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Cost-effectiveness of Telemedicine Intervention for Acute Myocardial Infarction: A Systematic Review

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Abstract

Background: One of the most important causes of mortality in the world is acute myocardial infarction. There are two general treatments including thrombolytic drugs and percutaneous coronary interventions. But, monitoring outpatient AMI treatment from a remote or rural location has emerged as a successful telemedicine technique. So, the present study aimed to review the economic evaluation studies of telemedicine in patients with acute myocardial infarction.

Methods: This study was conducted based on Preferred Reporting Items for Systematic Reviews and Meta-Analysis checklist (PRISMA is a 27-item checklist used to improve transparency in systematic reviews) guidelines in 2022. PubMed, Scopus, Web of Science, Proquest, Iranian databases (SID, Magiran), and Google Scholar were searched with the keywords of telemedicine and myocardial infarction from 2000 to 2022. After eliminating duplicates, titles and abstracts were screened based on inclusion and exclusion criteria, details, and the most important results of eligible studies were recorded in the data collection form.

Results: 904 records were identified in this search, of which 147 were duplicates. Finally, 6 records were included in this study. Among these studies, 4 were cost-effectiveness, one was cost analysis, and one was cost-utility. The willingness to pay threshold was between 20,000 and 100,000, and the outcomes were measured with QALY (Quality-adjusted life-years). The reviewed studies showed that telemedicine can improve outcomes such as quality of life and reduce disease costs.

Conclusions: The results showed that telemedicine interventions for acute myocardial infarction can be helpful, and cost-effective. However in some cases, it can cause increased costs and may not have a significant difference in effectiveness with other methods because of the condition and stage of the disease.

Keywords: Cost-effectiveness Analysis, Cost-benefit Analysis, Acute Myocardial Infarction, Telemedicine, Systematic Review

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Introduction

Cardiovascular Diseases (CVDs) are one of the important topics relates to the health system, and the burden of these diseases is increasing with the change of lifestyle and the process of industrialization in all countries (1). Heart diseases and blood vessel disorders, such as coronary, cerebrovascular, and rheumatic heart diseases, are collectively known as CVDs are the most common cause of death worldwide, claiming about 17.9 million lives every year, according to the WHO. Heart attacks and strokes account for more than 80% of CVD deaths, and one in three of these deaths happen too early in people who are younger than 70 years old (2). The highest death rate occurs in the Middle East compared to other parts of the world. It is predicted that within five years, the rate of death due to CVDs will be 15% in developed countries, 77% in China, and other Asian countries increased by 106%, which has led to disability,

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↑What is "already known" in this topic:
Treatment methods for acute myocardial infarction are different, and previous studies have compared some of these methods. This study has examined the available studies in the economic evaluation of telemedicine with other methods.

→What this article adds:
This comparative study has shown that the use of telemedicine and the development of technology in treating this disease can improve many outcomes.

loss of workability, daily activities of sufferers and heavy costs in the treatment system (3). In this regard, Europeans also have a high mortality rate due to ischemic heart disease. In addition, it has a high economic burden for these countries, so in 2017, the cost of this disease was more than 18 million Euros (4, 5). In Iran, the most common cause of death in recent decades has changed from infectious diseases to heart disease (6).

According to the latest statistics in the United States, 70.0% of major CVD events were related to low and moderate cardiovascular Health (CVH), which 2.0 million of these events could be prevented each year if all US adults achieve high CVH (7). The high prevalence of acute myocardial infarction, in addition to mortality, is the leading cause of chronic heart failure after acute myocardial infarction in these patients. For this reason, minimizing the duration of acute coronary heart attack is very important (1). Due to the importance of these complications in protecting people from death, most of the healthcare financial resources in the world are allocated to these diseases every year, which will cost $1.1 trillion up to 2035 (8).

In acute heart attack, there are two general treatments, including thrombolytic drugs and percutaneous coronary interventions, combined with different strategies. Significant progress has been made in treating advanced methods of percutaneous coronary interventions in recent years, but it is an expensive method. But the findings show that the implementation of this method reduces the overall costs of the disease and the duration of hospitalization,. Hence, the cost of the patients in this method was $8413, and the patients who were treated with drug treatment were $9836 (9). In addition to the benefits of early treatment of acute heart attacks, performing these measures can significantly increase the costs of the health system (10). Therefore, taking preventive measures with the help of new technologies, including telemedicine, can help to act faster and less expensively (11).

Telehealth or telemonitoring has been proposed as an effective method in remote patient care so the World Health Organization considers telemedicine a vital factor for diagnosis, treatment, and prevention to promote health (12). Various care services for patients with cardiovascular diseases, including early prevention, acute care, rehabilitation, chronic disease management, and palliative care, can be delivered through telemedicine (13).

Different studies showed the effectiveness of telemedicine in the treatment of cardiovascular diseases. In this regard, Kruse et al. concluded that telemedicine reveals promise as an alternative modality of care for cardiovascular disease (12). Also, Farabi et al., in a similar systematic review, pointed out that Clinical outcomes are improved and considerable cost savings are achieved through telemedicine. Service delivery can be more cost-effective when telemedicine and usual care are used concurrently (14). Other systematic reviews showed that telemedicine is a favorable intervention in the healthcare field for CVD patients (15, 16). Based on these studies, alongside clinical outcomes, economic outcomes are important to all stakeholders. Therefore, economic evaluation studies can be used for economic consequences because of the balance of three factors: Cost, clinical and financial benefits, and the willingness-to-pay (WTP) threshold of payers (17). Therefore, due to the lack of a systematic review regarding the economic evaluation of telemedicine compared to other hospital procedures regarding acute myocardial infarction patients and the application of the results of these studies by health policy-makers regarding the provision or lack of provision of the necessary infrastructure for telemedicine and its importance in immediate treatment and at low cost to patients, this study aimed to conduct a systematic review of economic evaluation studies for acute myocardial infarction in three areas of cost, clinical outcomes, and willingness to pay.

Methods

We conducted this systematic review based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (18) in May 2022.

Literature search

For extracting related documents regarding the research purpose, PubMed, Scopus, Web of Science, Proquest, Iranian databases (SID, Magiran), and Google Scholar were searched from January 2000 to May 2022 by telemedicine and myocardial infarction keywords and their synonyms in Medical Subject Headings (MeSH). The Search terms consisted of different types of CVD, such as heart failure, myocardial infarction , and acute myocardial infarction, and different types of cardiac telemedicine with various economic evaluation methods.

Based on each database's characteristics, we defined and used this strategy in selected databases (Appendix 1). The search strategies were repeated and confirmed by two research team members. The reference list of related articles was also reviewed to identify more related articles. An example of a search strategy is as follows:

("Myocardial Infarct*" OR "Cardiovascular Stroke*" OR "Heart Attack*" OR "Acute Coronary Syndrome*" OR ACS OR HF OR "myocardial ischemia" OR "coronary heart disease*" OR "Coronary Disease*" OR "Cardiac Failure" OR "Heart Decompensation" OR "Right-Sided Heart Failure" OR "Right Sided Heart Failure" OR "Myocardial Failure" OR "Congestive Heart Failure" OR "Left-Sided Heart Failure" OR "Left Sided Heart Failure" OR "heart disease*") AND ("Mobile Health" OR mHealth OR Telehealth OR eHealth OR telemedicine OR telecommunication OR telemonitoring OR teleradiology OR telepathology OR telerehabilitation OR "remote consultation" OR teleconsultation OR "Tele-rehabilitation*" OR "Tele rehabilitation*" OR "Remote Rehabilitation*" OR "Virtual Rehabilitation*" OR "telecardiology" OR "tele-cardiology" OR "tele-expertise in cardiology" OR "Tele-echocardiography" OR "Tele-Ultrasound" OR "Tele-Echo" OR "tele emergency service*" OR "tele-emergency service*" OR "remote emergency service*") AND ("Cost-Benefit Analyses" OR "Cost Benefit Analysis" OR "Cost Benefit Analyses" OR "Cost Effectiveness" OR "Cost-Benefit Data" OR "Cost Benefit Data" OR "Cost-Utility Analysis" OR "Cost Utility Analysis" OR "Cost-Utility Analyses" OR "Economic Evaluation" OR "Economic Evaluations" OR

"Marginal Analysis" OR "Marginal Analyses" OR "Cost Benefit" OR "Costs and Benefits" OR "Benefits and Costs" OR "Cost-Effectiveness Analysis" OR "Cost Effectiveness Analysis").

Inclusion and exclusion criteria

The inclusion criteria were studies in English or Persian, original studies of economic evaluation of telemedicine for acute myocardial infarction, studies based on the Markov model or decision tree, and cost evaluation studies using QALY as output. The exclusion criteria were studies related to using telemedicine for other cardiovascular diseases, case studies, letters, letters to the editor, editorials, commentaries, conference papers, perspectives, and no access to the full text of the study.

Quality assessment

The QHES checklist was the tool we used to evaluate the methodological quality of the included studies. The QHES instrument consists of 16 criteria to assess economic evaluation studies. Two independent reviewers scored the text of each article. They assigned a score to each item in the checklist; items that only partially met a criterion got half of the score. Then, they calculated a total score for each study. Studies with a score above 85, between 85 and 75, between 75 and 55, and below 55 were classified as "excellent quality," "very good," "good," and "poor quality," respectively (19).

Data analysis

Initially, the abstract of all searched records was entered into EndNote x8 software. After removing duplicates, the title and abstract of studies were screened, and those related to the cost-effectiveness of telemedicine for acute myocardial infarction were identified. Two reviewers repeated this step and resolved disputed cases by negotiating with a third person. Then, two reviewers read the full text of the relevant studies and settled any disagreement with a third person's help.

The reviewers prepared a data extraction form using Excel software. They recorded key features of each record, including country, type of economic evaluation, perspective, time horizon, discount rate (costs, effectiveness), currency year, willingness to pay threshold, type of sensitivity analysis, type of disease, population, compared interventions, and outcomes.

Results

Search result

The search yielded 904 studies from databases, and 5 records from other sources. After eliminating 147 duplicates, 687 titles and abstracts were examined, and 660 records were removed. Then, the inclusion and exclusion criteria were applied to the full text of 17 articles, and finally, 6 articles were selected for the study (Figure 1).

Based on Table 1, the included studies had a good to excellent quality in terms of their methodologies. The average score was 75, the lowest score was 58 (20) and the highest score was 89 (21).

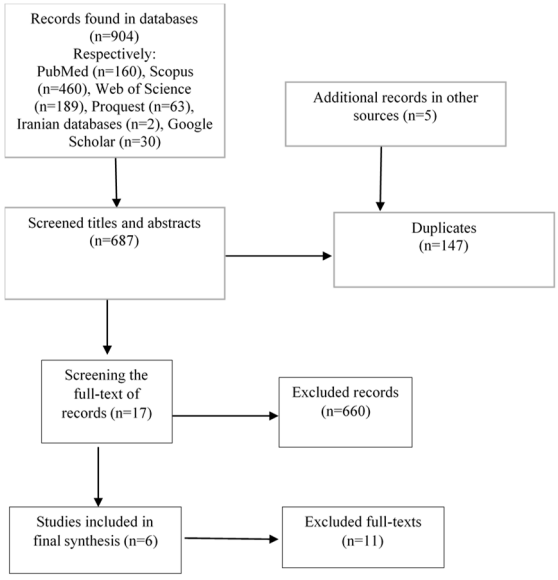

Figure 1. Study flow diagram

Table 2 shows the characteristics and main results of the included studies.

Of the six studies reviewed, four were cost-effectiveness studies (21-24), One article was an economic evaluation (20), and one was a cost-utility analysis study (25). These studies have been conducted in the United States (21), the Netherlands (22, 25), the United Kingdom (23), Denmark (24), and Italy (20), respectively. The Markov model was used in only one study (21), while other studies used comparison groups. The perspectives of the studies are respectively from the hospital, societal perspective, UK health system, healthcare provider, healthcare system, and department of cardiology. The time horizon was 5 years (20, 24), one year (21, 25), it was not assigned (23), and finally, it was not applied because of three months follow-up period (22).

Discount rates (costs, effectiveness) were not assigned in 2 studies (20, 25). In one of the studies, the costs were not discounted but a three percent discount rate was used for 5-year periods (22). In another study costs and benefits were discounted at 5 percent (24), in two studies, costs and benefits were not discounted (21, 23).

The willingness to pay threshold in one study was $100,000 per QALY(21). In another study, compared to a comparative intervention, it was 69% cost-effectiveness in the willingness to pay 0, 86% in the willingness to pay 245,530, and with the willingness to pay adjusted based on the severity of the disease, it was equal to $22,840 (22). In another study in the Netherlands, the willingness to pay threshold was between 21989 and 87957 dollars per QALY(25).

Table 1. QHES checklist: Check the quality of the studies

Reference	Q_1	Q_2	Q_3	Q_4	Q_5	Q_6	Q_7	Q_8	Q_9	Q_{10}	Q_{11}	Q_{12}	Q_{13}	Q_{14}	Q_{15}	Q_{16}	Total
Vinayak Bhardwaj 2021	7	3	6	0	7	6	5	7	7	3	6	8	7	6	8	3	89
RutgerW. M. Brouwers 2021	7	2	5	0	7	5	3	6	8	4	6	8	7	4	8	3	83
Padraig Dixon 2016	7	2	8	0	5	6	5	0	8	5	6	6	7	0	7	3	75
Helle Wallach Kildemoes 2004	7	2	6	0	4	2	5	7	8	4	6	6	6	0	7	0	66
Natale Daniele Brunetti 2013	7	2	6	0	0	0	6	0	6	3	6	6	6	0	7	3	58
Roderick Willem Treskes 2022	7	2	8	0	7	6	5	4	7	3	6	8	7	0	8	2	80
Average																	75

Table 2. Characteristics and results of the included studies

Reference & Year	Country	Discount rate(costs, effectiveness)	Willingness to pay threshold	currency, year	sample size	Perspective	Time horizon	Intervention vs comparator	Incremental costeffectiveness ratio (US $ 2022)	outcomes	Cost(US$ 2022)	Tye of Sensitivity analysis	Mean QALY/YLG/VTE avoided/ Symtomatic VTE event
Bhardwaj et al., 2021 (21)	USA	costs and benefits were not discounted Discount rate, Willingness to pay threshold, year	$100,000 per QALY	2021	1064 200 DHI group 864 historical control group	hospital perspective	1year,with 30 day cycles	DHI plus standard compared with standard of care alone	Standard of care Dominated	QALYs	Corrie 18289.65 Standard of care 29718.69	probabilities and gamma distributions	Corrie 7.88 Standard of care 7.08
Brouwers et al., 2021 (22)	Netherlands	Costs were Not discounted. 3%discounting for a 5-year period	€20 000 ($22 840)	2021	300 patients	societal perspective	not do	Cardiac telerehabilitation (CTR) with center-based (CR)	incremental societal costs were often lower for CTR	Costs QALYs	CTR 20645.61 CR 24806.80	NA	total mean [SE] QALYs for 4 quarters CTR 0.841 [0.012] CR 0.844 [0.011]
Dixon et al., 2016 (23)	UK	costs and benefits were not discounted	20000 30000	2012	641 participants	UK health system perspective	NA	telehealth with usual care	18655.17	Costs QALY	usual care 625.33 intervention 862.41	First,the imputed base case verification was analyzed. then, the base case (imputed) results were assessed	SE usual care 0.786 (0.005) Intervention 0.798 (0.005)

Table 2. Continued

Reference & Year	Country	Discount rate(costs, effectiveness)	Willingness to pay threshold	currency, year	sample size	Perspective	Time horizon	Intervention vs comparator	Incremental costeffectiveness ratio (US $ 2022)	outcomes	Cost(US$ 2022)	Tye of Sensitivity analysis	Mean QALY/YLG/VTE avoided/ Symtomatic VTE event
Kildemoes et al., 2004 (24)	Denmark	costs and benefits discounted at 5 percent	no official threshold value with respect to how much society is willing to pay	1999	9,800 patients	health-care provider	five years	telemedicine programs to reduce the thrombolytic delay with Current Presentation Delay	incremental cost per life year gained (DKK854.700) 177,4$	1 year GL LY LY∗ Cost Cost∗ Cost/LY Cost/LY∗	Telemedicine 63275659.98 Campaign 10648406.12 Combination 63245073.73 Marginal 63275659.98	one by one, the base case estimates for compain and marginal cost/LY for the combination	Telemedicine GL 8,45 LY 537 LY* 306 Campaign GL 4,90 LY 311 LY* 177 Combination GL 14,13 LY 897 LY* 511 Marginal GL 9,23 LY 596 LY* 334
Brunetti et al., 2014 (20)	Italia	NA	NA	2012	109750 underwent prehospital field triage electrocardiogram	regional health-care system	5-year	Electrocardiogram prehospital telemedicine triage with conventional emergency department triage	cost per STEMI QALY saved 3010.84$	Cost, LY, QALY	Total cost 2864493.22	NA	Presumed STEMI patients saved per y, n 6856
Treskes et al., 2022 (25)	Netherlands	NA	(US $21,989) and (US $87,957) per QALY	May 2016 December 2018	200 patients	department of cardiology's	1 year	eHealth intervention and regular follow-up in patients with AMI	eHealth is less costly and provide more quality of life	costs and QALY	Intervention 3392.87±2867.87 control group 4054.04±4156.51 This yielded a cost reduction of 661.17per patient	Sensitivity analysis was done by changing costs	mean QALY per patient 0.74 for the intervention group and 0.69 for the control group

Bhardwaj et al. used probabilistic sensitivity analysis where each parameter had a random distribution. In their study, beta distribution and gamma distribution were used for probabilities and costs and reduced utility, respectively (21). Kildemoes and Kristiansen assessed one-by-one assumptions for sensitivity analysis, and The consequences were compared with the base case estimates of discounted cost/LY, alone and in combination. (24).

In Dixon et al. study, they conducted sensitivity analyses in the base case imputed cost effectiveness analysis and evaluated the base case imputed results for their sensitivity to self-reported secondary care use. (23). the quality-adjusted life year (QALY) (21-23, 25), GL (gained saved or deaths avoided), LY (life years gained in 5 years), Cost/LY (24) and cost (20, 22-25) are considered for the outcomes and cost effectiveness of interventions. In incremental cost-effectiveness ratio in studies, a digital health intervention to improve acute myocardial infarction can reduce costs by $ 10231.37 per patient (21), In Dixon et al. study, the incremental cost-effectiveness ratio is reported as 18655.17(23), In Denmark the incremental cost per life year gained was $113.3 (DKK 854,700) in 1999 (24). Quality of life has been measured with the EQ-5D-5L questionnaire (21-23), in one study, the SF-36 questionnaire was used (25).

Discussion

This systematic review is the first study that thoroughly investigates the economic aspects of telemedicine and its impact on the prevention, treatment, and rehabilitation of acute myocardial infarction. In this study, we considered the full economic evaluation methods, including cost-effectiveness and cost-utility in three areas cost, clinical outcomes, and willingness to pay. We explored all methods and devices of telemedicine for patients with acute myocardial infarction. The present study, which conducted a systematic review of 6 studies, indicated that telemedicine is useful and cost-effective but in some cases, it can cause an increase in costs and may not have a significant difference in effectiveness with other methods, and its use depends on the condition and stage of the disease than other conventional care services for patients with acute myocardial infarction. Cowie's study showed that telemedicine is a good method for patients with hypertension ,despite its high costs.it transfers care services from the hospital to home, reducing hospitalization costs, and enhancing the quality of life of patients with this diseases (26).

Besides, Digital Health Intervention (DHI) recovery in AMI was dominant and located in the zone 2 cost-effectiveness plane that shows reduced costs and increased QALYs. It reduces costs per patient by $10,231.37 and increases quality-adjusted survival by 0.80 QALYs (21). Contrary to the results of this study in cardiovascular diseases systematic review, the DHIs had higher QALY compared to usual care in all studies and ten studies reported an increase in costs and only five studies recorded a decrease. So the cost-effectiveness of the interventions was conditional on the willingness-to-pay threshold (27). In this regard, Treskes et al. concluded that smartphone e-health in post-AMI patients was cost effective, but because of its locating in zone 1 and increasing costs, it is recommended to use this method in places where there is no physical visit outside due to the increase in costs (25). Similar to the present study, Farabi et al. According to the study, the UK and New Zealand reported the highest and lowest values of the Incremental Cost-effectiveness Ratio, which were $515,082 and $2099, respectively. In the current study, the highest and lowest of these values were $18655.17 and $113.3 for the UK and Denmark, respectively (14).

Jiang et al. contrary to the present study reported the type of devices to deliver healthcare for cardiovascular disease patients. Short message service (1/14, 7%), telephone support (1/14, 7%), mobile app (1/14, 7%), video conferencing system (5/14, 36%), digital transmission of physiologic data (telemonitoring; 5/14, 36%), and wearable medical device (1/14, 7%) were the main methods for delivering healthcare. In 43% (6/14) of studies, the DHIs obtained higher QALYs with cost saving and in 57% (8/14) of studies, they got QALYs at a higher cost with an acceptable ICER (28).

Although in most articles, the results of tele-rehabilitation in heart patients had lower costs and in clinical effects had equal or higher effects, which can be said to be a cost-effective tool for the care of heart disease patients (29, 30) but in Brouwers study the cost of Cardiac Tele-rehabilitation (CTR) for the patients with coronary artery disease was higher compared to center-based Cardiac rehabilitation. However, CTR is cost-effective compared to center-based CR and can be more used in treatment (22). Tele-health for patients with raised cardiovascular disease risk is estimated to be cost effective at £20,000 per QALY (23). Kildemoes and Kristiansen compared reducing thrombolysis delay in patients with acute myocardial infarction using pre-hospital telemedicine with Current Presentation Delay and concluded that despite the reduction delay, there is a limited effect on mortality that depending on how the gained years are socially valued, telemedicine could be Cost-effectiveness (24).

In another study, Brunetti et al. triaged patients suspected of acute cardiac disease using a pre-hospital electrocardiogram (ECG) and compared them with conventional emergency department treatment. They found that 109750 ECGs have been sent and evaluated by telemedicine and 629 myocardial infarctions were identified and equivalent to 69 lives per year gained for at $3010.84 (1546.83 - 3918.63). It shows that pre-hospital telemedicine electrocardiogram triage can reduce up to 69 deaths per year and save $12.66 to $60 per EKG consultation (totals $1,393,330.64 to $6,592,574.28) (20). As found in one meta-analysis study, outside the hospital, ECG and advance notification in patients with acute myocardial infarction has reduced mortality and door to balloon and needle time, and it is recommended

to identify AMI patients using ECG (31). In Treskes et al. study (25) e-Health intervention was vs routine follow-up in individuals with acute myocardial infarction. This method consisted the blood pressure monitor, weight scale, electrocardiogram device, and step counter. They concluded that this intervention can be useful in post-MI patients and in environments without suitable facilities for clinic visits (25).

Because different factors are effective in cost effectiveness, such as age, gender, threshold values in different countries, disease epidemiology, methods of measuring cost and effectiveness, and costs of intervention and medical equipment are different in countries and should be taken into account for valuation (32, 33). Among the studies, a difference in willingness to pay threshold has been reported for the interventions. This difference was from 20,000 to 100,000, which 3 studies were close to 20,000 (22, 23, 25). Similar to the present study, Kruse et al. telemedicine was shown to be substantially linked with a reduction in hospitalizations and readmissions (45%). Better mortality and cost-effectiveness (both 40%) were also often reported, as were better health outcomes (35%) (28).

Mohammadzadeh et al. also concluded that tele-cardiology as one of the methods of telemedicine can aid in the early detection and treatment of cardiovascular disorders. It offers a high potential for lowering healthcare expenditures while improving quality of life and patient satisfaction (34). On the contrary, Snoswell et al. pointed out that Despite the fact that tele-health has overwhelmingly favorable patient benefits and boosts efficiency for many services, it fails to reduce the cost of care delivery for the health system routinely (35). Farabi et al., the future development of lower-cost telemedicine technologies, their implementation and follow-up over longer time periods, and an increase in the number of patients covered by this service will improve the cost-effectiveness of this technology over traditional care services (14). This conclusion can be similar to our study.

Limitations

The number of studies was limited and each intervention considered a specific indicator of acute myocardial infarction. Another limitation of this study is the inclusion of studies written in the English and Persian languages. The third limitation is that, this issue has not been studied in low-income countries and this makes it impossible to generalize the results of the cost and willingness to pay threshold to other countries, especially low-income countries.

Conclusion

This systematic review showed that telemedicine interventions can be effective in the fields of pre-hospital diagnosis using EKG, and patient recovery depending on the countries social values. The use of smart mobile phones has higher costs than other methods, which should be considered. Although telemedicine reduced the time for the patient to reach the needle, it was not very effective and should be investigated in future studies. According to the results, it is suggested that economic evaluation studies of telemedicine regarding acute myocardial infarction should also be conducted in low-income countries. It will provide the basis for conducting systematic review studies and comparing their results with the findings of similar studies in high-income countries. Also, the results of these studies can provide health managers and policymakers with the necessary telemedicine infrastructure and institutionalize its use in the pre-hospital system by healthcare workers and its acceptance by patients.

Authors' Contributions

Design and study team: Majid Abedinejad, Mohammad Hadian, Soudabe Behrooj, Saeed Bagheri Faradonbeh, Nadia Saniee. Conceptualization: Majid Abedinejad, Mohammad Hadian, Soudabe Behrooj, Saeed Bagheri Faradonbeh. Data management: Majid Abedinejad, Saeed Bagheri Faradonbeh, Nadia Saniee. Formal analysis: Majid Abedinejad, Saeed Bagheri Faradonbeh. Writing, reviewing, and editing: Majid Abedinejad, Soudabe Behrooj, Saeed Bagheri Faradonbeh.

Ethical Considerations

This study received ethical approval from the School of Health Management, Iran University of Medical Sciences (IR.IUMS.REC.1400.506).

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Conflict of Interests

The authors declare that they have no competing interests.

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Appendix 1. Search strategies

Database	Search strategy
PubMed	((Infarct*[tiab] AND Myocardial[tiab]) OR "Myocardial Infarct*"[tiab] OR "Cardiovascular Stroke*"[tiab] OR (Stroke*[tiab] AND Cardiovascular[tiab]) OR "Heart Attack*"[tiab] OR "Acute Coronary Syndrome*"[tiab] OR ("Coronary Syndrome*"[tiab] AND Acute[tiab]) OR (Syndrome*[tiab] AND "Acute Coronary"[tiab]) OR ACS[tiab] OR HF[tiab] OR "myocardial ischemia"[tiab] OR "coronary heart disease*"[tiab] OR "Coronary Disease*"[tiab] OR (Disease*[tiab] AND Coronary[tiab]) OR (Disease*[tiab] AND "Coronary Heart"[tiab]) OR ("Heart Disease*"[tiab] AND Coronary[tiab]) OR "Cardiac Failure"[tiab] OR "Heart Decompensation"[tiab] OR (Decompensation[tiab] AND Heart[tiab]) OR ("Heart Failure"[tiab] AND "Right-Sided"[tiab]) OR ("Heart Failure"[tiab] AND "Right Sided"[tiab]) OR "Right-Sided Heart Failure"[tiab] OR "Right Sided Heart Failure"[tiab] OR "Myocardial Failure"[tiab] OR "Congestive Heart Failure"[tiab] OR ("Heart Failure"[tiab] AND Congestive[tiab]) OR ("Heart Failure"[tiab] AND "Left-Sided"[tiab]) OR ("Heart Failure"[tiab] AND "Left Sided"[tiab]) OR "Left-Sided Heart Failure"[tiab] OR "Left Sided Heart Failure"[tiab] OR "heart disease*"[tiab]) AND ("Mobile Health"[tw] OR (Health[tiab] AND Mobile[tiab]) OR mHealth[tiab] OR Telehealth[tw] OR eHealth[tiab] OR telemedicine[tw] OR telecommunication[tiab] OR telemonitoring[tiab] OR teleradiology[tiab] OR telepathology[tiab] OR telerehabilitation[tiab] OR "remote consultation"[tw] OR teleconsultation[tiab] OR "Tele-rehabilitation*"[tiab] OR "Tele rehabilitation*"[tiab] OR "Remote Rehabilitation*"[tiab] OR "Virtual Rehabilitation*"[tiab] OR "telecardiology"[tw] OR "tele-cardiology"[tw] OR "tele-expertise in cardiology"[tw] OR "Tele-echocardiography"[tw] OR "Tele-Ultrasound"[tiab] OR "Tele-Echo"[tw] OR "tele emergency service*"[tiab] OR "tele-emergency service*"[tiab] OR "remote emergency service*"[tiab]) AND ((Analyses[tiab] AND "Cost-Benefit"[tiab]) OR (Analysis[tiab] AND "Cost-Benefit"[tiab]) OR "Cost-Benefit Analyses"[tiab] OR "Cost Benefit Analysis"[tiab] OR (Analyses[tiab] AND "Cost Benefit"[tiab]) OR (Analysis[tiab] AND "Cost Benefit"[tiab]) OR "Cost Benefit Analyses"[tiab] OR "Cost Effectiveness"[tiab] OR (Effectiveness[tiab] AND Cost[tiab]) OR "Cost-Benefit Data"[tiab] OR "Cost Benefit Data"[tiab] OR (Data[tiab] AND "Cost-Benefit"[tiab]) OR "Cost-Utility Analysis"[tiab] OR (Analyses[tiab] AND "Cost-Utility"[tiab]) OR (Analysis[tiab] AND "Cost-Utility"[tiab]) OR "Cost Utility Analysis"[tiab] OR "Cost-Utility Analyses"[tiab] OR "Economic Evaluation"[tiab] OR "Economic Evaluations"[tiab] OR (Evaluation[tiab] AND Economic[tiab]) OR (Evaluations[tiab] AND Economic[tiab]) OR "Marginal Analysis"[tiab] OR (Analyses[tiab] AND Marginal[tiab]) OR (Analysis[tiab] AND Marginal[tiab]) OR "Marginal Analyses"[tiab] OR "Cost Benefit"[tiab] OR "Costs and Benefits"[tiab] OR "Benefits and Costs"[tiab] OR "Cost-Effectiveness Analysis"[tiab] OR (Analysis[tiab] AND "Cost-Effectiveness"[tiab]) OR "Cost Effectiveness Analysis"[tiab]) AND 2000:2022[dp]
Scopus	((TITLE-ABS-KEY(Infarct*) AND TITLE-ABS-KEY(Myocardial)) OR TITLE-ABS-KEY("Myocardial Infarct*") OR TITLE-ABS-KEY("Cardiovascular Stroke*") OR (TITLE-ABS-KEY(Stroke*) AND TITLE-ABS-KEY(Cardiovascular)) OR TITLE-ABS-KEY("Heart Attack*") OR TITLE-ABS-KEY("Acute Coronary Syndrome*") OR (TITLE-ABS-KEY("Coronary Syndrome*") AND TITLE-ABS-KEY(Acute)) OR (TITLE-ABS-KEY(Syndrome*) AND TITLE-ABS-KEY("Acute Coronary")) OR TITLE-ABS-KEY(ACS) OR TITLE-ABS-KEY(HF) OR TITLE-ABS-KEY("myocardial ischemia") OR TITLE-ABS-KEY("coronary heart disease*") OR TITLE-ABS-KEY("Coronary Disease*") OR (TITLE-ABS-KEY(Disease*) AND TITLE-ABS-KEY(Coronary)) OR (TITLE-ABS-KEY(Disease*) AND TITLE-ABS-KEY("Coronary Heart")) OR (TITLE-ABS-KEY("Heart Disease*") AND TITLE-ABS-KEY(Coronary)) OR TITLE-ABS-KEY("Cardiac Failure") OR TITLE-ABS-KEY("Heart Decompensation") OR (TITLE-ABS-KEY(Decompensation) AND TITLE-ABS-KEY(Heart)) OR (TITLE-ABS-KEY("Heart Failure") AND TITLE-ABS-KEY("Right-Sided")) OR (TITLE-ABS-KEY("Heart Failure") AND TITLE-ABS-KEY("Right Sided")) OR TITLE-ABS-KEY("Right-Sided Heart Failure") OR TITLE-ABS-KEY("Right Sided Heart Failure") OR TITLE-ABS-KEY("Myocardial Failure") OR TITLE-ABS-KEY("Congestive Heart Failure") OR (TITLE-ABS-KEY("Heart Failure") AND TITLE-ABS-KEY(Congestive)) OR (TITLE-ABS-KEY("Heart Failure") AND TITLE-ABS-KEY("Left-Sided")) OR (TITLE-ABS-KEY("Heart Failure") AND TITLE-ABS-KEY("Left Sided")) OR TITLE-ABS-KEY("Left-Sided Heart Failure") OR TITLE-ABS-KEY("Left Sided Heart Failure") OR TITLE-ABS-KEY("heart disease*")) AND (TITLE-ABS-KEY("Mobile Health") OR (TITLE-ABS-KEY(Health) AND TITLE-ABS-KEY(Mobile)) OR TITLE-ABS-KEY(mHealth) OR TITLE-ABS-KEY(Telehealth) OR TITLE-ABS-KEY(eHealth) OR TITLE-ABS-KEY(telemedicine) OR TITLE-ABS-KEY(telecommunication) OR TITLE-ABS-KEY(telemonitoring) OR TITLE-ABS-KEY(teleradiology) OR TITLE-ABS-KEY(telepathology) OR TITLE-ABS-KEY(telerehabilitation) OR TITLE-ABS-KEY("remote consultation") OR TITLE-ABS-KEY(teleconsultation) OR TITLE-ABS-KEY("Tele-rehabilitation*") OR TITLE-ABS-KEY("Tele rehabilitation*") OR TITLE-ABS-KEY("Remote Rehabilitation*") OR TITLE-ABS-KEY("Virtual Rehabilitation*") OR TITLE-ABS-KEY("telecardiology") OR TITLE-ABS-KEY("tele-cardiology") OR TITLE-ABS-KEY("tele-expertise in cardiology") OR TITLE-ABS-KEY("Tele-echocardiography") OR TITLE-ABS-KEY("Tele-Ultrasound") OR TITLE-ABS-KEY("Tele-Echo") OR TITLE-ABS-KEY("tele emergency service*") OR TITLE-ABS-KEY("tele-emergency service*") OR TITLE-ABS-KEY("remote emergency service*")) AND ((TITLE-ABS-KEY(Analyses) AND TITLE-ABS-KEY("Cost-Benefit")) OR (TITLE-ABS-KEY(Analysis) AND TITLE-ABS-KEY("Cost-Benefit")) OR TITLE-ABS-KEY("Cost-Benefit Analyses") OR TITLE-ABS-KEY("Cost Benefit Analysis") OR (TITLE-ABS-KEY(Analyses) AND TITLE-ABS-KEY("Cost Benefit")) OR (TITLE-ABS-KEY(Analysis) AND TITLE-ABS-KEY("Cost Benefit")) OR TITLE-ABS-KEY("Cost Benefit Analyses") OR TITLE-ABS-KEY("Cost Effectiveness") OR (TITLE-ABS-KEY(Effectiveness) AND TITLE-ABS-KEY(Cost)) OR TITLE-ABS-KEY("Cost-Benefit Data") OR TITLE-ABS-KEY("Cost Benefit Data") OR (TITLE-ABS-KEY(Data) AND TITLE-ABS-KEY("Cost-Benefit")) OR TITLE-ABS-KEY("Cost-Utility Analysis") OR (TITLE-ABS-KEY(Analyses) AND TITLE-ABS-KEY("Cost-Utility")) OR (TITLE-ABS-KEY(Analysis) AND TITLE-ABS-KEY("Cost-Utility")) OR TITLE-ABS-KEY("Cost Utility Analysis") OR TITLE-ABS-KEY("Cost-Utility Analyses") OR TITLE-ABS-KEY("Economic Evaluation") OR TITLE-ABS-KEY("Economic Evaluations") OR (TITLE-ABS-KEY(Evaluation) AND TITLE-ABS-KEY(Economic)) OR (TITLE-ABS-KEY(Evaluations) AND TITLE-ABS-KEY(Economic)) OR TITLE-ABS-KEY("Marginal Analysis") OR (TITLE-ABS-KEY(Analyses) AND TITLE-ABS-KEY(Marginal)) OR (TITLE-ABS-KEY(Analysis) AND TITLE-ABS-KEY(Marginal)) OR TITLE-ABS-KEY("Marginal Analyses") OR TITLE-ABS-KEY("Cost Benefit") OR TITLE-ABS-KEY("Costs and Benefits") OR TITLE-ABS-KEY("Benefits and Costs") OR TITLE-ABS-KEY("Cost-Effectiveness Analysis") OR (TITLE-ABS-KEY(Analysis) AND TITLE-ABS-KEY("Cost-Effectiveness")) OR TITLE-ABS-KEY("Cost Effectiveness Analysis")) AND time span(2000-2022)

Appendix 1. Search strategies

Database	Search strategy
Web of Science	((TS=(Infarct*) AND TS=(Myocardial)) OR TS=("Myocardial Infarct*") OR TS=("Cardiovascular Stroke*") OR (TS=(Stroke*) AND TS=(Cardiovascular)) OR TS=("Heart Attack*") OR TS=("Acute Coronary Syndrome*") OR (TS=("Coronary Syndrome*") AND TS=(Acute)) OR (TS=(Syndrome*) AND TS=("Acute Coronary")) OR TS=(ACS) OR TS=(HF) OR TS=("myocardial ischemia") OR TS=("coronary heart disease*") OR TS=("Coronary Disease*") OR (TS=(Disease*) AND TS=(Coronary)) OR (TS=(Disease*) AND TS=("Coronary Heart")) OR (TS=("Heart Disease*") AND TS=(Coronary)) OR TS=("Cardiac Failure") OR TS=("Heart Decompensation") OR (TS=(Decompensation) AND TS=(Heart)) OR (TS=("Heart Failure") AND TS=("Right-Sided")) OR (TS=("Heart Failure") AND TS=("Right Sided")) OR TS=("Right-Sided Heart Failure") OR TS=("Right Sided Heart Failure") OR TS=("Myocardial Failure") OR TS=("Congestive Heart Failure") OR (TS=("Heart Failure") AND TS=(Congestive)) OR (TS=("Heart Failure") AND TS=("Left-Sided")) OR (TS=("Heart Failure") AND TS=("Left Sided")) OR TS=("Left-Sided Heart Failure") OR TS=("Left Sided Heart Failure") OR TS=("heart disease*")) AND (TS=("Mobile Health") OR (TS=(Health) AND TS=(Mobile)) OR TS=(mHealth) OR TS=(Telehealth) OR TS=(eHealth) OR TS=(telemedicine) OR TS=(telecommunication) OR TS=(telemonitoring) OR TS=(teleradiology) OR TS=(telepathology) OR TS=(telerehabilitation) OR TS=("remote consultation") OR TS=(teleconsultation) OR TS=("Tele-rehabilitation*") OR TS=("Tele rehabilitation*") OR TS=("Remote Rehabilitation*") OR TS=("Virtual Rehabilitation*") OR TS=("telecardiology") OR TS=("tele-cardiology") OR TS=("tele-expertise in cardiology") OR TS=("Tele-echocardiography") OR TS=("Tele-Ultrasound") OR TS=("Tele-Echo") OR TS=("tele emergency service*") OR TS=("tele-emergency service*") OR TS=("remote emergency service*")) AND ((TS=(Analyses) AND TS=("Cost-Benefit")) OR (TS=(Analysis) AND TS=("Cost-Benefit")) OR TS=("Cost-Benefit Analyses") OR TS=("Cost Benefit Analysis") OR (TS=(Analyses) AND TS=("Cost Benefit")) OR (TS=(Analysis) AND TS=("Cost Benefit")) OR TS=("Cost Benefit Analyses") OR TS=("Cost Benefit Analyses") OR TS=("Cost Effectiveness") OR (TS=(Effectiveness) AND TS=(Cost)) OR TS=("Cost-Benefit Data") OR TS=("Cost Benefit Data") OR (TS=(Data) AND TS=("Cost-Benefit")) OR TS=("Cost-Utility Analysis") OR (TS=(Analyses) AND TS=("Cost-Utility")) OR (TS=(Analysis) AND TS=("Cost-Utility")) OR TS=("Cost Utility Analysis") OR TS=("Cost-Utility Analyses") OR TS=("Economic Evaluation") OR TS=("Economic Evaluations") OR (TS=(Evaluation) AND TS=(Economic)) OR (TS=(Evaluations) AND TS=(Economic)) OR TS=("Marginal Analysis") OR (TS=(Analyses) AND TS=(Marginal)) OR (TS=(Analysis) AND TS=(Marginal)) OR TS=("Marginal Analyses") OR TS=("Cost Benefit") OR TS=("Costs and Benefits") OR TS=("Benefits and Costs") OR TS=("Cost-Effectiveness Analysis") OR (TS=(Analysis) AND TS=("Cost-Effectiveness")) OR TS=("Cost Effectiveness Analysis"))
Proquest	TI,AB,SU((Infarct* AND Myocardial) OR "Myocardial Infarct*" OR "Cardiovascular Stroke*" OR (Stroke* AND Cardiovascular) OR "Heart Attack*" OR "Acute Coronary Syndrome*" OR ("Coronary Syndrome*" AND Acute) OR (Syndrome* AND "Acute Coronary") OR ACS OR HF OR "myocardial ischemia" OR "coronary heart disease*" OR "Coronary Disease*" OR (Disease* AND Coronary) OR (Disease* AND "Coronary Heart") OR ("Heart Disease*" AND Coronary) OR "Cardiac Failure" OR "Heart Decompensation" OR (Decompensation AND Heart) OR ("Heart Failure" AND "Right-Sided") OR ("Heart Failure" AND "Right Sided") OR "Right-Sided Heart Failure" OR "Right Sided Heart Failure" OR "Myocardial Failure" OR "Congestive Heart Failure" OR ("Heart Failure" AND Congestive) OR ("Heart Failure" AND "Left-Sided") OR ("Heart Failure" AND "Left Sided") OR "Left-Sided Heart Failure" OR "Left Sided Heart Failure" OR "heart disease*") AND TI,AB,SU("Mobile Health" OR (Health AND Mobile) OR mHealth OR Telehealth OR eHealth OR telemedicine OR telecommunication OR telemonitoring OR teleradiology OR telepathology OR telerehabilitation OR "remote consultation" OR teleconsultation OR "Tele-rehabilitation*" OR "Tele rehabilitation*" OR "Remote Rehabilitation*" OR "Virtual Rehabilitation*" OR "telecardiology" OR "tele-cardiology" OR "tele-expertise in cardiology" OR "Tele-echocardiography" OR "Tele-Ultrasound" OR "Tele-Echo" OR "tele emergency service*" OR "tele-emergency service*" OR "remote emergency service*") AND TI,AB,SU((Analyses AND "Cost-Benefit") OR (Analysis AND "Cost-Benefit") OR "Cost-Benefit Analyses" OR "Cost Benefit Analysis" OR (Analyses AND "Cost Benefit") OR (Analysis AND "Cost Benefit") OR "Cost Benefit Analyses" OR "Cost Effectiveness" OR (Effectiveness AND Cost) OR "Cost-Benefit Data" OR "Cost Benefit Data" OR (Data AND "Cost-Benefit") OR "Cost-Utility Analysis" OR (Analyses AND "Cost-Utility") OR (Analysis AND "Cost-Utility") OR "Cost Utility Analysis" OR "Cost-Utility Analyses" OR "Economic Evaluation" OR "Economic Evaluations" OR (Evaluation AND Economic) OR (Evaluations AND Economic) OR "Marginal Analysis" OR (Analyses AND Marginal) OR (Analysis AND Marginal) OR "Marginal Analyses" OR "Cost Benefit" OR "Costs and Benefits" OR "Benefits and Costs" OR "Cost-Effectiveness Analysis" OR (Analysis AND "Cost-Effectiveness") OR "Cost Effectiveness Analysis")
Google Scholar	Allintitle=heart, cost, cardiac, Myocardial, coronary, telemedicine, ehealth, mhealth, mobile health, telerehabilitation, tele
Iranian databases (SID, Magiran)	Persian equivalents of heart, cost, cardiac, Myocardial, coronary, telemedicine, ehealth, mhealth, mobile health, telerehabilitation, tele