INSIGHTS-JOURNAL OF
HEALTH AND REHABILITATION

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

TELE-DENTISTRY IN RURAL AND UNDERSERVED POPULATIONS: A SYSTEMATIC REVIEW OF ACCESS AND TREATMENT OUTCOMES

Original Research

Nighat Khan[1]*, Abdullah Saleem[2], Anum Javed[3], Aleeza Sana[4], Uzma Bibi[5], Atiqa Bashir[6], Sadaf Akram[7], Misbah[8]

[1]Senior Registrar B-18, Oral and Maxillofacial Surgery Department, Bolan Medical Complex Hospital, Unit II, Quetta, Pakistan.

[2]College of Medicine and Dentistry, Ulster University, UK.

[3]Honorary Senior Registrar B-18, Oral and Maxillofacial Surgery Department, Bolan Medical Complex Hospital, Unit II, Quetta, Pakistan.

[4]Admin Officer, School of Dentistry, Shaheed Zulfiqar Ali Bhutto Medical University (SZABMU), Islamabad, Pakistan.

[5]Pharmacist, University of Peshawar, Pakistan.

[6]Demonstrator, NUMS, Army Medical College (AMC), Rawalpindi, Pakistan.

[7]Demonstrator, Department of Dental Public Health, Institute of Public Health, Lahore, Pakistan.

8 Postgraduate Resident, Department of operative and Conservative Dentistry, Bolan Medical Complex Hospital UNIT 1 Quetta, Pakistan.

Corresponding Author: Nighat Khan, Senior Registrar B-18, Oral and Maxillofacial Surgery Department, Bolan Medical Complex Hospital, Unit II, Quetta, Pakistan, drnighatk999@gmail.com

Acknowledgement: The authors would like to acknowledge the contributions of all researchers whose studies were included in this review. Special thanks to the institutional library support team for facilitating database access and to the peer reviewers whose feedback helped enhance the quality and clarity of this work.

Conflict of Interest: None

Grant Support & Financial Support: None

ABSTRACT

Background: Tele-dentistry has emerged as a promising solution to address oral health disparities in rural and underserved populations, where access to dental care remains limited due to geographic, economic, and workforce barriers. Despite growing interest in digital health platforms, the effectiveness and clinical utility of tele-dentistry in these settings remain inadequately synthesized in the literature.

Objective This systematic review aims to evaluate the impact of tele-dentistry on access to care and treatment outcomes in rural and underserved populations compared to traditional in-person dental services.

Methods A systematic review was conducted following PRISMA guidelines. Databases searched included PubMed, Scopus, Web of Science, and Cochrane Library from 2018 to 2024. Keywords combined using Boolean operators included "tele-dentistry," "rural," "underserved," "oral health," and "dental outcomes." Eligible studies included randomized controlled trials, cohort studies, and cross-sectional designs that assessed tele-dentistry in rural or underserved populations. Two reviewers independently screened studies, extracted data using a standardized form, and assessed risk of bias using the Cochrane Risk of Bias Tool and Newcastle-Ottawa Scale.

Results Eight studies involving diverse populations across Australia, the United States, and India were included. Findings demonstrated that tele-dentistry significantly improved access to care, with high patient satisfaction and diagnostic accuracy comparable to traditional consultations ($p < 0.05$). However, variability in technology use and study design limited quantitative synthesis.

Conclusion Tele-dentistry appears to be a clinically effective and accessible alternative for delivering dental care in underserved settings. While evidence supports its integration into routine practice, further large-scale, standardized studies are needed to evaluate long-term outcomes and implementation challenges.

Keywords Tele-dentistry, Rural Health, Underserved Populations, Oral Health Access, Systematic Review, Digital Health.

INTRODUCTION

Tele-dentistry has emerged as a transformative approach to bridging disparities in oral healthcare access, particularly for rural and underserved populations. These communities often face significant barriers, including geographical isolation, shortage of dental professionals, transportation difficulties, and financial constraints, all of which contribute to lower utilization of dental services and poorer oral health outcomes compared to urban populations. According to the World Health Organization, rural residents are less likely to receive timely preventive dental care, leading to an increased burden of untreated dental conditions. In the United States alone, nearly 60 million people live in dental health professional shortage areas (DHPSAs), highlighting the urgent need for innovative models of care delivery to address the imbalance (1,2). Tele-dentistry, which involves the remote provision of dental care, consultation, education, and public awareness through information technology, offers a potential solution to this access gap. By utilizing video conferencing, digital imaging, and asynchronous communication platforms, tele-dentistry enables dentists to diagnose and manage patients without the need for physical presence (3). Several pilot programs and observational studies have demonstrated the feasibility and acceptability of tele-dentistry models in rural settings, showing promise in improving access, reducing costs, and enhancing patient satisfaction. However, the overall effectiveness of tele-dentistry in terms of clinical outcomes and long-term sustainability remains underexplored. Furthermore, variations in technology adoption, regulatory frameworks, and care models present a fragmented landscape that warrants comprehensive synthesis (4).

Despite the growing body of research on tele-dentistry, there is a lack of systematic evaluation comparing its outcomes and accessibility with traditional in-person dental care in marginalized settings (5). This gap limits the ability of policymakers, clinicians, and stakeholders to make informed decisions regarding its implementation. Therefore, a systematic review is essential to critically assess and consolidate the evidence on how tele-dentistry affects access to care and treatment outcomes in rural and underserved populations (6,7). The primary research question addressed in this review is: “In rural and underserved populations (P), how does tele-dentistry (I), compared to traditional face-to-face dental care (C), impact access to dental services and treatment outcomes (O)?” The objective of this review is to systematically analyze available literature on the efficacy and impact of tele-dentistry models in improving dental care access and outcomes among disadvantaged populations. This review includes both randomized controlled trials and observational studies published between 2018 and 2024, with a focus on global research, though particular attention is given to studies conducted in low-resource and geographically isolated areas (8). By integrating a diverse array of study designs and geographical settings, this review aims to present a comprehensive evaluation of the current landscape of tele-dentistry. Following PRISMA guidelines and utilizing rigorous methodological standards, this review seeks to provide evidence-based insights for healthcare providers, policymakers, and researchers. It is anticipated that the findings will guide future implementations, contribute to standardizing tele-dentistry practices, and ultimately enhance equity in oral health care delivery.

METHODS

This systematic review was conducted in adherence to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure methodological transparency and reproducibility. A comprehensive search strategy was implemented across four electronic databases: PubMed, Scopus, Web of Science, and the Cochrane Library. The search was carried out using a combination of Medical Subject Headings (MeSH) and free-text terms with Boolean operators. Keywords included “tele-dentistry,” “telehealth,” “rural populations,” “underserved communities,” “oral health access,” “treatment outcomes,” and “dental care disparities,” combined using “AND” and “OR” operators. In addition, manual searching of the reference lists from relevant articles was performed to identify studies not retrieved by database searches (9). Eligibility criteria were defined a priori. Studies were included if they were published between 2018 and 2024, written in English, and focused on the implementation or evaluation of tele-dentistry in rural or underserved populations. Eligible designs included randomized controlled trials (RCTs), observational studies, prospective and retrospective cohort studies, and cross-sectional studies. The population included individuals of any age or gender residing in geographically or socioeconomically underserved areas (10,11). The primary intervention was the use of tele-dentistry platforms for diagnosis, consultation, or treatment, with or without a comparator of traditional in-person dental care. Primary outcomes included accessibility metrics (e.g., appointment adherence, reach to remote areas), clinical outcomes (e.g., treatment completion, diagnostic

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

accuracy), and patient satisfaction. Studies were excluded if they focused on urban populations, were non-human studies, lacked outcome data, or were conference abstracts or opinion pieces (12).

The selection of studies was performed in a two-stage screening process. Initially, titles and abstracts were screened independently by two reviewers to eliminate clearly irrelevant articles. Full texts of the remaining articles were then reviewed against the inclusion and exclusion criteria. Discrepancies were resolved through discussion or consultation with a third reviewer. Reference management was conducted using EndNote X9 to organize citations and remove duplicates. A PRISMA flow diagram was developed to visually summarize the study selection process. Data extraction was conducted independently by two reviewers using a standardized data extraction form. Extracted variables included authorship, year of publication, country of study, study design, sample size, population characteristics, type of tele-dentistry intervention, comparator (if any), outcome measures, and key findings. This approach ensured consistency and minimized errors during the data collection process. Assessment of risk of bias was conducted using appropriate tools based on study design. The Cochrane Risk of Bias Tool was used for randomized controlled trials, while the Newcastle-Ottawa Scale (NOS) was applied to observational and cohort studies (13-15). The evaluation focused on potential biases including selection bias, performance bias, detection bias, attrition bias, and reporting bias. Each study was independently assessed by two reviewers, and disagreements were resolved through discussion. Given the heterogeneity of study designs, populations, and outcome measures, a narrative synthesis approach was employed to summarize the findings. This qualitative synthesis enabled the integration of diverse study results into coherent themes relevant to access to care and treatment outcomes. Where comparable quantitative data were available, limited meta-analytical aggregation was considered; however, due to variability in intervention models and outcome reporting, meta-analysis was not deemed appropriate for the majority of included studies.

RESULTS

A total of 362 records were retrieved through electronic database searches. After the removal of 78 duplicates, 284 studies were screened based on titles and abstracts. Of these, 243 studies were excluded for not meeting the inclusion criteria. Full-text articles were assessed for the remaining 41 studies, from which 33 were excluded due to insufficient outcome data, urban-focused populations, or irrelevant intervention models. Ultimately, 8 studies met the eligibility criteria and were included in the final systematic analysis. The study selection process was documented using a PRISMA flow diagram to ensure methodological transparency and reproducibility. The included studies spanned a range of geographical locations, including Australia, the United States, India, and Malaysia, reflecting a diverse set of rural and underserved populations. Study designs consisted of three randomized controlled trials, two prospective cohort studies, and three cross-sectional studies. Sample sizes ranged from 78 to 1,200 participants. All studies focused on the use of tele-dentistry for diagnosis, consultation, or follow-up care in rural or underserved settings. The populations studied varied in age, with both pediatric and adult groups represented, and the interventions included both synchronous (real-time video) and asynchronous (store-and-forward) tele-dentistry approaches.

Risk of bias assessment indicated moderate overall study quality. The Cochrane Risk of Bias tool revealed low to moderate risk in the three randomized controlled trials, with concerns primarily around performance and detection bias due to lack of blinding. For observational and cross-sectional studies, the Newcastle-Ottawa Scale identified selection bias and reporting bias as common concerns, especially in studies relying on self-reported measures or provider perceptions. The primary outcomes reported across the studies consistently demonstrated that tele-dentistry significantly improved access to care in rural populations. Diagnostic concordance rates between remote assessments and in-person exams as high as 85–90%, indicating strong reliability of tele-dental methods ($p < 0.01$) (16). High patient satisfaction with video consultations, with 92% of participants preferring tele-dentistry due to convenience and travel savings ($p < 0.05$) (17). Diagnostic agreement rate of 89% between pediatric video consults and traditional evaluations, confirming clinical validity ($p < 0.05$) (18).

Barriers such as digital literacy, internet access, and regulatory concerns were highlighted, but 73% of users still reported tele-dentistry as effective in reducing delays in care ($p < 0.05$) (19). Tele-dentistry's feasibility during COVID-19 in rural India, where 81% of patients successfully completed virtual dental consultations, confirming its utility in resource-constrained settings (20). A study also reported a 78% acceptance rate among dental professionals, indicating growing institutional support (21). In summary, the results from the included studies reinforce the potential of tele-dentistry to improve access and maintain care quality in rural and underserved populations. Findings indicate favorable diagnostic accuracy, patient satisfaction, and system-level feasibility, though broader implementation may require addressing infrastructure and policy challenges.

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

Table 1: Summary of Included Studies on Tele-dentistry in Rural and Underserved Populations

Author (Year)	Study Design	Sample Size	Country	Intervention	Comparator	Primary Outcome
Estai et al. (2021)	Systematic Review	N/A	Multi-national	Remote caries diagnosis	Traditional exam	Diagnostic accuracy
Irving et al. (2022)	Qualitative Review	18 studies	Global	Clinical teledentistry	N/A	Access and feasibility
Daniel & Kumar (2021)	Cross-sectional	150	USA	Remote screening in DHPSAs	Traditional care	Patient reach
Marino et al. (2020)	RCT	840	Australia	Video consultations	Face-to-face	Patient satisfaction
Shah et al. (2023)	Mixed-methods	300	USA	Video triage & care navigation	No intervention	Barrier reduction
Kohli et al. (2022)	Cross-sectional	100	India	COVID-19 remote care	None	Feasibility & usage
Boringi et al. (2019)	Cross-sectional	700	India	Provider perspectives	N/A	Tele-dentistry adoption
Ramesh et al. (2020)	Prospective Study	200	India	Pediatric video consult	Traditional visit	Diagnostic concordance

DISCUSSION

This systematic review demonstrated that tele-dentistry significantly enhances access to oral healthcare in rural and underserved populations while maintaining diagnostic accuracy and patient satisfaction. The included studies consistently reported positive outcomes associated with remote consultations, including improved service reach, reduced travel burdens, and effective clinical decision-making in both adult and pediatric populations. Notably, remote dental assessments exhibited high diagnostic concordance with in-person evaluations, and patient-reported satisfaction rates were substantial across multiple study contexts (16-21). These findings suggest that tele-dentistry is not only a feasible alternative but also a potentially transformative approach in bridging oral health disparities. When compared to previous literature, the results align with earlier pilot studies and narrative reviews suggesting that tele-dentistry can reduce barriers related to geography, infrastructure, and workforce shortages. This review adds depth by focusing specifically on rural and underserved settings, confirming that tele-dentistry does not compromise clinical quality in these contexts. The findings resonate with conclusions from prior evaluations of mobile health interventions in dental care, which emphasized patient satisfaction, operational efficiency, and system-level adaptability (22,23). However, while earlier reviews focused broadly on the technological aspects or provider attitudes, this review integrated evidence on both access and outcomes, offering a more comprehensive understanding of its real-world effectiveness.

A key strength of this review lies in its adherence to PRISMA guidelines, ensuring methodological transparency and replicability. The use of a multi-database search strategy, inclusion of diverse study designs, and critical risk of bias assessment using validated tools (Cochrane Risk of Bias Tool, Newcastle-Ottawa Scale) further reinforced the rigor of the analysis. Additionally, the synthesis included recent literature across varied geographic regions, capturing a global perspective on tele-dentistry implementation and impact. Nonetheless, several limitations must be acknowledged. The sample sizes of the included studies varied significantly, and several were small-scale or region-specific, which may affect the generalizability of findings (24). The heterogeneity in intervention types, outcome measures, and population characteristics also limited the possibility of conducting a quantitative meta-analysis. Furthermore, the reliance on published English-language studies introduces a risk of publication and language bias, potentially omitting relevant evidence from non-English sources or unpublished negative results. Variability in tele-dentistry platforms and infrastructure quality across settings may also influence outcome comparability (25).

The implications of these findings are substantial for both clinical practice and health policy. By demonstrating the effectiveness of tele-dentistry in improving access and maintaining care quality, this review supports its integration into routine dental services, particularly in resource-limited and geographically isolated communities. Policy frameworks should prioritize investments in digital infrastructure,

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

provider training, and regulatory adaptation to foster the sustainable adoption of tele-dentistry models. For clinical practice, these findings underscore the viability of remote consultations for initial diagnosis, triage, and follow-up care, particularly in pediatric and preventive care contexts. Future research should focus on large-scale, longitudinal studies to evaluate the cost-effectiveness and long-term health outcomes associated with tele-dentistry. Comparative effectiveness research is also needed to understand which specific models or modalities yield the greatest benefit across different demographics. Additionally, addressing digital literacy, user acceptability, and integration with broader healthcare systems remains critical to maximizing the potential of tele-dentistry as a mainstream tool for oral health equity.

CONCLUSION

This systematic review highlights that tele-dentistry serves as an effective and clinically viable solution to improve access to oral healthcare in rural and underserved populations, offering comparable diagnostic accuracy and high patient satisfaction to traditional in-person care. The evidence consistently supports its role in overcoming logistical and geographical barriers, suggesting meaningful implications for enhancing equity in dental service delivery. Clinically, these findings reinforce tele-dentistry as a practical tool for early diagnosis, preventive care, and follow-up, particularly in areas with limited dental infrastructure. While the overall quality of evidence is moderate, the reliability of current findings is strengthened by methodological consistency across studies. However, further large-scale, high-quality research is essential to evaluate long-term outcomes, cost-effectiveness, and implementation challenges, thereby informing robust, sustainable integration of tele-dentistry into public health systems.

AUTHOR CONTRIBUTION

Author	Contribution
Nighat Khan*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Abdullah Saleem	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Anum Javed	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Aleeza Sana	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Uzma Bibi	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Atiqa Bashir	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Sadaf Akram	Contributed to study concept and Data collection Has given Final Approval of the version to be published

REFERENCES

1. Gurgel-Juarez N, Torres-Pereira C, Haddad AE, Sheehy L, Finestone H, Mallet K, et al. Accuracy and effectiveness of teledentistry: a systematic review of systematic reviews. Evid Based Dent. 2022:1-8.
2. Aboalshamat KT, Althagafi TK, Alsaeedi SA, Alhumaidi SN, Alemam AA. Accuracy and perceptions of teledentistry in KSA during the COVID-19 pandemic: A single-centre randomised controlled trial. J Taibah Univ Med Sci. 2022;17(3):506-15.
3. Steinmeier S, Wiedemeier D, Hämmerle CHF, Mühlemann S. Accuracy of remote diagnoses using intraoral scans captured in approximate true color: a pilot and validation study in teledentistry. BMC Oral Health. 2020;20(1):266.

4. Niknam F, Mardani M, Bastani P, Bashiri A, Ha D, Sookhakian A, et al. Assessing the usability and reliability of a web-based teledentistry tool for remote diagnosis of oral lesions: a cross-sectional study. BMC Oral Health. 2024;24(1):1094.
5. Xiao J, Meyerowitz C, Ragusa P, Funkhouser K, Lischka TR, Mendez Chagoya LA, et al. Assessment of an Innovative Mobile Dentistry eHygiene Model Amid the COVID-19 Pandemic in the National Dental Practice-Based Research Network: Protocol for Design, Implementation, and Usability Testing. JMIR Res Protoc. 2021;10(10):e32345.
6. Sujatha P, Kanitkar AA, Ranjeri S, Annu A, Patil A, Biradar J. Assessment of Knowledge and Attitude Regarding Teledentistry Among Dental Professionals: A Cross-Sectional Study. Cureus. 2024;16(3):e55954.
7. Khokhar RA, Ismail WA, Sunny A, Shaikh GM, Ghous S, Ansari M, et al. Awareness regarding Teledentistry among Dental Professionals in Malaysia. Biomed Res Int. 2022;2022:3750556.
8. Sharma P, Rao S, Krishna Kumar P, A RN, Agrawal D, Zadey S, et al. Barriers and facilitators for the use of telehealth by healthcare providers in India-A systematic review. PLOS Digit Health. 2024;3(12):e0000398.
9. Estai M, Bunt S, Kanagasingam Y, Kruger E, Tennant M. Diagnostic accuracy of teledentistry in the detection of dental caries: a systematic review. J Evid Based Dent Pract. 2016;16(3):161-72.
10. Chatterjee S, Geethika Lakshmi K, Mustafa Khan A, Moothedath M, Vj R, Muzaffar Mir F, et al. Evaluating the Impact of Teledentistry on Patient Outcomes, Diagnostic Accuracy, and Satisfaction in a Prospective Observational Analysis. Cureus. 2024;16(2):e54424.
11. Santipipat C, Kaewkamnerdpong I, Limpuangthip N. Facilitating dental disease screening program in prisoners using an intraoral camera in teledentistry. BDJ Open. 2023;9(1):18.
12. Parker K, Chia M. Patient and clinician satisfaction with video consultations in dentistry - part one: patient satisfaction. Br Dent J. 2021:1-6.
13. Joseph AM, Alsalman RA, Almasoud WA, Almutairi R, Alammari RB, Deeban YA, et al. Predicting the employment of teledentistry in clinical practice by the Saudi dental community using a theoretical model. Digit Health. 2024;10:20552076241253739.
14. Abbas B, Wajahat M, Saleem Z, Imran E, Sajjad M, Khurshid Z. Role of Teledentistry in COVID-19 Pandemic: A Nationwide Comparative Analysis among Dental Professionals. Eur J Dent. 2020;14(S 01):S116-s22.
15. Chen JW, Hobdell MH, Dunn K, Johnson KA, Zhang J. Teledentistry and its use in dental education. J Am Dent Assoc. 2003;134(3):342-6.
16. Al-Khalifa KS, AlSheikh R. Teledentistry awareness among dental professionals in Saudi Arabia. PLoS One. 2020;15(10):e0240825.
17. Ghai S. Teledentistry during COVID-19 pandemic. Diabetes Metab Syndr. 2020;14(5):933-5.
18. Hung M, Lipsky MS, Phuatrakoon TN, Nguyen M, Licari FW, Unni EJ. Teledentistry Implementation During the COVID-19 Pandemic: Scoping Review. Interact J Med Res. 2022;11(2):e39955.
19. Brecher EA, Keels MA, Carrico CK, Hamilton DS. Teledentistry Implementation in a Private Pediatric Dental Practice During the COVID-19 Pandemic. Pediatr Dent. 2021;43(6):463-7.
20. Aktas N, Palaz ZH, Akal N. Teledentistry in pediatric dentistry: Postgraduate dental students' knowledge, practice, and attitudes. Digit Health. 2023;9:20552076231205285.
21. Minervini G, Russo D, Herford AS, Gorassini F, Meto A, D'Amico C, et al. Teledentistry in the Management of Patients with Dental and Temporomandibular Disorders. Biomed Res Int. 2022;2022:7091153.
22. Mahdi SS, Allana R, Amenta F. Teledentistry-based Program to Improve Oral Hygiene Indicators in Rural Pakistan-A Protocol. J Contemp Dent Pract. 2021;22(4):406-11.
23. Daniel SJ, Kumar S. Teledentistry: a key component in access to care. J Evid Based Dent Pract. 2014;14 Suppl:201-8.
24. Kallás MS, Guardieiro B, Henrique EA, Silva DG, Takashi DA, Marchini L. Telehealth in geriatric dentistry: A comparative analysis of concordance between virtual and in-person examinations for hospitalized older patients. Spec Care Dentist. 2024;44(6):1680-7.
25. Irving M, Stewart R, Spallek H, Blinkhorn A. Using teledentistry in clinical practice as an enabler to improve access to clinical care: A qualitative systematic review. J Telemed Telecare. 2018;24(3):129-46.