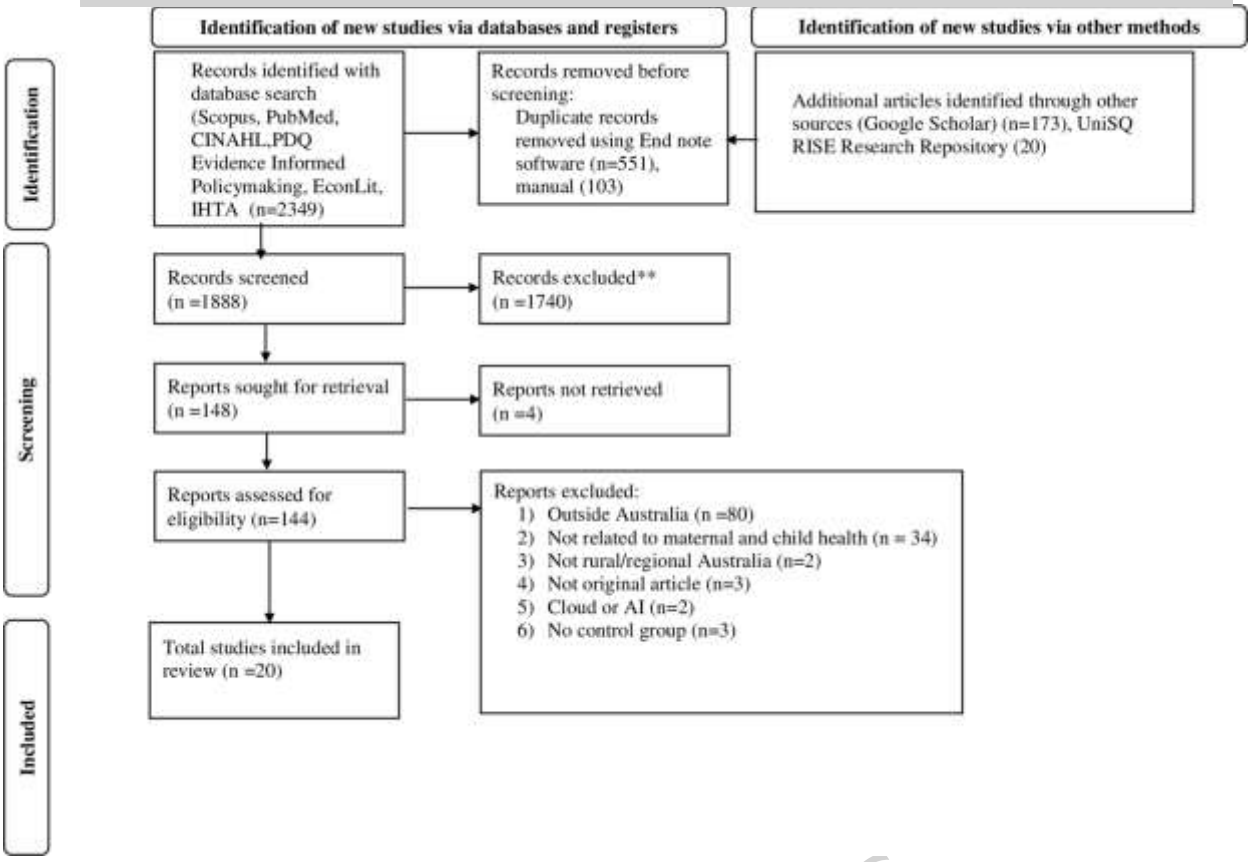

Fig. 1 PRISMA flow diagram of selection process of studies on economic impact of telehealth on maternal and child health in regional, rural,
and remote Australia

Table 1: Characteristics of the included studies (n=20)

S. no.	Author/year	Study design	Study setting	Discipline	Study population	Sample size	Type of intervention used and time horizon/comparator	Outcome of measure	Key findings
1	Rasekaba TM, et al./2018	RCT	regional	gestational diabetes mellitus	pregnant women	95	Adjunct TeleGDM for 2 years/usual care	Assess the association between service utilization and cost with the two alternative models.	1) There were no variations among the groups regarding appointment numbers, rates of cesareans, macrosomia, large for gestational age, admission to the special care nursery, or newborn birth weight. 2) The intervention did not influence the total number of clinic appointments or service provider expenses. 3) Participants who received the intervention achieved optimal glycemic control more rapidly
2	Armfield NR, Donovan T, Bensink ME, Smith AC./2012	POS	regional	neonatal acute care	neonates	19	teleconsultation for 12 months/usual care	1) Number of neonatal consultations with telemedicine 2) actual cost savings from telemedicine 3) estimating the potential cost savings	1) 19 cases of neonatal teleconsultation. 2) The health system realized a net saving of A$54,400 3) The projected net savings using teleconsultation amounted to A$206,073
3	Smith AC, et al/2003	ROS	regional	unspecified	caregivers of childrden	400	video conference for 12 months/face-to-face	1) Time spent traveling, 2) distance traveled 3) Compare costs incurred by families	1) median time spent: 30 min vs 80 min for videoconference and usual care, respectively 2) Distance traveled: 20 km vs 70 km for videoconference and usual care, respectively 3) Videoconference is the

									cheapest option
4	Snoswell CL, North JB, Caffery LJ./2020	ROS	regional	fracture	children	2692	1) telehealth 2) employment of a virtual health practitioner for 3 years/usual care	1) Compare the cost of three scenarios: patient travel, telehealth, and virtual health worker	1) The virtual health practitioner model was cost-effective.
5	Smith AC, Scuffham P, Wootton R./2007	ROS	Rural	unspecified child health service	children	1499	telehealth for 5 years/usual care	1) Number of consultations 2) Compare the cost of telehealth with usual care	1) total of 1499 telehealth consultations, 2) net saving A$600,000 resulted from telehealth
6	Smith AC, et al./2007	ROS	regional	mental health	children	606	telehealth for 30 months/usual care	1) Number of consultations 2) Compare the cost of telehealth with usual care	1) total of 606 telehealth consultations 2) net saving of $420,000 resulted from telehealth
7	Xu CQ, Smith AC, Scuffham PA, Wootton R./2008	ROS	regional	ENT	children	205	telehealth for 1 year/usual care	1) Total ENT consultation 2) Compare the cost of telehealth service with usual outpatient care	1) Total of 205 ENT consultations (88 with telehealth and 117 with usual care) 2) Cost: A$108 vs A$155 per consultation for telehealth and usual care, respectively
8	Smith AC, et al/2001	POS	regional	unspecified child health service	children	248	telehealth with a virtual health practitioner for 6 months/usual care	1) Total number of consultations 2) number of referrals 3) total hours of telepediatric activity 4) total patient referral avoided 5) total	1) 248 consultations 2) 88 referrals 3) total hours of telepediatric activity increased to 8 hr/month 4) 12 patient referrals avoided 5) Estimated minimum saving of $18,000.

								amount of cost saved.	
9	Kim E, et al./2023	decision analytic model	regional	retinopathy of prematurity	preterm infants	342	1) Provide training to SN about DRP telemedicine to take retinal images in the community for 5 years 2) Trained SNs to travel to the regional SCN for 5 years 3) usual care	1) Total number of preterm infants screened, compare the cost of the three alternative models	1) Total number of 342 preterm infants screened 2) of all alternative models, the most cost-effective model was determined to be the specialist nurse traveling to each special care nursery with portable digital retinal photography, costing A$363 per infant
10	Cottrell M, et al./2021	A retrospective audit	regional	Physiotherapy for a fracture	children	44	telehealth for 9 weeks/FIFO for 9 weeks	1) total service usage 2) Clinical intervention's adverse events and expenses.	1) Each service delivery model recorded a total of 33 appointment slots. 2) Patterns of referrals and slot usage are similar across models. 3) In both service delivery models, there were no reported safety incidents. 4) The telehealth approach resulted in a 13% estimated cost savings compared to the FIFO strategy
11	Estai M, Bunt S, Kanagasingam Y, Tennant M./2017	POS	Rural	dental care	children	2.7 million	telehealth dental screening for 1 year/usual care	1) Total number of screened children 2) Contrasting the expenses associated with dental screening in school children using two alternative models	1) Total number of 2.7 million children screened 2) Teledentistry saved $85 million annually.
12	Teoh J, et	ROS	rural and	dental care	children	367	telehealth/ usual care	1)Total number of	1) A total of 367 teledentistry consultations

	al/2018		regional					teleconsultations 2) Timely consultations, 3) comparing the cost of two alternative models.	2) of which 241 were timely (65.7%) 3) cost savings of A$3,160.81 for every additional timely teleconsult.
13	Bradford NK, Armfield NR, Young J, Smith AC./2014	ROS	regional	palliative care	Children	95	telehealth for 2 years/home visit or usual care	1) Total consultations 2) Compare the cost of three alternative models.	1) 95 total consultations 2) The costs of telehealth, OPD, and home visit were $294, $748, $1214, respectively.
14	Segal L et al/2023	RCT	regional	early behavioral sign of autism	children	192	iBASIS–Video Interaction for 18 months/usual care	iBASIS-VIPP with usual care cost comparison	1. 1 The mean estimated treatment cost difference was A$5131 (US$3607) per child for iBASIS-VIPP compared to usual care. 2. The average treatment cost difference per reduced case of autism spectrum disorder was A$37,181 (US$26,138). 3. 88.9% probability of cost savings for iBASIS-VIPP
15	Koh R et al./2016	POS	regional	early childhood dental caries	children	754	Home visit or telehealth for 5.5 years/usual care	1) Program expenses, treatment expenditures, indirect costs, and utility values were assessed. 2) compared three models	The incremental costs per 100 children reduced by $A224298.95 for telehealth and $A258899.6 for home visits compared to usual care.

								with incremental cost-effectiveness analysis	
16	Jacups SP, Kinchin I, McConnon KM./2018	ROS	rural	ENT surgical access	childrен	16	1) Surgery provided by a private hospital with an ENT coordinator 2) telehealth-supported ENT surgery for 8 weeks/current practice	1) Comparing the cost of the three alternative models	1) Telehealth has the potential to save $3626 to $5067 per patient. 2) Surgery provided by a private hospital with an ENT coordinator has the potential to save $2178 to $2711 per patient
17	Nguyen KH, et al/2020	POS	remote	ear diseases	childrен	2533	Telemedicine-based screening for 12 months/Deadly Ears Program alone (the existing approach that entails an outreach ENT surgical service and screening program)	Compared two alternative models with a cost-utility ratio at a specified willingness-to-pay acceptable value	1) The MTESS service exhibited a 98% likelihood of reaching a favorable cost-utility ratio at a willingness-to-pay threshold of A$50,000 per QALY
18	Brown A, et al./2021	ROS	Regional	Nutrition	Children	2143	mHealth for 10 weeks/usual care	Cost comparison between the two alternative models	The Incremental Cost-Effectiveness Ratio for reducing the energy intake from discretionary foods in the school lunch kits was A$0.24.
19	Burn E, et al./2015	POS	Regional	Physical activity	Women	263	MobileMums for 12 weeks/usual care	Compared two alternative models with cost-utility analysis	1) For every additional A$1.1 million to the health system, telehealth could yield a rise of 131 QALY

									2) The anticipated cost-effectiveness ratio per additional unit of benefit gained for the telehealth is A$8,608 per QALY gained, with 98% likelihood of cost-effectiveness at an acceptable value of A$64,000
20	Lee YY, et al./2021	Cluster RCT	Regional	Anxiety disorder	Children	1477	MoodGYM for 6 months/usual care	Compared two alternative models with cost-utility analysis	Telehealth has a 95% likelihood of cost savings.

NB: POS- Prospective Study, ROS- Retrospective Study, RCT-Randomized Controlled Trial

Table 2: Economic analysis included in the study.

s.no.	Author/year	Type of economic evaluation	Perspective	Cost items	Discipline	Type of intervention used and time horizon/comparator	Outcome	Telehealth effect	CHEERS 2022
1	Rasekaba TM. et al./*2018*	CCMA	health service	service provider cost	gestational diabetes mellitus	Adjunct TeleGDM for 2 years/usual care	The intervention did not influence service provider expenses.	the same	71%
2	Armfield NR, Donovan T, Bensink ME, Smith AC./2012	CA	health service	fixed equipment cost, fixed staff cost for installation, retrieval-related clinical staff cost, retrieval transport cost	neonatal acute care	teleconsultation for 12 months/usual care	1) The health system realized a net saving of A$54,400 2) The projected net savings using teleconsultation amounted to A$206,073	more	86%
3	Smith AC, etal/2003	CA	family perspective	travel cost, remaining childcare cost, meal cost, fuel cost, parking	unspecified child health care appointment	video conference for 12 months/face-to-face	Approximately 96% of families attending appointments in person reported incurring various	more	66%

				cost, cost related to time away from work, accommodation cost			costs		
4	Snoswell CL, North JB, Caffery LJ./2020	CBA	A rural site and a metropolitan partner	all human resource costs, patient subsidized travel costs	child fracture	1) telehealth 2) employment of a virtual health practitioner for 3 years/usual care	The virtual health practitioner model was cost-effective.	the same	96%
5	Smith AC, Scuffham P, Wootton R./2007	CMA	health service provider	Both fixed and variable costs	Multiple Child Health Service	telehealth for 5 years/usual outpatient child service	net saving A$600,000 resulted from telehealth	more	93%
6	Smith AC, et al./2007	CMA	health department	fixed and variable costs	mental health	telehealth for 30 months/usual care	net saving of $420,000 resulted from telehealth	more	86%
7	Xu CQ, Smith AC, Scuffham PA, Wootton R./2008	CMA	health department	The fixed and variable expenses associated with offering ENT services.	ENT	telehealth for 1 year/face-to-face	cost-savings of $7,621.	more	89%
8	Smith AC, etal/2001	CMA	health service	service provider cost	unspecified child health service	telehealth with a virtual health practitioner for 6 months/usual care	Estimated minimum savings of $18,000.	more	59%
9	Kim E,etal./2023	CMA	health service	SN time cost, paramedic and nonparamedic transport cost, SN travel allowances	retinopathy of prematurity	1) Provide training to SN about telehealth to take retinal images in the communit	Of all alternative models, the most cost-effective model was determined to be the specialist nurse traveling to each special care nursery with	more	89%

				cost, DRP specific costs		y for 5 years 2) Trained SNs to travel to the regional SCN for 5 years 3) usual care	portable digital retinal photography, costing A$363 per infant		
10	Cottrell M, et al./2021	CCMA	health service	Direct labor costs, travel costs (e.g., airfares, taxi vouchers, meal allowance, and accommodation) associated with the FIFO service model, taxi transfer costs, and service revenue costs	Physiotherapy for a fracture	telehealth for 9 weeks/FIFO for 9 weeks	The telehealth approach resulted in a 13% estimated cost savings compared to the FIFO strategy	more	89%
11	Estai M, Bunt S, Kanagasingam Y, Tennant M./2017	CMA	the oral health system	fixed and variable costs	child dental care	telehealth dental screening for 1 year/usual care	Teledentistry saved $85 million annually.	more	93%
12	Teoh J, etal/2018	CEA	societal perspective	fixed and variable costs	child dental care	telehealth dental consultation/usual care	cost savings of A$3,160.81 for every additional timely teleconsulting.	more	89%
13	Bradford NK, Armfield NR, Young J, Smith AC./2014	CMA	health service	Fixed and variable costs for all three approaches were determined	palliative care	telehealth for 2 years/home visit or OPD consultation (usual care)	The cost of telehealth, OPD, and home visit was $294, $748, $1214, respectively.	more	96%
14	Segal L etal/2023	CEA	third-party payer persp	The intervention cost for delivering	A child's early behavioral signs	iBASIS–Video Interaction for 18	The mean estimated treatment cost difference was	more	96%

			ective	iBASIS-VIPP included the following: (1) therapy costs, (2) direct travel costs, (3) therapy-related administration costs, and (4) training and supervision costs	of autism	months/usual care	A$5131 (US$3607) per child for iBASIS-VIPP compared to usual care. The average treatment cost difference per reduced case of autism spectrum disorder was A$37,181 (US$26,138) 88.9% probability of cost savings for iBASIS-VIPP		
15	Koh R et al./2016	CUA	Society	Cost of resources for the home-visit intervention, Costs for the telephone intervention, Healthcare costs for all children, Indirect costs,	early childhood dental caries	home visit or telehealth for 5.5 years/usual care	The incremental costs per 100 children reduced by $A224298.95 for telehealth and $A258899.6 for home visits compared to usual care.	more	89%
16	Jacups SP, Kinchin I, McConnon KM./2018	CEVA	health system	Staff time, medical services costs, including resources used in pre-surgery, surgery, and post-surgery procedures, and travel costs	Child ENT surgical access	Three alternative models: surgery provided by a private hospital with an ENT coordinator, telehealth-supported ENT surgery for 8 weeks/current practice (surgery at a public	1) Telehealth has the potential to save $3626 to $5067 per patient. 2) Surgery provided by a private hospital with an ENT coordinator has the potential to save $2178 to $2711 per patient	more	86%

						hospital)			
17	Nguyen KH,etal/2020	CUA	societal perspective	all fixed and variable costs included	ear diseases	Telemedicine-based screening for 12 months/Deadly Ears Program alone (the existing approach that entails an outreach ENT surgical service and screening program)	The MTESS service exhibited a 98% likelihood of reaching a favorable cost-utility ratio at a willingness-to-pay threshold of A$50,000 per QALY	more	93%
18	Brown A, et al./2021	CEA	societal perspective	all implementation costs	Nutrition	mHealth for 10 weeks/usual care	The Incremental Cost-Effectiveness Ratio for reducing the energy intake from discretionary foods in the school lunch kits was A$0.24.	more	86%
19	Burn E, et al./2015	CEA	Health system perspective	All intervention costs, costs relating to participants' healthcare use	Physical activity	MobileMums for 12 weeks/usual care	1) For every additional A$1.1 million to the health system, telehealth could yield a rise of 131 QALY 2) The anticipated cost-effectiveness ratio per additional unit of benefit gained for the telehealth is A$8,608 per QALY gained, with 98% likelihood of cost-effectiveness at an acceptable value of	More	89%

							A$64,000		
20	Lee YY, et al./2021	CUA	societal perspective	All implementation costs	Anxiety disorder	MoodGYM for 6 months/usual care	Telehealth has a 95% likelihood of cost savings.	More	86%

NB: CMA-cost minimization analysis, CEA-cost effectiveness analysis, CUA-cost utility analysis, CBA-cost benefit analysis, CCMA-cost comparison analysis, CA-cost analysis, CEVA-cost evaluation approach