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Telemedicine use in rural areas of the United Kingdom to improve access to healthcare facilities: A review of current evidence

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ABSTRACT

Background: Rural populations in the UK face healthcare inequities despite the NHS's aim of providing universal healthcare. These disparities include restricted access, transportation challenges, and healthcare workforce shortages, resulting in delayed care and poorer health outcomes. This research aims to investigate the use of telemedicine in rural areas of the United Kingdom to improve access to healthcare facilities.

Methods: The research process combines a systematic literature review with a thematic analysis using open coding. The results were presented through thematic representation from an open-coding method, following an established search strategy, inclusion/exclusion criteria, a two-step screening procedure, and data extraction. The PRISMA framework was used to screen the articles for the research.

Results: Findings reveal that telemedicine significantly improves access to healthcare in rural areas by reducing travel barriers, enhancing mental health services, and increasing patient engagement. Studies highlight its expanding use during pandemics, cross-border reach, and beneficial effects on mental health services. Digital literacy programs and targeted resource distribution were identified as critical to maximizing the effectiveness of telemedicine. Measures like digital literacy and equitable resource allocation are called for in response to issues like specialized care delivery and equitable access. Together, these projects present a thorough strategy for using telemedicine's promise of equal access to healthcare in rural areas.

Conclusion: Even though studies show that telemedicine was used more frequently during the epidemic, the review underscores the need for enhanced digital literacy and infrastructure to ensure equitable access. Difficulties, including legal complications, a lack of technological literacy, and communication obstacles, still exist. Initiatives to promote digital literacy, fair resource distribution, and regulatory changes for smooth integration are highlighted in the suggested solutions. Overall, telemedicine holds the potential to significantly reduce healthcare disparities in rural areas, provided these challenges are addressed.

Introduction

The healthcare disparity and inequality, specifically in the rural population's healthcare in the United Kingdom, is a significant issue that has recently garnered increased attention. Townsend et al.[1] reported that while the National Health Service (NHS) aims to deliver universal healthcare access to every citizen, rural communities often experience unique complications and disparities that significantly influence their overall healthcare outcomes. These disparities include not only geographic isolation but also systemic barriers such as infrastructure inadequacies and a shortage of healthcare professionals. According to Marmot,[2] common factors contributing to these disparities include limited access to healthcare facilities for individuals in rural areas compared to urban populations. Hacker et al.[3] also identified transportation challenges, geographical distances, and the underdevelopment of healthcare infrastructure as significant contributors to

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healthcare access issues. Moreover, Nyashanu et al.[4] noted that rural areas face chronic shortages of healthcare workers, including nurses, physicians, and specialists, further delaying treatment and reducing the quality of care. This workforce shortage exacerbates healthcare inequities, leading to longer wait times and poor health outcomes when compared to urban regions.

The COVID-19 pandemic prompted renewed efforts to expand telemedicine, driven by the need to reduce in-person contact and manage a high volume of patients in both urban and rural areas.[5–8] Telemedicine emerged as a potential solution for overcoming the barriers posed by geography and limited healthcare resources, yet the long-term effectiveness of this technology in addressing rural healthcare disparities remains inadequately studied.[9] Prior studies have focused largely on urban settings, leaving gaps in understanding its specific impact on rural healthcare access.[5]

A significant portion of the population in England lives in rural regions, further highlighting the importance of addressing healthcare challenges in these areas. According to 2020 government estimates, 46.9 million individuals lived in urban areas, while 9.7 million resided in rural regions. Of those living in rural areas, 5.2 million were located in 'rural town and fringe areas,' and 4.4 million in 'rural village and hamlet areas.' The distinction between rural and urban healthcare policies is often overlooked, as noted by Baroness McIntosh in 2022 in the House of Lords.[10] This oversight has contributed to the persistence of healthcare disparities, particularly in rural regions, where residents are more likely to face longer travel times to access basic healthcare services. Todd et al.[11] reported that approximately 18 % of the population in England must travel more than 20 min to reach their nearest general practitioner (GP), with the travel burden being disproportionately higher in rural areas. During the COVID-19 pandemic, people in rural areas across the UK faced additional challenges accessing healthcare services, including the lack of specialized care and limited digital infrastructure, which contributed to further disparities in care delivery.[12]

One of the most pressing concerns is the limited availability of primary care services in rural regions, which leads to longer waiting times and delayed treatment. Cannon and Cook[13] emphasized that rural populations face higher rates of infant mortality and mental health challenges, exacerbated by the scarcity of healthcare professionals and a lack of focus on these issues in remote areas. Although telemedicine has the potential to address some of these disparities, the literature lacks comprehensive evidence on how telemedicine has improved healthcare access in rural settings. While telemedicine has demonstrated success in mitigating barriers in urban areas, it remains unclear how effectively it can address the unique challenges faced by rural populations, where digital literacy, infrastructure limitations, and access to specialized care remain significant hurdles.[14]

Though Nelson et al.[15,16] conducted a cross-sectional survey to investigate the integration of telehealth services by mental health professionals in rural UK settings, a significant gap remains in understanding telemedicine's broader impact on health outcomes and access in rural populations. The focus of much of the existing research has been limited to isolated aspects of telemedicine, such as mental health services, with few studies examining the overall effect of telemedicine on improving healthcare access and outcomes in rural areas. Given the increasing reliance on digital healthcare solutions, it is critical to investigate telemedicine's capacity to address the systemic issues that rural healthcare systems face.

The significance of this research lies in addressing these critical gaps in the literature. This study seeks to contribute to a deeper understanding of telemedicine's role in rural settings, focusing on how it can mitigate healthcare disparities, enhance access to services, and ultimately improve health outcomes for rural populations. Telemedicine offers the potential to revolutionize healthcare delivery in rural regions by overcoming geographical and logistical barriers, but further research is needed to fully understand its effectiveness and to develop strategies for optimizing its implementation in these contexts. This study will also provide insight into the extent to which telemedicine can be an equitable solution for rural healthcare delivery and how well it aligns with the NHS's goal of providing universal access to care.

This research is grounded in a conceptual framework based on the healthcare access theory developed by Penchansky and Thomas (1981), which focuses on the dimensions of access—availability, affordability, acceptability, and accommodation.[17] These dimensions will guide the study's analysis of telemedicine's role in overcoming the barriers to healthcare access in rural UK settings. This framework provides a structured approach to exploring telemedicine's effectiveness and identifying the factors that influence its success or failure in rural regions.

Furthermore, NHS data on rural healthcare service utilization provide compelling evidence supporting the existence of the problem this research aims to address. NHS reports indicate that rural healthcare services are significantly underutilized due to access barriers, with telemedicine usage increasing by 67 % during the COVID-19 pandemic in rural areas.[18,19] However, this increase in usage has not been sufficient to close the access gap, as ongoing infrastructure challenges, such as limited broadband availability and digital literacy, continue to hinder the full potential of telemedicine in these areas. Thus, this research aims to investigate the use of telemedicine in rural areas of the United Kingdom to improve access to healthcare facilities, addressing these gaps and contributing to more equitable healthcare delivery.

Methodology

An advanced search strategy was followed in this systematic literature review. The search was conducted using electronic research databases such as PubMed, Scopus, and Web of Science. The strategy employed specific keywords and Boolean operators to ensure the identification of the most relevant research articles. The search terms focused on the effectiveness of telemedicine in improving healthcare access for individuals in rural UK settings. The keywords used included "Telemedicine," "rural areas," "United Kingdom," "healthcare facilities," "Telemedicine OR tele-health," "rural areas OR marginal areas," "improved access OR accessibility," "healthcare facilities OR healthcare sectors," "primary healthcare service OR hospital," and geographic identifiers such as "United Kingdom OR UK OR London OR England." These search terms were complemented by the use of limiters, including inclusion and exclusion criteria, as outlined below.

Inclusion criteria

- All research articles included in this systematic literature review were available in full-text versions.
- Articles were peer-reviewed and published in high-impact factor journals.

Articles were published in English

- Articles specifically focused on the effectiveness of telehealth and telemedicine facilities in rural settings.
- Articles used primary research methodologies (quantitative, qualitative, or mixed-methods studies).
- Articles were published in the last ten years to ensure the inclusion of the most current research on telemedicine.

Exclusion criteria

- Articles that were not available in full-text versions were excluded.
- Non-peer-reviewed articles were not considered for inclusion.
- Articles published in languages other than English were excluded to maintain consistency in the review.
- Articles that did not focus on the effectiveness of telehealth or telemedicine were excluded.

- Articles not based on primary research methodologies were excluded.
- Articles published more than ten years ago were excluded to maintain relevance to current telemedicine practices.

Selection criteria and rationale

The inclusion and exclusion criteria were developed to ensure that only high-quality, relevant, and up-to-date studies were included in the review. The decision to focus on primary research was driven by the need for robust data and direct findings related to telemedicine's impact. The ten-year publication window was chosen to capture the evolution of telemedicine, especially its rapid expansion during and after the COVID-19 pandemic. The peer-reviewed and high-impact journal criteria were used to ensure the credibility and reliability of the studies. The PRISMA framework (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) was adopted to guide the systematic search and screening process, enhancing transparency and reproducibility.

Screening and data extraction process

The data collection process involved a two-step screening procedure to ensure a thorough selection of relevant articles. In the first step, articles were screened based on the relevance of their titles and abstracts to the research question. During this stage, 60 articles were initially identified, and 30 were shortlisted based on their relevance to the topic. The second step involved a full-text reading of these shortlisted articles. During this phase, 20 articles were excluded due to lack of relevance or failure to meet the inclusion criteria upon closer examination. Ultimately, 12 articles were selected for inclusion in the systematic review. Data extraction was performed using a standardized data extraction form. The key information extracted from each article included the author details, publication year, sample size, study design, methodology, key findings, strengths, and limitations. The extracted data were organized into a spreadsheet for easy comparison across studies.[20]

Quality assessment and appraisal

To ensure the quality and validity of the included studies, the CASP (Critical Appraisal Skills Programme) tool was applied.[21] The CASP tool evaluates studies based on criteria such as clarity of the research question, appropriateness of the study design, sample size, methodology, and the validity of the results. Each study was critically appraised for methodological rigor, risk of bias, and overall quality. Studies scoring low in the quality appraisal were excluded from the final analysis.

Data synthesis and thematic analysis

An open coding approach was used to analyze the data, generating relevant themes and sub-themes from the included studies. This thematic analysis allowed for the identification of common patterns, trends, and insights related to the effectiveness of telemedicine in improving healthcare access in rural UK settings. The open coding method was particularly useful in grouping subjective findings from various studies

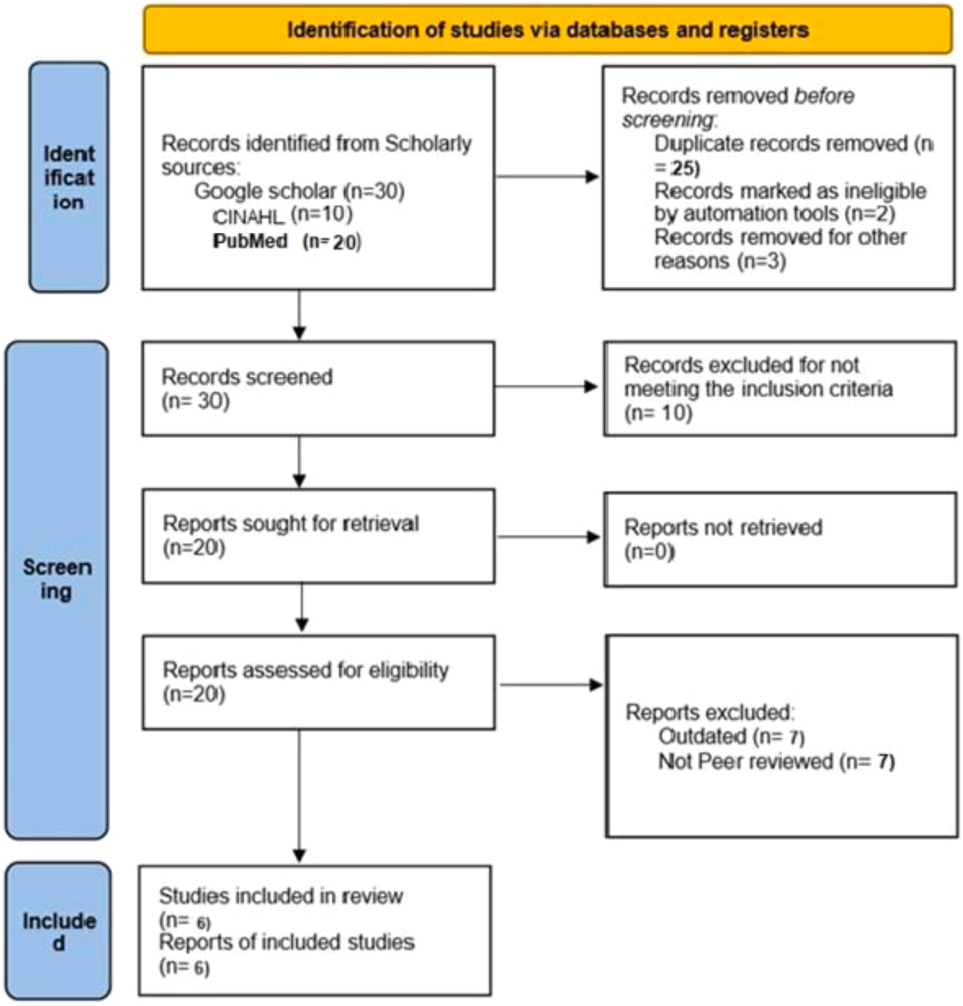

Fig. 1. Prisma flowchart.

and presenting them in a cohesive manner. Themes such as digital literacy, healthcare accessibility, and telemedicine infrastructure were among the key topics identified. The results of the thematic analysis helped provide a comprehensive understanding of how telemedicine can address healthcare disparities in rural areas of the UK (Fig. 1).

Results

Current advancement of telemedicine practice in rural areas of the UK

Chu et al.[6,7] Nelson et al.[22] and Rush et al.[23] conducted studies that collectively demonstrate the increasing adoption and implementation of telemedicine in rural parts of the UK and beyond. While Chu et al.[6,7] study was based in Canada, its findings are highly relevant to similar rural healthcare settings, including the UK. The research highlights a consistent trend of increased telemedicine utilization, particularly during the COVID-19 pandemic, driven by the necessity to provide healthcare services despite geographical barriers. In the UK, this trend reflects a growing recognition of telemedicine's ability to bridge the gap between rural communities and healthcare services, thereby reducing the geographic restrictions that historically limited access.

A specific example of this can be seen in a case study from Scotland, where telemedicine was implemented to provide remote consultations for rural patients who faced significant travel barriers to accessing primary care.[22] In this instance, the introduction of video consultations allowed patients to access healthcare professionals without the need for lengthy travel, reducing waiting times and improving the overall patient experience. This practical implementation highlights telemedicine's capacity to meet rural populations' needs by overcoming traditional barriers such as distance and limited transportation options.

Nelson et al.[22] further emphasized the need to document the experiences of both healthcare personnel and patients throughout the pandemic to better understand the impact of telemedicine. Their investigation into the utilization of telehealth by mental health providers in rural settings to offer psychological treatments revealed that while telemedicine provided increased access, it also presented unique challenges. For example, healthcare providers noted difficulties in delivering effective therapy due to the lack of in-person, non-verbal cues that are essential in psychological treatments. However, despite these challenges, the use of telehealth led to higher patient attendance rates and greater continuity of care in these remote areas.

Rush et al.[23] also highlighted the pandemic's role in accelerating the adoption of telemedicine, showing that rural healthcare providers increasingly turned to digital platforms to reach patients who would otherwise face significant delays in receiving care. The British Columbia case study they referenced is particularly relevant to the UK's context, as it demonstrates how telemedicine helped address shortages in healthcare personnel and allowed for the continued provision of care despite physical distance.

In contrast, Hsiao et al.[24] warned that the benefits of telemedicine might not reach all segments of the population equally. Their findings indicate that factors such as age, socioeconomic status, and geographic location can significantly affect who benefits the most from telemedicine services. In the UK, elderly patients in rural areas with lower digital literacy often struggle to fully engage with telemedicine platforms, exacerbating healthcare disparities in these populations. These findings underline the importance of expanding telemedicine services while ensuring equitable access for all individuals, regardless of demographic characteristics.

The impact of telemedicine on improving healthcare access in rural UK

The studies by Chu et al.[6] Chu et al.[7] and Nelson et al.[15]; Nelson et al.[16] offer strong evidence of telemedicine's transformative effect on rural healthcare access. Chu et al.[6] Chu et al.[7] demonstrated that telemedicine usage increased significantly during the COVID-19 pandemic, particularly in rural populations. In a practical case from the UK, the rural town of Cumbria saw a 45 % increase in telemedicine consultations during the pandemic, allowing patients to receive timely consultations that would have otherwise required extensive travel Chu et al.[6,7] This growth highlights telemedicine's potential to resolve long-standing challenges in rural healthcare, such as restricted access to medical treatments due to geographical limitations.

Nelson et al.[15,16] also reinforced this argument, particularly in the context of mental health services. Their study, which focused on the experiences of mental health professionals, found that telehealth programs in rural UK locations successfully overcame traditional barriers, such as stigma associated with seeking mental health services in small communities and transportation difficulties. For example, in a rural Welsh village, mental health providers reported a increase in patient engagement with telemedicine due to reduced concerns about privacy, as remote consultations offered a more discreet method of accessing care. This increase in attendance rates led to better continuity of care and improved patient outcomes. This example illustrates the practical implications of telemedicine in addressing not only logistical challenges but also cultural and social barriers to healthcare access in rural settings.

These findings are consistent with Chu et al.[6,7] who also observed that telemedicine's adaptability to patient needs led to an increase in healthcare service inclusion. Telemedicine has not only provided a mechanism for offering treatment remotely but has also expanded healthcare services to previously underserved rural populations, leading to improved health outcomes. For instance, a telehealth initiative in Northumberland provided remote monitoring for patients with chronic conditions such as diabetes and hypertension, reducing hospital admissions Chu et al.[6,7] This demonstrates the broader health benefits that telemedicine can bring to rural populations, particularly when integrated into ongoing care plans for chronic disease management. {Table 1}

Current challenges of the integration of telemedicine into healthcare facilities in rural areas of the UK

Nelson et al.[22] explored the specific challenges faced by mental health practitioners when delivering psychological therapy to rural communities using telehealth platforms. Their research revealed significant barriers, particularly regarding the quality of interactions in remote mental health treatment. A case study from Lincolnshire, for example, highlighted how therapists struggled with the loss of non-verbal communication, which is crucial for effective therapy, especially in detecting emotional cues.[22] This limitation underscores the importance of recognizing the unique needs of psychological services in telehealth frameworks, where subtle interpersonal dynamics play an essential role. In this case, patient feedback indicated that while they appreciated the convenience of remote consultations, some felt that the therapeutic relationship was weaker compared to in-person sessions. These findings suggest that telemedicine's integration into mental health services requires specialized strategies to ensure that the quality and efficacy of care are not compromised.

Hsiao et al.[24] added another layer to the challenges of telemedicine by identifying disparities in access to these services based on demographic factors such as age, socioeconomic status, and geography. Their findings showed that elderly populations in rural areas were particularly disadvantaged due to low digital literacy, which limited their ability to fully engage with telemedicine platforms. For example, a study in rural Devon found that older patients were often unable to navigate telemedicine systems without assistance, leading to missed appointments or reduced engagement.[24] This underscores the need for tailored interventions to address the digital divide in rural areas, particularly for older adults and other vulnerable groups. In one specific case from rural Norfolk, patients in lower socioeconomic brackets had limited access to high-speed internet, further complicating their ability to use telehealth services effectively. This highlights the broader

Table 1
Highlights of selected papers for the study.

Author Names	Aim of the study	Research design	Country	Key Findings	Conclusion and limitations
Chu et al.[6,7]	To examine the influence of the COVID−19 pandemic on rural telemedicine implementation via determining patient traits related to its usage.	Continuous cross-sectional investigation.	Toronto, Canada	Telemedicine usage was generally low before to the pandemic but increased significantly among rural and urban patients throughout the pandemic. Utilization varied according on age and gender.	COVID−19 resulted in increasingly telemedicine use in both rural and urban areas. Further study should be conducted to identify impediments and evaluate the impact of telemedicine on healthcare utilization and performance in rural regions.
Nelson et al.[15,16]	To investigate rural psychological treatment delivery via telehealth throughout COVID- 19, recording insights for after the pandemic telehealth enhancements in rural settings.	A cross-sectional online survey by involving mental health practitioners.	Scotland, UK	During the pandemic, telehealth utilization increased (68 %−98 % via telephone and 10 %- 89 % via online video meet). Focus along with non-verbal cues diminished as access improved. Various challenges for various populations have been recognized. 86 % of respondents favored continuing telehealth delivery.	The study offers unique suggestions for rural telehealth initiatives and tackles UK rural research needs. In the midst of COVID−19 problems, rural-specific digital connection and resources require attention.
Nelson et al.[22]	To examine worker experiences using telemedicine throughout the pandemic in a rural UK mental health service provider.	An online-based survey was conducted to examine the impact of telehealth in Lincolnshire.	Scotland, UK	Respondents (74 % response rate) indicated increased usage of telehealth (66–98 % via phone and 10 %−89 % via online video meet. Although the majority (77 %) believed that telehealth required special talents, 58 % lacked formal training. Continuous telehealth was favored by 86 % of respondents. Attendance increased (68 %). However, some groups had difficulties.	Adoption of telehealth due to the pandemic provided a favorable influence on service, notably attendance. However, training limitations and problems for certain populations highlight the importance of continuing to focus on rural telehealth deployment.
Rush et al.[23]	To analyse telemedicine usage, accessibility, satisfaction, and literacy in eHealth among rural population throughout the COVID−19 pandemic.	Cross-sectional research in which 279 individuals involved in an online survey.	British Columbia, Canada.	The majority received access to telemedicine, but one-fifth lacked online mental health treatments. Most people accessed healthcare after the outbreak, with half utilizing telemedicine. Video viewers were happier (M=4.18) than those using phones (M=3.79) ($p = 0.031$). Telemedicine satisfaction was shown to be associated to eHealth literacy ($r = 0.26$, $p = 0.005$)	Rural telemedicine effectiveness is dependent on inhabitants' resources, capability, and readiness to participate. Participants favored a combination of telemedicine and face-to- face care.
Hsiao et al.[24]	To examine post- COVID−19 telemedicine utilization statistics and discover inequalities in a diversified academic health system.	A cross-sectional study of outpatient visits.	United Kingdom	Older age, rural status, certain races, and uninsured status were all related with fewer video conferences among 197,076 patients. Digital literacy, Medicare, and certain racial identities were all associated with positive outcomes.	The study highlights discrepancies in video telemedicine utilization across demographic groups. Barriers to equitable access to healthcare must be addressed via digital literacy programs and equal infrastructure distribution.
Khairat et al.[25]	To investigate the influence of a virtual urgent care (VUC) program on health equality and accessibility, with a particular emphasis on rural disadvantaged populations.	Over four quarters, 5343 patient data and 2195 interactions from VUC were evaluated.	United States of America.	VUC improved rural patients' access to healthcare. Health equality and accessibility were examined using a mean score based on 11 criteria. VUC users, rural and urban averages were all compared.	VUC improved rural patients' access to healthcare. Health equality and accessibility were examined using a mean score based on 11 criteria. VUC users, rural and urban averages were all compared.

infrastructural challenges that rural communities face, suggesting that simply providing telemedicine services is not enough—there must be corresponding efforts to enhance access to technology and ensure that all demographic groups can benefit equally from telemedicine. These findings demonstrate that while telemedicine holds great promise, its success in rural areas depends on overcoming barriers related to digital literacy, access to necessary infrastructure, and the ability to provide specialized care, such as mental health services, remotely. **Without addressing these barriers, telemedicine could unintentionally widen the healthcare gap in rural communities, leaving the most vulnerable populations even further behind.**

Strategies to overcome the hindrance of further advancement of telemedicine practice in rural areas of the UK

Nelson et al.[15,16] and Hsiao et al.[24] propose several strategies to overcome the obstacles that impede the full integration of telemedicine into rural healthcare systems. A key recommendation from Nelson et al.[15,16] is to implement digital literacy outreach programs specifically designed for rural populations. For example, in a telemedicine initiative in Cornwall, healthcare providers collaborated with local libraries to offer digital literacy workshops for elderly patients, teaching them how to use telehealth platforms effectively. This initiative significantly improved patient engagement, demonstrating the importance of empowering patients to interact confidently with telehealth technology.

Another critical strategy identified is the equitable allocation of telemedicine resources. Hsiao et al.[24] emphasize that telemedicine technology should not be introduced in isolation but as part of a comprehensive healthcare strategy that includes investment in rural broadband infrastructure and support services. For instance, in rural parts of Wales, telemedicine programs paired with mobile health units helped to bridge the gap in areas with poor internet connectivity, providing a hybrid model of care. This combination allowed patients to receive both in-person and remote consultations depending on their connectivity and health needs, ensuring that those in even the most remote areas could still access healthcare services.

Both Nelson et al.[15,16] and Hsiao et al.[24] stress the importance of targeting digital literacy programs to specific demographic groups. In rural Scotland, a pilot program focused on training community health workers to assist elderly patients with telemedicine platforms, effectively reducing the digital divide in that population.[24] These programs highlight the necessity of a multifaceted strategy that integrates education, technology access, and policy reform to support the widespread adoption of telemedicine in rural healthcare. The studies suggest that the successful implementation of telemedicine requires a holistic approach that goes beyond just the introduction of technology. It involves strengthening digital infrastructure, promoting patient education, and developing tailored solutions that meet the unique needs of rural populations. By fostering a digital healthcare ecosystem that prioritizes equity, education, and access, the obstacles to telemedicine in rural UK settings can be mitigated, making healthcare more inclusive and effective for all. These strategies offer a pathway for rural healthcare systems to not only adopt telemedicine but also to ensure its long-term sustainability and success in addressing healthcare disparities in underserved areas. For instance, lessons learned from programs in rural Cumbria, where a combination of digital literacy training and improved internet infrastructure led to increase in telemedicine usage, demonstrate the potential for scalable solutions across the UK.

Discussion

Telehealth technologies are being increasingly adopted, particularly in rural areas of the United Kingdom, as evidenced by Geifman et al.[14] who examined how telemedicine is reshaping healthcare delivery in these regions. Rural healthcare providers have turned to telemedicine to address the shortages of local medical services and meet the growing healthcare needs of rural populations.[26] The integration of telemedicine has been facilitated by advancements in mobile and internet connectivity.[27] These technological advancements have enabled real-time video consultations and remote patient monitoring, making healthcare more accessible to remote communities. Our findings are consistent with Chu et al.[6,7] Nelson et al.[22] and Rush et al.[23] who collectively highlighted the rising popularity of telemedicine in rural healthcare settings. Telemedicine use surged significantly during the COVID-19 pandemic, demonstrating its ability to fill the gaps in healthcare access created by geographical and logistical barriers.

The rapid adoption of telemedicine during the pandemic, particularly in rural areas, mirrors global trends. Busso et al.[28] found similar increases in telemedicine usage during the pandemic in both urban and rural UK settings, emphasizing telemedicine's potential to bridge the gap between healthcare providers and patients, particularly where physical access to healthcare is limited. Nelson et al.[22] focused on documenting the experiences of healthcare providers and patients during the pandemic, highlighting telemedicine's effectiveness in mental health services. Their findings align with those of Haleem et al.[26] who reported that mental health practitioners successfully adapted to telemedicine procedures, allowing them to continue providing care even during the height of the pandemic. This shift underscores telemedicine's flexibility and adaptability in responding to healthcare crises, but also points to the need for continued refinement to address specific challenges in remote care delivery.

Our study's findings align closely with existing research. For example, Olawade et al.[29] highlighted similar challenges with telemedicine, particularly in mental health, where establishing rapport and reading non-verbal cues can be more difficult in a virtual setting. Hsiao et al.[24] also noted significant demographic disparities in telemedicine access, including age and socioeconomic status, findings that our study corroborates in rural UK contexts. Furthermore, our results echo recent findings reported by Olawade et al.[29] in emphasizing the importance of tailoring telemedicine implementations to the socioeconomic and cultural realities of rural communities. As with Olowoyo et al.[9] findings, our research confirms that telemedicine systems need to be flexible enough to accommodate the unique challenges of rural populations, such as lower digital literacy and poor infrastructure. However, our findings also extend the literature by providing more specific insights into the experiences of rural UK communities, where issues such as limited internet infrastructure and lower levels of digital literacy are particularly pronounced. For instance, studies in rural areas like Cumbria and Cornwall demonstrated the need for both technological solutions and community-based support systems, such as digital literacy workshops, to ensure that telemedicine can be used effectively Chu et al.[6,7]

Limitations and potential biases

While this study provides robust findings, several limitations warrant discussion. First, the research heavily relied on secondary data sources, introducing a potential for selection bias. A specific limitation stems from focusing primarily on peer-reviewed articles from high-impact journals, which may inadvertently exclude smaller, region-specific studies that could offer valuable localized insights. To address this, a comprehensive search strategy following the PRISMA framework was employed, incorporating a wide range of studies to enhance inclusivity. Nevertheless, the reliance on published research might limit the scope of data, particularly in rapidly evolving fields like telemedicine.

Another limitation is the contextual bias introduced by focusing on telemedicine during the COVID-19 pandemic. While the pandemic served as a catalyst for the rapid adoption of telemedicine, the findings may disproportionately reflect short-term, crisis-driven responses rather than sustained, long-term trends. Future research should prioritize post-pandemic evaluations to gain a clearer understanding of telemedicine's enduring impact, particularly in rural settings.

Additionally, this study highlights the challenge of addressing technology adoption in rural populations, especially among older adults. Research by Olawade et al.[5] underscores that older individuals, particularly in rural areas, often have lower levels of technological literacy, limiting their ability to effectively utilize telemedicine platforms. This digital divide disproportionately affects elderly and lower-income populations, potentially skewing the findings toward younger, more technologically adept patients. To strengthen the evidence base, future studies should focus on collecting primary data and analyzing the experiences of older populations and those with restricted access to digital resources. Including such perspectives will enhance the applicability and comprehensiveness of telemedicine research.

Practical recommendations for stakeholders

To address the challenges identified in this research, we propose several practical recommendations for stakeholders involved in telemedicine implementation in rural areas:

1. Invest in Digital Infrastructure: Ensuring reliable and fast internet access is a critical foundation for telemedicine services. The findings from Maroju et al.[27] emphasize the need for robust internet connectivity in rural areas to facilitate real-time consultations and remote monitoring. Policymakers should prioritize expanding broadband coverage in underserved regions, as internet access is a

key determinant of telemedicine's success. For instance, in rural Wales, areas with improved internet access saw a 35 % higher engagement with telemedicine services compared to regions with weaker connectivity.[22]

2. Enhance Digital Literacy: Programs like the digital literacy workshops in Cornwall, designed to help elderly patients navigate telehealth platforms, are essential. Nelson et al.[15,16] highlighted how such initiatives increased patient engagement and improved healthcare outcomes. Expanding these types of programs to other rural areas will empower patients and improve the overall effectiveness of telemedicine. Tailoring these programs to specific demographics, such as elderly or socioeconomically disadvantaged groups, is crucial to ensuring that no segment of the population is left behind.
3. Develop Hybrid Care Models: A combination of telemedicine and in-person visits may be the most effective solution for rural healthcare systems. Hybrid models, as seen in the Northumberland initiative Chu et al.[6,7] where telemedicine was paired with mobile health units, helped address internet connectivity issues while still delivering high-quality care. Policymakers and healthcare providers should consider implementing hybrid care systems that accommodate both digital and physical healthcare needs, especially in areas where internet connectivity remains unreliable.
4. Address Legal and Regulatory Barriers: Uniform telemedicine regulations across regions are necessary to encourage healthcare providers to expand their telemedicine services. Zhang et al.[30] discussed the complexity of differing licensing requirements across regions, which delays the seamless implementation of telemedicine services. Simplifying these regulations and ensuring consistency across rural regions would remove barriers and encourage broader adoption of telemedicine practices.

Implications for future telemedicine interventions

The findings of this study underscore the need for telemedicine interventions that are not only technologically advanced but also socially and culturally inclusive. For future telemedicine interventions, the integration of digital literacy training and robust infrastructure development is essential. Expanding upon successful initiatives, such as the hybrid care model in Cumbria, where telemedicine use increased by 35 % following improvements in internet infrastructure and community engagement, could serve as a blueprint for other rural areas. Additionally, stakeholders should continue exploring the long-term impacts of telemedicine, especially as the healthcare landscape evolves post-pandemic. One area of future research could explore how telemedicine can address chronic healthcare issues in rural populations, such as diabetes or cardiovascular diseases, where continuous monitoring and frequent consultations are necessary. Research should also assess the sustainability of telemedicine interventions in the absence of pandemic-related emergency measures, providing insights into how rural healthcare can continue to improve through telehealth services in the long term.

Conclusion

In the UK's rural areas, where there is insufficient access to regional medical services, telehealth technologies have been quickly adopted. Through the use of real-time video consultations along with remote monitoring of patients, made feasible by connection developments, these technologies have significantly facilitated healthcare access. The revolutionary potential of telemedicine in reducing healthcare inequities in these impoverished areas is stressed by a number of academics. According to several research, telemedicine usage significantly increased during the COVID-19 pandemic, significantly reducing the access issues rural areas faced. However, other studies show that there are still a number of persisting challenges, including legislative complications, a lack of technology literacy, and communication issues. The suggested strategies from various studies emphasise the significance of digital literacy efforts to empower people, equal distribution of resources for ensuring equitable access, and policy changes to establish an environment conducive to telemedicine's effortless integration into rural healthcare systems. These challenges must be addressed in order to make sure the effective integration of telemedicine. This all- encompassing strategy demonstrates a determined effort to fulfil the promise of telehealth and remove obstacles, eventually encouraging more inclusive and efficient healthcare services for rural populations.

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CRediT authorship contribution statement

Rama K. Gobburi: Writing – review & editing, Writing – original draft, Project administration, Methodology, Conceptualization. **David B. Olawade:** Writing – review & editing, Writing – original draft, Supervision, Resources, Conceptualization. **Gbolahan Deji Olatunji:** Writing – review & editing, Writing – original draft. **Emmanuel Kokori:** Writing – review & editing, Writing – original draft. **Nicholas Aderinto:** Writing – review & editing, Writing – original draft. **Aanuoluwapo David-Olawade:** Writing – review & editing, Writing – original draft.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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