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Advantages and Challenges of Telecardiology and Providing Solutions for Its Successful Implementation: A Scoping Review

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ABSTRACT

Context: Implementation of health information technologies such as telecardiology has always been associated with many challenges. Identifying these challenges and planning to address them can lead to success in their implementation. The present study aimed to identify the advantages and disadvantages of using telecardiology and to provide solutions for its successful implementation based on the obtained results.

Evidence Acquisition: This scoping review was conducted in 2021. A search was done in PubMed, Scopus, and Web of Science databases by combining the related keywords. The data were gathered using an excel sheet data extraction form after applying the article selection steps. Then, data analysis was done through the content analysis method and the results were summarized and reported based on the study objectives.

Results: Totally, 30 articles were included in the study based on the inclusion and exclusion criteria. The advantages of telecardiology were divided into eight main categories, namely facilitating healthcare providing processes, medical education, healthcare quality, increasing Health Care Providers' (HCP) performance, reducing costs, availability and accessibility of healthcare services, data management, and patient monitoring. Additionally, the challenges of telecardiology implementation were classified into six categories; i.e., economic and financial difficulties, the nature of heart disease, human resources, difficulties related to Information Technology (IT), wearable devices challenges, and uncertainty of results.

Conclusion: Telecardiology systems are recommended to be used more to provide healthcare services to remote and rural areas as well as those with a lack of specialists. Due to the challenges facing the successful implementation of telecardiology, preliminary studies such as feasibility studies and acceptance and initial pre-implementation evaluations are warranted.

1. Context

Heart diseases are one of the most important causes of death worldwide (1). Access to healthcare services from initial to advanced levels can reduce the death rate amongst patients with heart diseases, especially in remote areas (2). However, providing healthcare services for patients in remote areas without specialists, particularly in cardiac care, has created significant challenges in the health system (3). The high sensitivity of providing high-quality and timely healthcare services for patients with cardiovascular disease has led managers and healthcare providers to consider using information technology to provide these services (4-6).

The use of telemedicine has been found to facilitate the provision of health services in remote areas and to pave the way for equity in health (7). The World Health Organization (WHO) has defined telemedicine as the provision of healthcare services by specialists through the transmission of information about the diagnosis, prevention, and treatment of diseases and other health-related problems (8). Telemedicine is, in fact, a supportive tool for providing a wide range of health services based on information technology innovations (9). Nowadays, many telemedicine

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services, from teleconsulting to telesurgery, are available for healthcare providers (10). One of these technologies is telecardiology, which is a type of telemedicine providing healthcare services. It includes diagnostic and treatment procedures for patients with heart diseases such as Heart Failure (HF), Coronary Artery Disease (CAD), and Congenital Heart Disease (CHD) by a remote clinician by using information technologies such as videoconferencing (11). Telecardiology facilitates communication between different centers and provides specialized services and cardiac counseling (11). In some cases, sending an on-time Electrocardiography (ECG) result to a cardiologist and providing the necessary initial intervention based on the ECG interpretation can save a patient's life. This will be possible by relying on the basic capabilities of telecardiology (12). In advanced levels of telecardiology, it is also possible to perform ECG using newly designed tools such as smartwatches or implantable devices in the patient's body. Besides, some technologies such as the Global Positioning System (GPS) can send these results to the relevant centers to provide appropriate healthcare services to patients (11). Furthermore, this technology can be used to train novice physicians and receive specialized consultations from healthcare providers (13, 14). In addition to facilitating the provision of specialized healthcare services (15) and improving the health of at-risk people for heart diseases, the use of telecardiology can significantly reduce costs (16, 17). For instance, in cases with minimal facilities and without a specialized cardiac center in remote areas, telecardiology can provide proper specialized services for patients, which can save up to several thousand dollars (18, 19).

Developing, implementing, and using telecardiology has many advantages. Similar to other technologies, however, it can be associated with many challenges. Therefore, many studies and projects in telecardiology have been conducted in recent years. Yeo et al. conducted a study in 2019 and showed that despite the many benefits of this technology, its high cost was one of the main challenges of its implementation (20). In another study done by Maia et al. in 2019, using tele-pediatric to provide cardiac care services enabled real-time communication, clinical information sharing, and provision of healthcare services in distant and local sites (21).

The present study aims to assess the benefits and challenges of using telecardiology for providing healthcare services to patients with cardiovascular disease. The study results can be used as a practical guide for policymakers and managers by identifying the benefits and challenges of implementing telecardiology and providing solutions for its implementation.

2. Evidence Acquisition

2.1. Study Design

This scoping review was conducted based on scoping review and systematic review guidelines in 2021 (22, 23). Generally, scoping reviews have three main parts, namely Population, Context, and Concept (PCC) (22, 23). Therefore, the study method was formulated based on these parts.

2.2. Search Strategy and Study Selection

A search was conducted in PubMed, Scopus, and Web of Science databases to find studies in English without time limitation by combining the following keywords: ("telecardiology" OR "tele-ECG" OR "tele echocardiography" OR "tele-CCU" OR "tele emergency") AND ("Advantages" OR "disadvantages" OR "adoption" OR "challenge" OR "barrier" OR "problem" OR "facilitator" OR "strategy").

2.3. Inclusion and Exclusion Criteria

The original articles about the advantages and challenges of telecardiology were selected. The chosen studies implemented telecardiology services for cardiovascular disease or assessed implemented projects. The studies that did not evaluate the advantages and challenges of telecardiology in implemented projects were excluded. Other article types than original articles, those that were not about telecardiology implementation, and those without an English full text were excluded, as well.

2.4. Data Extraction

Data extraction was done by two authors, and the disagreements were forwarded to the project manager. A data extraction form was utilized for extracting data from the selected studies. The data extraction form contained four main parts; i.e., article bibliometric data, methodological information, advantages and challenges, and results.

2.5. Data Analysis

Data analyses were done through content analysis, and the results were summarized and reported in form of tables and figures based on the study objectives.

3. Results

From the 177 articles found in the first step, 30 studies were included after applying the inclusion and exclusion criteria. The process of article selection based on the PRISMA flowchart has been depicted in Figure 1.

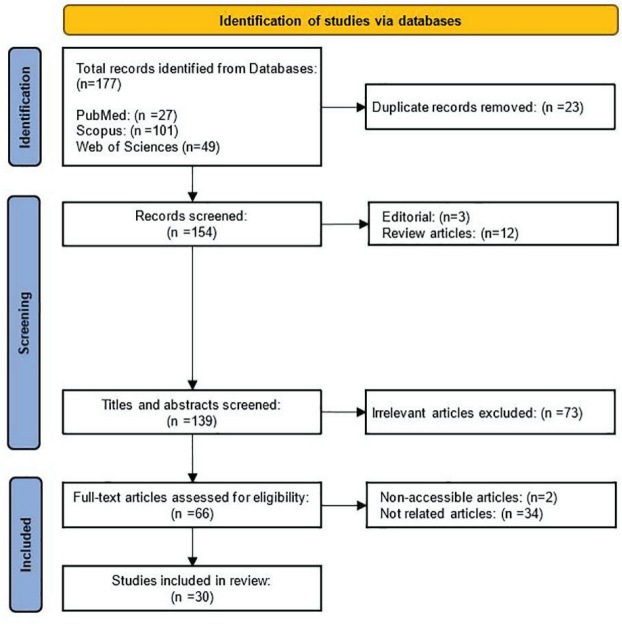

Figure 1. Article Selection Process based on the PRISMA Flowchart

The features of the selected studies have been presented in Table 1. Accordingly, the first article was conducted in 2009. Additionally, 73.33% of the articles (22 out of the 30 studies) were about telecardiology projects implementation.

Table 1. The Features of the Included Studies

	First author Year Country	Level of Use	Type of Use	Participants (Main Emphasis)	Type of Telecardiology	Type of Disease
1	Blazek, 2016 Switzerland (24)	Implementation	Monitoring	Physicians	Telemonitoring	Cardiorespiratory monitoring
2	Hansen, 2020 Norway (25)	Implementation	ECG interpretation	Nurses	Tele-ECG	Heart failure
3	Cuneo, 2019 USA (26)	Implementation	Risk stratification of fetal cardiac anomalies in an underserved population	Physicians and patients	Telecardiology	Fetal cardiac anomalies (CHF, arrhythmia)
4	Makkar, 2021 USA (27)	Implementation	Congenital heart disease screening in a level II neonatal intensive care unit	Physicians	Tele-ECG	Congenital heart disease
5	Hsieh, 2012 Taiwan (28)	Implementation	A model for tele-ECG implementation	Cardiologists	Tele-ECG	Cardiovascular disease
6	Behere, 2019 USA (29)	Assessment	Evaluation of tele-auscultation system	Cardiologists	Tele-auscultation	Cardiovascular disease
7	Mattos, 2020 Brazil (30)	Implementation	Screening congenital heart disease	Pediatricians	Telecardiology	Congenital heart disease
8	Shetty, 2017 India (31)	Feasibility study	Connecting to a rural area	Cardiologist, staff	Telecardiology	Cardiovascular disease
9	Finley, 2021 USA (32)	Initial implementation	Comparison of the use of telecardiology services and people who received regular services	Veterans	Telecardiology for outpatients	Cardiovascular disease
10	Dwivedi, 2021 India (33)	Implementation	Importance of imaging in work up of cardiovascular disease by using telemedicine in rural India	Physicians	Telecardiology/ teleradiology	Cardiovascular disease
11	Lacerda, 2014 Brazil (34)	Assessment	Comparative evaluation of the applicability of two approaches for reporting findings in the field of large-scale telecardiology	Physicians	Tele-electrocardiography	Cardiovascular disease
12	Rosier, 2016 France (35)	Implementation	Remote monitoring of cardiac implantable electronic devices such as pacemakers and defibrillators	-	Telemonitoring	Cardiac implantable electronic devices
13	Bonis, 2021 Italy (36)	Assessment	Management of STEMI diagnosis during the COVID-19 pandemic	Physicians	Tele-ECG	STEMI
14	Maines, 2021 Italy (37)	Implementation	Remote follow-up of pacemakers and implantable cardiac defibrillators	-	Telemonitoring	Patients with pacemakers and implantable cardiac defibrillators
15	Maia M.R. 2019 Portugal (21)	Implementation	Pediatric cardiology service	Pediatrician	Pediatric cardiology service	Pediatric care
16	Jatmiko, 2019 Indonesia (38)	Implementation	Early detection and monitoring of heart diseases based on the ECG signal		Tele-ECG	Cardiovascular disease
17	Yeo, 2019 Malaysia (20)	Initial assessment	-	Patients and individuals who used Internet services in their daily lives	Telecardiology	Cardiovascular disease
18	Chauhan, 2018 India (39)	Implementation	Tele-ECG support for primary care physicians reduced the pain-to-treatment time in acute coronary syndrome	Primary care physicians	Tele-ECG	Acute coronary syndrome
19	Yeo, 2017 Malaysia (40)	Assessment	-	Cardiologists, general physicians, patients, and the public	Telecardiology	Cardiovascular disease
20	Brunetti, 2016 Italy (41)	Implementation	Cardiovascular disease prevention with telecardiology	Patients	Telecardiology	Cardiovascular disease
21	Scheuermeyer, 2016 Canada (42)	Implementation	Remote ECG report	Physicians	Tele-ECG	Cardiovascular disease

22	Bansal, 2015 India (43)	Implementation	Training based on tele-ECG	Physicians	Tele-ECG	Cardiovascular disease
23	Bendelac, 2014 France (44)	Implementation	Ambulatory monitoring of patients with heart failure	Physicians	Remote monitoring	Heart failure
24	Rushworth, 2014 UK (45)	Implementation	Pre-hospital ECG E-transmission for myocardial infarction	Physicians and nurses	Telecardiology	Myocardial infarction
25	Khader, 2014 Jordan (46)	Implementation	Impact of live interactive telecardiology on diagnosis and disease management, patients' quality of life, and time- and cost-savings	Patients	Telecardiology	Cardiovascular disease
26	Moreau, 2014 France (47)	Implementation	Follow-up of implanted cardioverter defibrillators	Patients	Remote monitoring	Implanted cardioverter defibrillators
27	Theuns, 2012 Netherlands (48)	Implementation	The management of system-related complications in implantable defibrillator patients	Patients	Remote monitoring	Implantable defibrillator patients
28	Antonicelli, 2010 Italy (49)	Implementation	Telemonitoring on use of β-blockers in congestive heart failure	Physicians/ patients	Telemonitoring, telecardiology	Congestive heart failure
29	Pappas, 2010 UK (50)	Implementation	Physical examination in telecardiology and televascular consultations	Physicians/ patients	Telecardiology and televascular consultations	Cardiovascular disease
30	Giordano, 2009 Italy (51)	Implementation	Tele-management to prevent hospital readmission of patients with chronic heart failure	Physicians/ patients	Telecardiology/ telecardiology	Chronic heart failure

Abbreviations: STEMI, ST-elevation myocardial infarction; CHF, chronic heart failure; ECG, electrocardiography

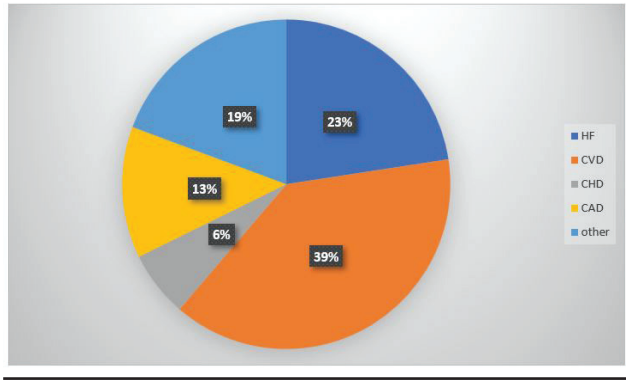

Figure 2. The Frequency of Using Telecardiology in the Studies Based on the Type of Heart Disease

Based on Table 1, most studies were conducted in India (four articles) and the USA (four articles). The results also showed that healthcare services based on telecardiology were provided for different types of heart disease. However, many studies included interventions for cardiovascular disease (Figure 2).

The results indicated that telemedicine and telecardiology were the most frequent keywords in the selected articles. The occurrence network of the keywords in different years has been shown in Figure 3, with the topics of interest being marked with a specific color.

The study results revealed the main advantages (eight main categories) and challenges (five main categories) of telecardiology (Table 2).

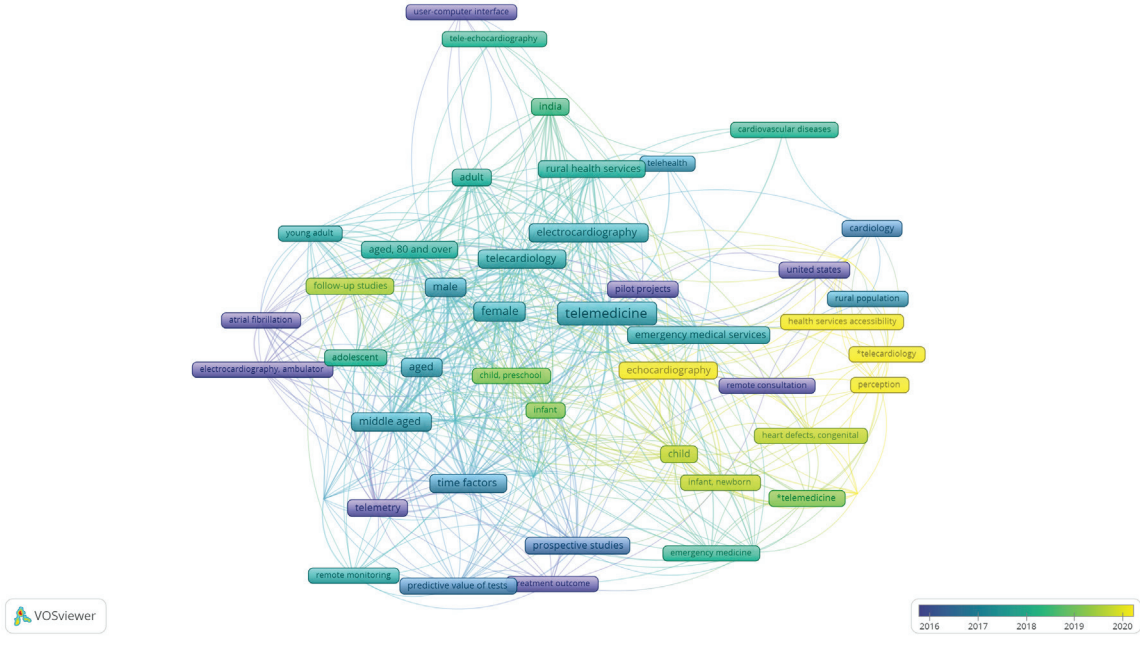

Figure 3. The Occurrence Network of the Keywords

Table 2. The Advantages and Challenges of Telecardiology for Providing Healthcare Services

Advantages/ Challenges	Categories	Subcategories	References
Advantages	Facilitating healthcare provision processes	Simplifying the workflow (Tele-ECG)	(25)
		Facilitating the performance of ultrasonography by staff (Telecardiology)	(26)
		Providing timely ECG interpretation and counseling to patients (Telecardiology)	(31)
		Effectiveness in the diagnosis and treatment of patients in rural areas (Telecardiology, Teleradiology)	(33)
		Fast diagnosis and triage (Tele-ECG, Telecardiology, Telemonitoring)	(45, 48, 52)
		A useful screening tool for murmur evaluation (Tele-auscultation)	(29)
		Supporting the treatment plan (Telecardiology)	(46)
		Preventing unnecessary device replacement (Telemonitoring)	(48)
		Assistance in determining the appropriate dose of beta-blockers (Telemonitoring, Telecardiology)	(49)
		Optimizing the use of various drugs (Telemonitoring, Telecardiology)	(49)
	Medical education	Increasing pediatricians' understanding of echocardiography (Telecardiology)	(30)
		Educating physicians in terms of ECG (Tele-ECG)	(43)
		Extensive education for patients with heart failure (Telemonitoring)	(44)
	Healthcare quality	Accurate, safe, and effective in CHD screening (Tele-ECG)	(27)
		Increasing healthcare services efficiency (Tele-ECG)	(28)
		Improving the prevention of the complications of cardiovascular disease (Telecardiology)	(41)
		Improve patients' quality of life (Telecardiology)	(46)
	Increasing HCPs' performance	Ability to provide a standard of care without the need for patient attendance (Telecardiology)	(26)
		Ease of use (Tele-auscultation, Tele-ECG)	(29, 39)
		Ensuring the continuity of patient monitoring (Telemonitoring)	(37)
		Increasing the participation of primary care nurses (Telecardiology, Televascular consultations)	(50)
	Reducing costs	Appropriate economic benefits for families (Telecardiology)	(26)
		Saving transfer costs (Tele-ECG)	(27)
		Significant cost reduction (Tele-ECG, Telemonitoring)	(28, 39, 47, 51)
		Reducing the readmission of patients in hospitals and saving costs (Telecardiology)	(51)
	Availability and accessibility of healthcare services	Providing healthcare services in distant and local sites (Telecardiology, Tele-pediatric)	(21, 26)
		Preventing the unnecessary transfer of most infants to regional level III/IV NICUs (Tele-ECG)	(27)
		High-quality ECGs successfully received by rural clinical staff (Telecardiology)	(31)
		Addressing a part of the need for specialized physicians in disadvantaged areas (Tele-pediatric)	(21)
		Reduction of waiting time (Telecardiology)	(20)
		Reduction of unnecessary transfers (Telecardiology)	(20)
		Facilitating healthcare services in rural areas (Telecardiology)	(20)
		Improving patient-physician relationships (Telecardiology)	(45)
	Data management	Intangible data acquisition (Telemonitoring)	(24)
		Possibility to calculate the received oxygen (Telemonitoring)	(24)
		Transfer of imaging data (Tele-ECG)	(25)
		Improving data management (Tele-ECG)	(28)
		Enabling real-time communication and sharing of clinical information (Tele-pediatric)	(21)
		Sharing information in a shorter time (Telecardiology, Tele-ECG)	(20, 42)
		Safe data sharing (Tele-ECG)	(42)
	Patient monitoring	Evaluating vital signs in different body parts (Telemonitoring)	(24, 48)
		Long-term monitoring of physiological effects (Telemonitoring)	(24)
		Facilitating patients' living conditions at home (Telemonitoring)	(44)
Challenges	Economic and financial challenges	Social and economic issues	(17)
		Reimbursement of regulation challenges	(15)
		High costs of implementing telecardiology devices	(40)
	Human resources	Resistance of healthcare providers and patients to accepting and using telecardiology	(20, 50)
		Preference of face-to-face counseling over virtual counseling	(40)
	IT-related challenges	Some problems in interoperability between devices	(15)
		Difficult management of system alerts by increase in the number of alerts	(35)
		Information confidentiality	(40)
		Data transfer network problems	(45)
	Wearable devices challenges	Not applicable for sensitive skin	(15, 24)
		The size of wearable tools	(15)
	Other	Uncertainty of results	(48)
		The severity of the disease	(17)

Abbreviations: ECG, electrocardiography; CHD, chronic heart disease; HCP, healthcare provider; NICU, neonatal intensive care unit; IT, information technology.

Based on the results, implementing telecardiology services had some challenges such as economic and financial challenges, the nature of heart disease, human resources, challenges related to information technology, and wearable devices challenges. The suggestions for implementing telecardiology services included assessing the acceptance of telecardiology services (17), use of technology acceptance models before implementing telecardiology (20), assessing the effectiveness (17), degree of patient adherence (25), training for use of the device (26, 44, 48, 52), and conducting more studies in the field (15). Other recommendations were establishing a telemedicine platform to ensure compatibility between different devices (15, 21), defining regulations and procedures for telecardiology services (15), defining reimbursement rules for different monitoring methods (15), minimizing external and internal devices for remote monitoring (32), introducing telecardiology to users to ensure successful implementation (32), and using telecardiology in educational interventions (50).

4. Discussion

Most of the articles chosen in the present study had implemented telecardiology projects. They pointed out the advantages and challenges of using these systems. Up to now, limited studies have been done on the challenges associated with the implementation of telecardiology. One of the most critical strategies for successful health information systems is to study the challenges and barriers of implementation and to perform initial evaluations of the implemented systems (53). Thus, to achieve better results from implementing telecardiology systems, further studies are warranted.

The present study results showed that few studies were conducted on the benefits and challenges of telecardiology in remote and rural areas, while there seem to be serious problems and challenges in the implementation of telemedicine projects in these areas due to their geographical location.

In cardiovascular patients, providing timely services is one of the main reasons for using telecardiology. In fact, patients should be provided with the necessary services in any place (urban or rural) and at any time based on monitoring and surveys (54). However, one of the main reasons for using telemedicine is to provide services to people in remote areas (55). Thus, attention should be paid to the identification of the challenges of providing telemedicine services to people in these areas. Telemedicine-based services can be used as a tool to implement equity in healthcare delivery, especially in remote areas with a lack of specialists (56). Based on the current study findings, no study was done on telecardiology and its benefits and challenges in many parts of the world. Hence, telecardiology projects are recommended to be considered in different countries, especially in those with a high prevalence of cardiovascular disease.

The occurrence network analysis of the study indicated a change in the trend of the studies in the recent years. Accordingly, telecardiology services have moved towards the use of new technologies such as smartwatches and artificial intelligence algorithms in monitoring and providing healthcare services for patients with cardiovascular disease. Nonetheless, using these new technologies in providing telecardiology services is still at the beginning levels. Therefore, further studies are required to be conducted to achieve success and to increase the acceptance of telemedicine services based on artificial intelligence (57).

The present study results demonstrated that the use of different types of telecardiology such as telemonitoring, tele-ECG, distance education, and remote cardiac counseling in providing health services to patients was accompanied by many benefits including facilitating healthcare provision processes, medical education, healthcare quality, increasing the performance of healthcare providers, reduction of costs, availability and accessibility of healthcare services, data management, and patient monitoring. In many cases, the use of telecardiology facilitated the provision of healthcare services for patients with cardiovascular disease. However, it cannot be certainly claimed that telecardiology can facilitate service provision for heart patients in all conditions. Yet, the use of this technology can facilitate the provision of services in remote areas with the lack of cardiologists. Simplifying the workflow (25), facilitating the performance of ultrasonography by staff (26), providing timely ECG interpretation and counseling to patients (31), effective diagnosis and treatment of patients in rural areas (33), and fast diagnosis and triage (48, 52) were some benefits of telecardiology in facilitating healthcare provision.

According to the present study results, given that telecardiology allows telecommunication between healthcare professionals, it can be used as an educational tool for educating inexperienced physicians and patients. However, there is disagreement amongst experts and policymakers about the financial benefits of telecardiology, with some pointing to the positive impact of reducing costs and some pointing to increased costs. In some cases, using the simple facilities of telecardiology, the need to set up some clinics and healthcare centers that require much money can be eliminated. The use of telecardiology services in remote and rural areas can also facilitate patient monitoring in these areas.

The current study findings indicated that despite the numerous benefits, the implementation of telecardiology systems might face challenges, which could affect their success. One of these challenges was related to economic and financial obstacles in project implementation (40). Thus, the cost-effectiveness of these systems is recommended to be assessed accurately. Another significant challenge in the telecardiology implementation was related to information and communication technology infrastructure (15), especially in developing countries and remote regions. Based on the results, developing countries can develop communication infrastructure, making it possible to expand the provision of services in all regions. Since many problems related to information technology result from the production of different systems and the difficulty of interacting between them, more studies have to be done on the interoperability of systems.

One of the most important strategies for successful implementation of telecardiology systems is assessing the acceptance of telecardiology services (17). The current study results showed that only one study was conducted on

the factors affecting the acceptance of telecardiology based on technology acceptance models (20). Therefore, further studies are recommended to be carried out in this field. By minimizing the external and internal devices (implantable and wearable telemonitoring devices) for remote monitoring of cardiovascular disease, their usability can be increased. Introducing telecardiology potentials and abilities to users to ensure its successful implementation (32) is yet another strategy that can be used to implement telecardiology systems.

5. Conclusion

The study findings suggested further employment of telecardiology systems to provide healthcare services to remote and rural areas as well as those with a lack of specialists. Considering the challenges facing the successful implementation of telecardiology, preliminary studies such as feasibility studies and acceptance and initial pre-implementation evaluations are warranted. Moreover, regarding the financial issues associated with the implementation and continuation of using telecardiology, authorities should pay attention to supplying sustainable financial resources to provide these services. Further studies on the implementation, use, and evaluation of telecardiology systems are also suggested, because some studies have emphasized the need for future studies on the effects of telecardiology on the process of providing healthcare services. Combining information technology-based services with innovations in artificial intelligence is one of the new trends in the field of telecardiology that has been considered and used in recent years. These services can make telecardiology easier to use and reduce the costs. Therefore, more studies are recommended to be performed in this area.

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Authors' Contribution

AG, NA, and SJ designed the study. AG and NA supervised the study. MM, ML, and AG prepared the preliminary draft of the manuscript. SJ and AG checked the clinical and technical aspects of the manuscript. SSH, ML, and MM revised the manuscript critically. All authors read and approved the final draft of the manuscript.

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