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Telemedicine in Cardiological Care in Rural Areas: A Review of Implementation Barriers and Efficacy Indicators

Dominika Ciesielska

ORCID: https://orcid.org/0009-0007-8548-1112

dciesielska600@gmail.com

Medical University of Lublin

Aleje Racławickie 1; 20-059 Lublin; Poland

Natalia Zięba

ORCID: https://orcid.org/0009-0005-4554-9536

natalia.zieba03@gmail.com

Medical University of Lublin

Aleje Racławickie 1; 20-059 Lublin, Poland

Mateusz Czech
ORCID: https://orcid.org/0009-0008-6980-6930
mateuszcz102@gmail.com
Medical University of Lublin
Aleje Racławickie 1; 20-059 Lublin, Poland

Miłosz Cisłak
ORCID: https://orcid.org/0009-0006-3999-6185
milosz.cislak@gmail.com
Medical University of Lublin
Aleje Racławickie 1; 20-059 Lublin, Poland

Michał Chojęta
ORCID: https://orcid.org/0009-0007-0911-971X
michalchojeta9@gmail.com
Medical University of Lublin
Aleje Racławickie 1; 20-059 Lublin; Poland

Jakub Czmok
ORCID:https://orcid.org/0009-0006-0869-9305
kubel2003@gmail.com
Medical University of Lublin
Aleje Racławickie 1; 20-059 Lublin, Poland

Dominik Tarczyński
ORCID: https://orcid.org/0009-0004-5307-0130
dominik.tarczynski02@gmail.com
Medical University of Lublin
Aleje Racławickie 1; 20-059 Lublin, Poland

Anna Mazur
ORCID:https://orcid.org/0009-0001-2568-0781
mazurania2801@gmail.com
Medical University of Lublin
Aleje Racławickie 1; 20-059 Lublin, Poland

Katarzyna Kociuba
ORCID: https://orcid.org/0009-0003-1265-2452
katarzyna.kociuba1115@gmail.com
Medical University of Lublin
Aleje Racławickie 1; 20-059 Lublin, Poland

Mikołaj Brzusek
ORCID: https://orcid.org/0009-0005-6266-6988
mrib3002@gmail.com
Medical University of Lublin
Aleje Racławickie 1; 20-059 Lublin, Poland

Corresponding Author: Dominika Ciesielska, dciesielska600@gmail.com

Abstract

Background: Rural communities are characterized by increased incidence of cardiovascular diseases and higher mortality rates, which result from limited access to specialized medical care. The use of telecardiology technologies allows for the circumvention of geographical barriers through remote monitoring of patients' vital signs.

Aim: The aim of this study is to provide a comprehensive review of clinical effectiveness indicators for telemedicine and to identify systemic, organizational, and socio-demographic barriers hindering its implementation in rural areas.

Materials and Methods: This non-systematic review includes studies published in the PubMed database between 2021 and 2025 concerning telemedicine in cardiac care in rural areas. The keywords used included: telemedicine, telehealth, telecardiology, remote patient monitoring,

cardiology, cardiovascular care, heart failure, rural health, rural areas, implementation barriers, digital literacy, broadband internet, quality of life, and patient outcomes.

Results: Remote care for patients with heart failure reduces the number of readmissions and lowers mortality, resulting in cost savings for the healthcare system. The development of these technologies is hindered by the phenomenon of digital exclusion caused by a lack of broadband connectivity and low technological competence among patients. Additional difficulties stem from challenges with the integration of IT systems and the lack of consistent reimbursement policies.

Conclusions: The implementation of telecardiology in the form of integrated hybrid models yields tangible clinical benefits. However, the effective and stable use of remote systems in the long term requires the parallel expansion of local network infrastructure and the application of artificial intelligence algorithms for the automatic verification of incoming telemetry data.

Keywords: telemedicine, telecardiology, remote patient monitoring, heart failure, rural health

1. Introduction

1.1. Definition and scope of telecardiology

Telemedicine is defined as the remote provision of healthcare services and the exchange of medical and clinical information between patients and healthcare professionals, using telecommunications and electronic technologies [1, 2]. Telecardiology, one of the most advanced fields of telemedicine, uses these technologies for the remote diagnosis, monitoring, and treatment of patients with cardiovascular diseases [3, 4]. The scope of telecardiology is highly diverse and includes remote patient monitoring (RPM), teleconsultations, telerehabilitation, as well as educational support for patients [4, 5, 6].

The tools used in telecardiological care are divided into non-invasive systems (e.g., ECG recorders, digital blood pressure monitors, electronic scales, mobile apps, and smart wearable devices) and invasive systems (e.g., implantable cardioverter-defibrillators and pulmonary artery pressure sensors) [3, 6, 7]. These tools enable continuous real-time data transmission,

allowing for the early detection of potentially life-threatening events, such as heart failure decompensation or arrhythmias, and the implementation of timely clinical interventions [1, 4].

1.2. Health and Organizational Challenges in Rural Areas

Populations living in rural areas face significant, systemic health challenges, a phenomenon referred to in the literature as the "rural health penalty" [8]. These patients are characterized by higher prevalence rates of cardiovascular disease risk factors, including hypertension, diabetes, obesity, smoking, and physical inactivity [9]. This translates into mortality rates from cardiovascular causes that are significantly higher than in urban populations [8, 9]. From an organizational perspective, healthcare in rural areas is hampered by infrastructural barriers: geographic isolation, significant distances from medical facilities, and a lack of adequate public transportation [8].

The healthcare system in these areas faces serious staffing shortages, affecting both primary care physicians and specialists. It has been noted, among other things, that over 85% of rural counties in the United States have no cardiologists within their borders [8, 9]. Organizational challenges also include the closure of local hospitals and limited capacity for preventive care [8]. Additionally, these populations face digital exclusion. Areas with limited infrastructure (referred to as "medical deserts") suffer from a lack of high-speed broadband and low household access to digital devices, which constitutes a structural barrier to the implementation of e-health services [7, 8, 10].

1.3. Rationale and Objective of the Study

Given the significant health disparities and limited access to specialized cardiac care between urban and rural areas, the use of telemedicine technologies appears to be a key solution. Telecardiology has the potential to overcome patients' geographic isolation, reduce travel costs, limit the number of hospital visits, and ensure rapid medical intervention, which is extremely important for people with chronic cardiovascular diseases. However, the introduction of these technologies is often hindered by numerous implementation barriers.

These include broadband connectivity deficits, low digital literacy among older patients, incomplete legal frameworks, reimbursement issues, and the overall complexity of the systems for medical staff. The aim of this study is to provide a comprehensive review of clinical effectiveness indicators for telemedicine and to identify systemic, organizational, and socio-

demographic barriers hindering its implementation in rural areas. Understanding the interrelationships between technological infrastructure deficits and healthcare system limitations is essential for designing contextually optimal digital interventions that will effectively reduce health inequalities in cardiology.

2. Materials and Methods

This study is a structured narrative (non-systematic) review of the scientific literature, aimed at identifying and analyzing the relationship between indicators of telemedicine's clinical effectiveness and structural barriers to its implementation in rural cardiology care. The search was conducted using the PubMed database, limiting the publication timeframe to 2021–2025. The keywords used included: "telemedicine," "telehealth," "telecardiology," "remote patient monitoring," "cardiology," "cardiovascular care," "heart failure," "rural health," "rural areas," "implementation barriers," "digital literacy," "broadband internet," "quality of life," and "patient outcomes."

Studies were eligible for inclusion if they directly assessed the role, effectiveness, and barriers to the implementation of e-health solutions among patients with cardiovascular diseases living in rural and geographically isolated areas. The analysis included original studies (including randomized controlled trials and observational studies), meta-analyses, descriptions of national pilot programs, as well as peer-reviewed review articles and guidelines from scientific societies. The selection process considered only full-text publications published in English and Polish.

Exclusion criteria included non-full-text publications for which only a conference abstract or a letter to the editor was available. Articles not directly related to the topic of remote cardiological care in rural areas, articles published before 2021, and non-peer-reviewed sources, such as commercial blogs or popular science articles, were also excluded from the analysis.

Due to the heterogeneity of the research projects and the endpoints evaluated, a qualitative narrative synthesis of the collected data was conducted. Given the nature of the review, no formal risk-of-bias evaluation was performed. A limitation of this study is the scarcity of similar studies reflecting the local Polish healthcare context, resulting in a heavy reliance on English-language literature.

3. Efficacy Indicators of Telecardiology Care

3.1. Clinical and Organizational Parameters

Clinical efficacy indicators for telecardiology are primarily based on the assessment of mortality reduction and rehospitalization rates [3, 4]. Studies demonstrate that the timely implementation of remote patient monitoring, including those with heart failure, significantly reduces the risk of readmission within 30 days of discharge [11]. Recent meta-analyses indicate that telemonitoring reduces the risk of first hospitalization due to heart failure by approximately 20–22% (OR = 0.78; RR = 0.80) and overall mortality by 19% (OR = 0.81) compared to standard care [6, 12]. A comparison of different forms of telemonitoring indicates that invasive hemodynamic monitoring, for example using pulmonary artery pressure sensors, is more effective at reducing the rate of hospitalizations due to heart failure (relative risk 0.72) than non-invasive methods (relative risk 0.83) [6, 12]. The reduction in the number of hospitalizations is approximately 30% [7, 13].

In emergency situations, such as ST-segment elevation myocardial infarction (STEMI), prehospital ECG transmission and remote consultation with a cardiologist shorten the time from symptom onset to medical intervention, reducing the time to activation of the catheterization laboratory and initiation of reperfusion by as much as 30–40 minutes [2, 3].

Organizational performance indicators include reducing the workload on healthcare facilities, lowering the percentage of unnecessary visits to emergency departments, and reducing direct and indirect healthcare costs, including transportation expenses and losses resulting from patient absenteeism at work [2, 3, 4, 14]. Modern network configurations, which connect central specialized medical centers with rural branches, allow for the optimization of human resources and improved access to cardiological procedures in underserved areas [10]. The measurable economic benefit has been demonstrated, among other things, by a reduction in annual care costs (e.g., from €1,170 to €1,070 per patient) and by a 44% reduction in readmissions, which in selected care models resulted in system-wide savings of approximately $10 million [2, 4].

The effectiveness of digital interventions in underserved areas is also confirmed by Polish pilot programs, in which patients were successfully monitored in collaboration with primary care physicians, generating over 100,000 remote measurements [13].

3.2. Improving quality of life and patient engagement

A primary component in evaluating telemedicine interventions involves patient-reported outcomes, with particular emphasis on improvements in quality of life [7]. Meta-analyses and clinical trials indicate that telemonitoring leads to statistically significant improvements in emotional functioning and subjective health status. These changes are assessed using questionnaires such as the CHFQ, EQVAS, MLHFQ, or KCCQ [6, 13]. A measurable benefit, also following the use of telerehabilitation programs, is the improvement in patients' physical fitness and functional status, reflected in a reduction in their NYHA class [13].

The effectiveness of digital solutions depends on the level of patient engagement in the therapeutic process [1, 4, 7]. The use of mobile devices, automated reminders, and educational video platforms increases adherence to medical recommendations [1, 7]. These methods improve the management of risk factors, particularly blood pressure and lipid profile [2, 4]. The implementation of these solutions translates into high acceptance and satisfaction rates. A significant proportion of respondents view the role of virtual systems in cardiac care positively and sometimes prefer them over traditional outpatient visits [2].

3.3. National Perspective and Care Quality Indicators

From a systemic perspective, telecardiology helps reduce disparities in access to care, counteracting the so-called "rural health penalty" in isolated areas [8]. Spatial analyses of healthcare, conducted for example in the southern regions of the U.S., indicate that populations with the highest cardiovascular risk reside in areas characterized by a shortage of cardiologists and limited access to broadband internet [8, 15]. As a result, the areas that could benefit most from the implementation of telemedicine face the greatest infrastructure barriers [8].

However, data from European countries, including pilot programs implemented in Poland (e.g., in the Podkarpackie Voivodeship in socially excluded areas), indicate that supervised telecardiology programs overcome geographical limitations. They enable the implementation of guideline-based care and improve the prognosis of patients with limited access to the healthcare system [13].

Despite these benefits, there is a lack of widely accepted indicators for assessing the quality of telemedicine services [7]. It is proposed that a national evaluation framework be developed,

encompassing regular monitoring of the extent to which patients use digital tools, the frequency of false alarms, and the long-term cost-effectiveness of the system [7].

4. Barriers to Telemedicine Implementation in Rural Areas

4.1. Digital Exclusion and Lack of Digital Literacy

The digital divide constitutes a major barrier to the implementation of telemedicine in non-urban areas. This phenomenon stems not only from infrastructure limitations but primarily from low levels of digital literacy and health literacy. Age and lower educational attainment are independent predictors of lack of access to telemedicine tools [1, 16, 17]. Patients who are proficient in using the internet for social purposes often lack e-health skills, which is associated, among other things, with a terminology barrier in medical applications [17].

The effectiveness of digital solutions is also limited by natural aging processes. Sensory deficits (in vision and hearing) make it difficult to use mobile devices [17], and cognitive impairments may prevent patients from independently participating in remote care [11, 17]. Older demographic groups are characterized by a fear of making technical errors, resulting in data loss or delays in filling prescriptions [17]. Concerns about the cybersecurity of implantable devices and video platforms are also a significant obstacle [1, 17].

Some patients prefer in-person visits out of fear of losing the direct relationship with their doctor. The limited ability to interpret nonverbal cues during telemedicine consultations can lead to communication errors and a sense of dehumanization in care [17].

The implementation of digital systems is hindered by a lack of systematic technical support and user training [17]. As a result, patients in rural areas often rely on family assistance [16]. However, the involvement of third parties increases the risk of privacy breaches when discussing sensitive medical data [17]. A solution to this problem could be the introduction of local programs based on digital health navigators, who are responsible for providing direct education and technical support to patients [18].

4.2. Infrastructural limitations

The foundation of telecardiology care is a stable ICT infrastructure, the lack of which in rural and isolated areas contributes to the phenomenon of digital redlining [8, 19]. Despite investments in network expansion, a significant percentage of the rural population still lacks

access to broadband internet and stable cellular coverage [8, 15, 18]. These limitations cause connectivity issues, such as data transmission delays, video call interruptions, and poor image and sound quality [4, 9, 20]. Consequently, specialists assess some of these visits as failing to meet clinical standards [9].

Technological challenges compound shortages of medical staff. Spatial analyses indicate that areas with the lowest availability of high-speed internet are characterized by a simultaneous shortage of cardiologists and primary care physicians [8, 15]. The coexistence of staffing shortages and technological barriers requires the implementation of dedicated, hybrid models of remote care to overcome geographical barriers [10]. Isolated rural communities, struggling with difficulties in accessing healthcare facilities, higher unemployment, and higher mortality from cardiovascular causes, face the greatest difficulties in using e-health [8, 21, 22].

Hardware limitations also affect the patient's home environment, as rural residents are less likely to own smartphones or computers capable of video consultations [16, 17, 23]. From the perspective of medical facilities, a logistical challenge is providing patients with certified telemonitoring devices and ensuring their return [9]. It is also emphasized that patients' personal equipment is not standardized, and its low diagnostic quality poses a risk of obtaining unreliable cardiac parameters [9, 24].

4.3. Systemic and financial barriers

The implementation of digital solutions in cardiology, which accelerated during the COVID-19 pandemic, faces legislative and financial constraints [2, 24]. A systemic barrier reported by healthcare providers is the lack of stable reimbursement and the inconsistency of insurers' systems for covering the costs of virtual services [2, 4, 5, 7]. Although some countries introduced temporary reimbursement parity for remote and in-person consultations in response to the pandemic, the risk of these changes being reversed discourages smaller facilities from investing in remote monitoring programs [11, 19]. Initial expenditures on software licenses, servers, and monitoring devices represent a significant financial burden for clinics, particularly given the reality of limited public budgets [4, 14, 20, 25].

Regulations governing the practice of medicine also pose a challenge, as they sometimes prohibit the provision of care to patients located in another jurisdiction or state. This limits the ability to bridge geographical distances using telemedicine [4, 19, 26]. The development of

platforms and devices dedicated to heart failure is slowed by lengthy administrative procedures related to product approval by regulatory agencies, such as the FDA [4, 12].

Data security remains an critical issue, as transmitted and stored cardiological data, which may be the target of cyberattacks [4, 19, 24]. The risk of patient privacy breaches and the need to implement costly encryption systems that comply with standards such as HIPAA in the U.S. influence the decisions of healthcare facility managers [4, 19, 25]. Additionally, the issue concerns commercial mobile health (mHealth) applications, whose privacy policies are often unclear and raise concerns regarding the potential transfer of data to third parties [4, 24].

4.4. Barriers to Medicine-Technology Collaboration

At the level of clinical interaction, a major obstacle for cardiologists is the limited ability to perform a reliable physical examination [9]. The inability to auscultate heart and lung sounds or palpate for edema via video link raises concerns about missing signs of acute decompensation. This creates uncertainty among staff and concerns about legal claims (litigation concerns) arising from medical malpractice [2, 19]. This phenomenon is exacerbated by the lack of uniform national guidelines, including in the field of preventive cardiology, that would categorize conditions eligible for the safe replacement of an in-person visit with a teleconsultation [5, 19, 20, 27].

The implementation of digital systems leads to disruption and modification of the existing workflow in outpatient clinics [5, 9, 28]. A common complaint among practitioners is the lack of integration between third-party software and the hospital's electronic health records (EHRs), which forces duplicate data entry [2, 20, 25, 28]. At the same time, the constant influx of data from home telemonitoring and wearable sensors causes data overload for physicians and results in fatigue from false alarms that require manual verification [12, 19, 20, 25].

Teleconsultations also involve psychosocial considerations. Physicians and patients—especially older adults and immigrants—highlight the risk of a diminished therapeutic relationship, difficulties in interpreting nonverbal cues, and a greater likelihood of misunderstandings [4, 17]. For this reason, researchers recommend that virtual-first care models be implemented selectively and targeted at stable cardiac patients [2, 4, 17, 25]. Assessment of the quality of these solutions using specialized tools, such as the Tele-QoL protocol, and data analysis indicate the need to treat remote monitoring as a supplement to care, rather than as a

universal substitute for in-person monitoring of patients with chronic heart failure [3, 4, 6, 29, 30].

5. Conclusions

The accumulated evidence from the literature unequivocally indicates that telemedicine in cardiac care for the rural population is a highly effective clinical tool; however, its scaling is hindered by a complex network of structural, systemic, and social barriers. From the perspective of effectiveness indicators, remote patient monitoring (particularly in cases of heart failure) and e-consultations effectively reduce rehospitalization rates, optimize care costs, and shorten the time required to initiate treatment in emergency situations. Properly organized telecardiology programs in remote areas improve patients' quality of life and functional status, serving as a tool to address disparities in access to care, known as the "rural health penalty."

An analysis of implementation barriers reveals a significant disparity. Rural populations, which—due to staffing shortages and geographical distances—would benefit most from telecardiology, are the most severely affected by digital exclusion and infrastructure gaps (digital redlining). The dependence of telemedicine's effectiveness on access to broadband internet, adequate equipment, and digital literacy (especially among the geriatric population) means that without adequate support, these services may actually exacerbate existing health inequalities.

Barriers to implementation also lie with healthcare providers and the healthcare systems themselves. Widespread acceptance of telecardiology by medical staff is limited by inconsistent reimbursement and legislative frameworks, as well as gaps in the interoperability of devices with electronic health records (EHRs). The necessity of relying on monitoring data while being unable to conduct a traditional physical examination increases the risk of diagnostic errors and the phenomenon of data overload among physicians.

For telecardiology services to function sustainably and safely in rural areas, it is necessary to move away from treating them as a complete replacement for traditional medicine in favor of integrated hybrid models. The success of these solutions requires synchronized investments in telecommunications infrastructure, local patient education programs, and the broader integration of artificial intelligence (AI) algorithms for filtering and predicting telemetric data, which will allow for the safe offloading of clinical staff.

Author's contribution:

Conceptualization: Dominika Ciesielska

Methodology: Natalia Zięba, Katarzyna Kociuba, Anna Mazur

Software: Not applicable

Check: Miłosz Cisłak

Formal analysis: Mateusz Czech, Mikołaj Brzuzek

Investigation: Michał Chojęta, Jakub Czmok

Sources: Dominika Ciesielska

Data curation: Katarzyna Kociuba, Dominik Tarczyński

Writing-rough preparation: Dominika Ciesielska, Natalia Zięba, Mateusz Czech, Dominik Tarczyński

Writing review and editing: Miłosz Cisłak, Michał Chojęta

Visualization: Jakub Czmok, Mikołaj Brzuzek

Supervision: Dominika Ciesielska

Project administration: Dominika Ciesielska, Anna Mazur

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References

1. Boriani G, Maisano A, Bonini N, et al. Digital literacy as a potential barrier to implementation of cardiology tele-visits after COVID-19 pandemic: the INFO-COVID survey. *J Geriatr Cardiol*. 2021;18(9):739-747. https://doi.org/10.11909/j.issn.1671-5411.2021.09.003
2. Huerne K, Eisenberg MJ. Advancing telemedicine in cardiology: a comprehensive review of evolving practices and outcomes in a postpandemic context. *Cardiovasc Digit Health J*. 2024;5(2):96-110. https://doi.org/10.1016/j.cvdhj.2024.02.001
3. Mohammadzadeh N, Rezayi S, Tanhapour M, Saeedi S. Telecardiology interventions for patients with cardiovascular disease: a systematic review on characteristics and effects. *Int J Med Inform*. 2022;158:104663. https://doi.org/10.1016/j.ijmedinf.2021.104663
4. Tolu-Akinnawo O, Ezekwueme F, Awoyemi T. Telemedicine in cardiology: enhancing access to care and improving patient outcomes. *Cureus*. 2024;16(6):e62852. https://doi.org/10.7759/cureus.62852
5. Muehlensiepen F, Hoffmann MJ, Nübel J, et al. Acceptance of telemedicine by specialists and general practitioners in cardiology care: cross-sectional survey study. *JMIR Form Res*. 2024;8:e49526. https://doi.org/10.2196/49526
6. Ezimoha K, Faraj M, Kanduri Hanumantharayudu S, et al. The impact of remote patient monitoring on clinical outcomes in heart failure patients: a meta-analysis. *Cureus*. 2025;17(9):e92812. https://doi.org/10.7759/cureus.92812
7. Takahashi EA, Schwamm LH, Adeoye OM, et al. An overview of telehealth in the management of cardiovascular disease: a scientific statement from the American Heart Association. *Circulation*. 2022;146(25):e558-e568. https://doi.org/10.1161/CIR.0000000000001107

8. Al Juboori R, Barker D, Yockey A, et al. Telehealth-readiness, healthcare access, and cardiovascular health in the Deep South: a spatial perspective. *Int J Environ Res Public Health*. 2025;22(7):1020. https://doi.org/10.3390/ijerph22071020
9. Burchim S, Miller S, Beima-Sofie K, et al. Rural perspectives on digital health in cardiovascular care: qualitative study of interviews with rural and rural-serving primary care providers and cardiologists. *J Med Internet Res*. 2025;27:e77234. https://doi.org/10.2196/77234
10. Tisdale RL, Purmal C, Kalwani N, et al. Opportunities to address specialty care deserts and the digital divide through the Veterans Health Administration's telehealth hub-and-spoke cardiology clinic: retrospective cohort study. *J Med Internet Res*. 2024;26:e53932. https://doi.org/10.2196/53932
11. Xu H, Granger BB, Drake CD, Peterson ED, Dupre ME. Effectiveness of telemedicine visits in reducing 30-day readmissions among patients with heart failure during the COVID-19 pandemic. *J Am Heart Assoc*. 2022;11(7):e023935. https://doi.org/10.1161/JAHA.121.023935
12. De Lathauwer ILJ, Nieuwenhuys WW, Hafkamp F, et al. Remote patient monitoring in heart failure: a comprehensive meta-analysis of effective programme components for hospitalization and mortality reduction. *Eur J Heart Fail*. 2025;27(9):1670-1685. https://doi.org/10.1002/ejhf.3568
13. Wańczura P, Aebisher D, Stecko W, et al. Supervised telemedical monitoring in the heart failure population in the regions of social exclusion is associated with improved functional capacity and quality of life. *Pol Arch Intern Med*. 2025;135(4):16954. https://doi.org/10.20452/pamw.16954
14. Haleem A, Javaid M, Singh RP, Suman R. Telemedicine for healthcare: capabilities, features, barriers, and applications. *Sens Int*. 2021;2:100117. https://doi.org/10.1016/j.sintl.2021.100117
15. Troy AL, Xu J, Wadhera RK. Access to care and cardiovascular health in US counties with low versus higher broadband internet availability. *Am J Cardiol*. 2023;209:190-192. https://doi.org/10.1016/j.amjcard.2023.09.111
16. Rasekaba TM, Pereira P, Rani GV, Johnson R, McKechnie R, Blackberry I. Exploring telehealth readiness in a resource limited setting: digital and health literacy among older people in rural India (DAHLIA). *Geriatrics (Basel)*. 2022;7(2):28. https://doi.org/10.3390/geriatrics7020028

17. Kaihlanen AM, Virtanen L, Buchert U, et al. Towards digital health equity: a qualitative study of the challenges experienced by vulnerable groups in using digital health services in the COVID-19 era. *BMC Health Serv Res*. 2022;22(1):188. https://doi.org/10.1186/s12913-022-07584-4
18. Levander XA, VanDerSchaaf H, Barragán VG, et al. The role of human-centered design in healthcare innovation: a digital health equity case study. *J Gen Intern Med*. 2024;39(4):690-695. https://doi.org/10.1007/s11606-023-08500-0
19. Lieneck C, Weaver E, Maryon T. Outpatient telehealth implementation in the United States during the COVID-19 global pandemic: a systematic review. *Medicina (Kaunas)*. 2021;57(5):462. https://doi.org/10.3390/medicina57050462
20. van Tilburg ML, Spin I, Pisters MF, et al. Barriers and facilitators to the implementation of digital health services for people with musculoskeletal conditions in the primary health care setting: systematic review. *J Med Internet Res*. 2024;26:e49868. https://doi.org/10.2196/49868
21. Adamowicz JL, Christensen A, Howren MB, et al. Health-related quality of life in head and neck cancer survivors: evaluating the rural disadvantage. *J Rural Health*. 2022;38(1):54-62. https://doi.org/10.1111/jrh.12571
22. Kolluri S, Stead TS, Mangal RK, et al. Telehealth in response to the rural health disparity. *Health Psychol Res*. 2022;10(3):37445. https://doi.org/10.52965/001c.37445
23. Finley BA, Palitsky R, Charteris E, Pacheco C, Kapoor D. Outpatient telecardiology perceptions among rural, suburban, and urban veterans utilizing in-person cardiology versus telecardiology services: a mixed methods analysis. *J Rural Health*. 2021;37(4):812-820. https://doi.org/10.1111/jrh.12586
24. Kędzierski K, Radziejewska J, Sławuta A, Wawrzyńska M, Arkowski J. Telemedicine in cardiology: modern technologies to improve cardiovascular patients' outcomes-a narrative review. *Medicina (Kaunas)*. 2022;58(2):210. https://doi.org/10.3390/medicina58020210
25. Mahalwar G, Kumar A, Kalra A. Virtual cardiology: past, present, future directions, and considerations. *Curr Cardiovasc Risk Rep*. 2023;17(6):117-122. https://doi.org/10.1007/s12170-023-00719-0
26. Totten AM, Womack DM, Griffin JC, et al. Telehealth-guided provider-to-provider communication to improve rural health: a systematic review. *J Telemed Telecare*. 2024;30(8):1209-1229. https://doi.org/10.1177/1357633X221139892

27. Visseren FLJ, Mach F, Smulders YM, et al. 2021 ESC guidelines on cardiovascular disease prevention in clinical practice. *Eur Heart J*. 2021;42(34):3227-3337. https://doi.org/10.1093/eurheartj/ehab484
28. Savira F, Sanigorski A, Namara KM, et al. Perspectives on telehealth implementation in Australia: an exploratory qualitative study with practice managers and general practitioners. *Int J Med Inform*. 2024;188:105473. https://doi.org/10.1016/j.ijmedinf.2024.105473
29. Scholte NTB, Gürgöze MT, Aydin D, et al. Telemonitoring for heart failure: a meta-analysis. *Eur Heart J*. 2023;44(31):2911-2926. https://doi.org/10.1093/eurheartj/ehad280
30. Greffin K, Muehlan H, van den Berg N, et al. Setting-sensitive conceptualization and assessment of quality of life in telemedical care-study protocol of the Tele-QoL project. *Int J Environ Res Public Health*. 2021;18(19):10454. https://doi.org/10.3390/ijerph181910454