Dissertation Training

at

International Institute of Health Management Research

COST-EFFECTIVENESS OF DIGITAL HEALTH INTERVENTIONS IN CARDIOVASCULAR DISEASE MANAGEMENT: A NARRATIVE REVIEW

by

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PG/22/080

Under the guidance of

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PGDM (Hospital and Health Management)

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The certificate is awarded to

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A NARRATIVE REVIEW

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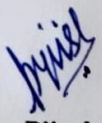

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The dissertation is in fulfilment of the course requirements.

I wish her all success in all her future endeavours.

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CERTIFICATE OF APPROVAL

The following dissertation titled "**COST-EFFECTIVENESS OF DIGITAL HEALTH INTERVENTIONS IN CARDIOVASCULAR DISEASE MANAGEMENT: A NARRATIVE REVIEW**" at **International Institute of Health Management Research, New Delhi** is hereby approved as a certified study in management carried out and presented in a manner satisfactorily to warrant its acceptance as a prerequisite for the award of PGDM (Hospital & Health Management) for which it has been submitted. It is understood that by this approval, the undersigned do not necessarily endorse or approve any statement made, opinion expressed or conclusion drawn therein, but approve the dissertation only for the purpose it is submitted.

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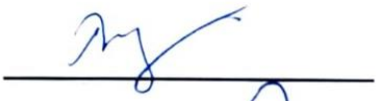
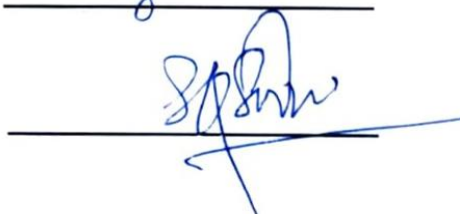
Dr. Nishita Bee	
Dr. Sumant Swain	

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This is to certify that **Mrs. Prateeksha Yadav,** a graduate student of the **PGDM (Hospital & Health Management)** has worked under our guidance and supervision. She is submitting this dissertation titled **"COST-EFFECTIVENESS OF DIGITAL HEALTH INTERVENTIONS IN CARDIOVASCULAR DISEASE MANAGEMENT: A NARRATIVE REVIEW"** at the **International Institute of Health Management Research, New Delhi** in partial fulfilment of the requirements for the award of the **PGDM (Hospital & Health Management.**

This dissertation has the requisite standard and to the best of our knowledge no part of it has been reproduced from any other dissertation, monograph, report or book.

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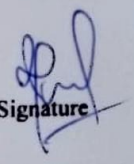

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Mrs. Prateeksha Yadav

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Name of the Organisation in Which Dissertation Has Been Completed:

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Area of Dissertation: "Cost Effectiveness of Digital Health Interventions for CVD management: A Narrative Review".

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Strengths: dedicated, hardworking

Suggestions for Improvement: Be more proactive

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I fall short of words whenever I want to express my feelings towards my parents, **Mr. S.B. Yadav**, **Mrs. Kiran Yadav**, **Dr. Chitranjan Verma** and **Dr. Mridula Verma**. Their constant, undemanding love, sacrifice, dedication, and prayers have helped me achieve whatever I am today.

My brother, **Dr. Suhang Verma**, and sister-in-law, **Dr. Deepmala Modi**, thank you for being a solid and constant support system.

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LIST OF ABBREVIATIONS

S.NO.	ABBREVIATIONS	FULL FORM
1.	IIHMR	International Institute of Health Management Research
2.	DHI	Digital Health Intervention
3.	CVD	Cardiovascular Disease
4.	TM	Telemonitoring
5.	HF	Heart Failure
6.	CHD	Coronary Heart Disease
7.	HTA	Health Technology Assessment
8.	QALY	Quality-Adjusted Life Year

9.	ICER	Incremental Cost-Effectiveness Ratio
10.	WTP	Willingness To Pay
11.	CR	Cardiac Rehabilitation
12.	RPM	Remote Patient Monitoring
13.	ECG	Electro-Cardiography
14.	CHF	Chronic Heart Failure
15.	PRISMA	Preferred Reporting Items for Systematic Review and Meta Analyses
16.	RCT	Randomised Controlled Trial
17.	HTM	Home Telemonitoring

CHAPTER 1

OVERVIEW OF THE ORGANISATION

1.1 INTRODUCTION

In 2008, IIHMR University launched the International Institute of Health Management Research (IIHMR), New Delhi. Under the Societies Registration Act of 1958, IIHMR University was established in October 1984. IIHMR Delhi is critical to the optimal function of healthcare sector both in India and in the Asia-Pacific region, especially in response to the growing demands of sustainable operation and administration solutions.

IIHMR Delhi is an institute of higher education that promotes research in the field of health and hospital management; helps develop expertise to formulation of policies; develops strategies and their effective implementation; promotes individual and institutional abilities to build a robust and efficient healthcare domain. Capacity building is not just limited to academic programs, but the multi-dimensional approach expands to management development programs, knowledge-based and skills-based training and development courses, research studies seminars/webinars and workshops.

1.2 FOUR CORE ACTIVITIES

- Academic postgraduate and doctoral courses in health and hospital management to meet in response to the emerging needs of the industry.
- Research related to the framing of health policies and programs at national and global level.
- Management development programs to provide continued education and executive programs for working professionals to help them enhance their knowledge and

upgrade their skills in response to the increasing demand of highly skilled healthcare professionals.

- Technical consultations on the flagship programs at state and national level to address the gaps in planning as well as strategizing.

1.3 FEATURES OF THE ORGANIZATION

The Institute is an autonomous body of international stature with the vision to shape tomorrow's healthcare and has been developing leaders for several years by educating students in the fields of health, hospital, and health information technology. Over the years, IlHMR-Delhi has made its name as the national and global platform for carving out skilled and vibrant, socially aware healthcare management professionals. The institute has progressed as a leader in research, capacity building, community programs, and policy framing in the field of health care. Through its cutting-edge academic program, infrastructure accomplished by multidisciplinary faculty, and research, IIHMR has carved out a space for itself.

1.4 AIM OF THE ORGANIZATION

IIHMR emphasizes the management aspects of health care, equipping students with skills in strategic planning, operations management, human resources management, and organizational behavior specifically tailored for the healthcare industry. The institute's research programs cover health systems management, which includes understanding the structure, functions, and governance of health systems, as well as policies and regulations that govern the delivery of health care services. IIHMR's programs offer training in hospital administration, covering topics such as hospital operations management, quality management, patient safety, and health care accreditation. The institute provides insights

into healthcare financing, including health insurance systems, reimbursement mechanisms, health economics, and cost-effectiveness analysis in healthcare.

With the growing importance of information technology in health care, IIHMR offers training in health information systems, health data management, health analytics, and the use of technology to improve health care delivery. IIHMR incorporates economic training into their programs to develop an understanding of economic principles and their applications in health care decision-making, resource allocation, and health care policy analysis.

Several governmental and civil society organizations have contacted the IIHMR to offer technical assistance for capacity building and policy research requirements that will lead to the creation of creative and equitable health care solutions. Overall, IIHMR-Delhi strives to bridge the gap between theory and practice in health management by offering a comprehensive range of educational programs, conducting research, and providing support in policy formulation and implementation. They aim to strengthen health systems, improve health care delivery, and contribute to the overall advancement of the health care sector. IIHMR engages in research and advocacy activities to support the development and implementation of effective health policies and plans. They work towards promoting evidence-based decision-making, fostering collaborations with stakeholders, and advocating for equitable and sustainable health systems. Threats to the public health, natural disasters, armed conflicts, and related humanitarian crises are all addressed by IIHMR. This involves conducting research, providing technical expertise, and offering support in areas such as emergency preparedness, disaster management, and health system resilience. In addition to their Masters and doctoral programs, IIHMR-Delhi offers highly specialized and popular Management Development Programs (MDP). These programs are designed to cater to the educational needs of health professionals, both in-service aspirants and those from the country and overseas. The MDPs cover various topics

in health management and provide practical knowledge and skills to enhance leadership and management capabilities.

1.5 MISSION

IIHMR Delhi conducts research to generate knowledge and insights into health management practices and challenges. Their research activities contribute to evidence-based decision-making, policy formulation, and the development of innovative solutions for improving health care delivery. The institute provides training programs to develop skilled professionals who can effectively manage health care systems and programs. Their training programs cover a wide range of topics, including health management, health systems, hospital administration, health economics, and information technology, among others.

IIHMR Delhi offers consultancy services to organizations in the health care sector. They provide expertise, guidance, and solutions to address specific challenges and improve management practices. Their consultations may include areas such as strategic planning, process optimization, quality improvement, and operational efficiency. IIHMR Delhi actively engages in institutional networking at national and global levels. They collaborate with other organizations, academic institutions, and international bodies to exchange knowledge, share best practices, and foster collaborations in the field of health management. This networking helps in keeping pace with global developments, adapting to emerging trends, and promoting knowledge sharing. By focusing on research, training, consultation, and institutional networking, IIHMR Delhi strives to contribute to the improvement of health care management and overall health standards, both at the national and global levels.

1.6 VISION

IIHMR is a premier institute dedicated to contributing to social equity and development by supporting programs aimed at the poor and deprived populations. Through its educational, research, and consulting initiatives, the institute aims to improve the health and well-being of marginalized communities and address healthcare disparities. IIHMR offers postgraduate and doctoral programs to meet the increasing demand for healthcare professionals in the field of public health, both at the national and global levels. These programs provide comprehensive education and training to equip students with the knowledge and skills necessary to address complex health challenges. IlHMR recognizes the importance of continuous learning and offers operational management development programs and administrative programs for working professionals. These programs enable healthcare professionals to upgrade their knowledge and expertise, keeping them abreast of the latest developments and trends in the healthcare industry. IIHMR places a strong emphasis on knowledge dissemination. The institute actively shares research findings, best practices, and expertise with the broader healthcare community. By disseminating knowledge and information, IIHMR aims to contribute to evidence-based decision-making and the advancement of healthcare management practices. IIHMR's commitment to quality, responsibility, trust, transparency, and the dissemination of knowledge and information is reflected in its efforts to enhance healthcare management education, research, and program management. Through its initiatives, the institute strives to make a meaningful impact on social equity, support under-served populations, and improve the overall healthcare sector, both nationally and globally.

CHAPTER 2

PROJECT OUTLINE

BACKGROUND

Digital health interventions (DHIs) signify a groundbreaking fusion of technology and healthcare, designed to improve patient care by increasing accessibility, reducing costs, and providing personalized treatment options.(1) In the realm of cardiovascular diseases (CVDs), a significant global health issue, the potential benefits of digital health interventions (DHIs) have been explored in clinical trials. For example, telemonitoring (TM) has been shown to notably decrease all-cause mortality and heart failure (HF)-related events in patients with heart failure.(2) Likewise, an internet-based expert system called CardioFit has been found to enhance physical activity levels in patients suffering from coronary heart disease (CHD).(3)A meta-analysis supported these findings, showing a decrease in cardiovascular event rates and better management of risk factors for CVDs through DHIs. Despite these benefits, the cost-effectiveness of DHIs is still under examination, with research emphasizing the need for health technology assessments (HTAs) to provide decision-makers with insights into their clinical and economic impacts.(4)

OBJECTIVE

1. Identify and synthesize existing evidence on the cost-effectiveness of DHIs in managing various cardiovascular conditions.
2. Analyze the types of DHIs evaluated, the targeted cardiovascular diseases, and the main findings regarding cost-effectiveness outcomes.
3. Identify research gaps and areas for future investigation in the cost-effectiveness of DHIs for CVD management.

RESEARCH QUESTION:

What is the cost-effectiveness of various digital health interventions (DHIs) in the management of various cardiovascular diseases (CVDs), and what research gaps exist for further exploration in this area?

METHODOLOGY:

SEARCH STRATEGY: A comprehensive literature search will be conducted in electronic databases including Embase, Scopus, PubMed and Google scholar. The search strategy will incorporate keywords related to digital health interventions, cardiovascular diseases, and health economic evaluation. The search will be limited to studies published from January 2011 onwards. Additionally, manual searches of reference lists of relevant articles and systematic reviews will be performed.

INCLUSION AND EXCLUSION CRITERIA: Full-text journal articles in English will be included if they meet the following criteria:

Target population: Patients with cardiovascular diseases.

Intervention: Digital health interventions aimed at promoting or delivering clinical interventions for cardiovascular conditions.

Comparison: Comparison with conventional care or other digital health interventions.

Outcome: Full-scale health economic evaluation conducted as a cost-effectiveness analysis, cost-utility analysis, cost-benefit analysis, or cost-consequence analysis.

STUDY SELECTION: After removing duplicates, titles and abstracts will be screened for eligibility. Full texts of potentially eligible articles will then be reviewed for verification.

DATA EXTRACTION:

A data extraction form will be used to collect relevant information from the included studies. Data items will include general study information, study characteristics, methodology details, and a summary of findings. The primary outcome of interest will be the cost-effectiveness of DHIs.

DATA ANALYSIS AND PRESENTATION:

A descriptive synthesis of the included studies will be provided, summarizing the types of DHIs evaluated, targeted cardiovascular diseases, modelling methods, perspectives, time horizons, and main cost-effectiveness outcomes. The number of studies included and excluded during the selection process will be presented in a flowchart. Additionally, the methodological quality of the included studies and the cost-effectiveness outcomes will be summarized.

EXPECTED OUTCOME:

Synthesis of evidence on the cost-effectiveness of digital health technologies in cardiovascular disease management.

Identification of factors influencing the cost-effectiveness of digital health technologies and areas for further research.

TIME FRAME:

3 months

ETHICAL CONSIDERATION:

Since the data is collected from secondary data sources, ethical clearance for data collection was waived. The study has been approved by the IIHMR Institutional Scientific Review Board.

ABSTRACT

Digital health interventions (DHIs) are revolutionizing the intersection of technology and healthcare by aiming to enhance patient care through better access, cost efficiency, and tailored treatment.(1) In the realm of cardiovascular diseases (CVDs), which is a significant global health challenge, DHIs have demonstrated considerable promise in clinical research. For example, telemonitoring (TM) has been linked with lower all-cause mortality rates and fewer heart failure (HF)-related incidents among HF patients,(2)while the internet-based system CardioFit has been effective in boosting physical activity levels in individuals with coronary heart disease (CHD).(3)A comprehensive meta-analysis supports these findings, showing that DHIs can decrease cardiovascular event rates and improve various CVD risk factors. Nevertheless, the cost-effectiveness of DHIs is still being debated, emphasizing the need for thorough health technology assessments (HTAs) to guide decision-makers on their clinical and economic value. (4)

This study aims to identify and synthesize existing evidence on the cost-effectiveness of DHIs in managing various cardiovascular conditions, analyze the types of DHIs evaluated, and identify research gaps for future investigation. A comprehensive literature search will be conducted in electronic databases including Embase, Scopus, PubMed, and Google Scholar, focusing on studies published from January 2011 onwards. Data will be extracted and summarized to provide a descriptive synthesis of the cost-effectiveness outcomes. The expected outcomes include a synthesis of evidence on the cost-effectiveness of digital health technologies in CVD management, and identification of factors influencing their cost-effectiveness and areas for further research.

CHAPTER 3

INTRODUCTION

In a society that is rapidly advancing, digital technology is pivotal in enhancing human health and overall well-being. It is essential to continually assess both its effectiveness and efficiency. According to the World Health Organization (WHO), eHealth is defined as "the cost-effective and secure application of information and communication technologies to support health and health-related activities, including healthcare services, health monitoring, health literature, and health education, as well as knowledge and research."(5)Digital health technology encompasses diverse domains including e-learning, telemedicine, mobile health, and health information systems. It also leverages innovations in related fields such as artificial intelligence, big data analytics, and genomics, which enhance the ability to store and rapidly analyze health-related information. (6) This ability is especially valuable for developing data-driven analytical models that enhance safety, manage clinical risks, and improve the quality of healthcare services.(7)Cardiovascular diseases (CVDs) are responsible for 17.9 million deaths annually, representing 31% of global mortality.(8)Throughout the COVID-19 pandemic, digital health technologies proved effective in contact tracing, managing isolation, enhancing primary care, and facilitating communication between the public and authorities.(9)Nations such as South Korea, which have well-developed digital health infrastructures, demonstrated the significant role these technologies can play in handling public health emergencies. (10)

As the reliance on digital health interventions (DHIs) grows, evaluating their economic impact becomes essential. Health economic evaluations offer important insights into the cost-effectiveness of these technologies, aiding clinicians, patients, and payers in making informed decisions. Health technology assessment (HTA), which employs decision-

analytic modeling, integrates evidence on the cost-effectiveness of health technologies and interventions.(4)Despite their advantages, many healthcare facilities and services face challenges in evaluating the cost-effectiveness of various digital health solutions. The lack of standardized tools for comparative analysis highlights the need for robust evidence to navigate the swiftly evolving digital health field.(11)Although initial implementation costs of DHIs can be high, their widespread adoption can be achieved at relatively low costs once established.(12)The cost-effectiveness of DHIs is influenced by the balance between their clinical and economic benefits, implementation costs, and the payer's willingness-to-pay threshold. (13)

The aim of this study is to conduct a systematic review of the cost-effectiveness of digital health interventions (DHIs) in treating cardiovascular diseases (CVDs). This review will assess the impact of DHIs on standardized indicators, such as Quality Adjusted Life Years (QALYs), and healthcare expenditure, using the Median-Based Incremental Cost-Effectiveness Ratio (ICER). By evaluating the economic outcomes of DHIs, this study seeks to provide a comprehensive understanding of their value in CVD management, thereby informing policy and decision-making processes in healthcare systems.

OBJECTIVE

1. To identify and synthesize existing evidence on the cost-effectiveness of DHIs in managing various cardiovascular conditions.
2. To analyze the types of DHIs evaluated, the targeted cardiovascular diseases, and the main findings regarding cost-effectiveness outcomes.
3. To identify research gaps and areas for future investigation in the cost-effectiveness of DHIs for CVD management.

CHAPTER 4

REVIEW OF LITERATURE

Digital health embodies the integration of science and technology with aspects of health, healthcare, daily living, and society. It covers a range of areas, including mobile health, telemedicine, telehealth, health information technology, wearable devices, and personalized medicine. The goal of digital health interventions (DHIs) is to improve access to care, lower costs, tailor treatments to individual needs, and enhance patient outcomes.(1)

DIGITAL HEALTH INTERVENTIONS AND CARDIOVASCULAR DISEASES

Cardiovascular diseases (CVDs) are responsible for a substantial share of global mortality, with 17.9 million deaths each year, representing 31% of all deaths.(8) Research has explored various digital health interventions (DHIs) for their potential in managing CVDs. For instance, telemonitoring (TM) has been effective in significantly lowering all-cause mortality and reducing heart-failure-related events among heart failure patients.(2)Additionally, the CardioFit internet-based expert system has been shown to enhance physical activity and improve the quality of life related to health in patients with coronary heart disease.(3)A meta-analysis of 51 studies confirmed that DHIs have a beneficial impact on cardiovascular events and control of risk factors. (14)

HEALTH ECONOMIC OUTCOMES OF DIGITAL HEALTH INTERVENTIONS

Assessing the health economic outcomes of digital health interventions (DHIs) is essential for understanding their impact on managing cardiovascular diseases (CVDs). Health technology assessment (HTA) using decision-analytic modeling consolidates cost-effectiveness data on health technologies and interventions, guiding healthcare policy and decision-making.(15)While the initial implementation costs of DHIs can be high, their

widespread adoption can be achieved at relatively low costs once they are in place.(16) The cost-effectiveness of DHIs hinges on a balance between clinical and economic advantages, implementation expenses, and the willingness-to-pay (WTP) thresholds set by payers. Previous HTA research has highlighted a scarcity of health economic studies on DHIs, although some DHIs have been found to reduce overall costs. (17)

TELEREHABILITATION IN CARDIOVASCULAR DISEASE MANAGEMENT

Cardiac rehabilitation (CR) plays a crucial role in secondary prevention for patients with cardiovascular diseases (CVDs), leading to notable reductions in morbidity and mortality while enhancing quality of life. Despite its benefits, obstacles such as low health literacy, transportation issues, and scheduling conflicts often limit participation in CR programs.(18)Telerehabilitation, which incorporates digital tools like smartphone apps and teleconsultations, addresses these challenges by facilitating remote monitoring and feedback. This approach helps improve self-management skills and supports lasting behavioral changes.(19)Research indicates that telerehabilitation is as effective as traditional center-based CR, offering comparable healthcare costs while improving accessibility and engagement. (20)

REMOTE PATIENT MONITORING IN CARDIOVASCULAR DISEASE MANAGEMENT

Remote patient monitoring (RPM) systems gather physiological data that is compatible with hospital medical equipment, enabling at-home healthcare for patients with chronic conditions.(21) For example, the Qilu Hospital of Shandong University has implemented a remote mobile monitoring center that utilizes mobile devices and landlines to transmit ECG data for ongoing real-time analysis and observation.(22) RPM and telemedicine technologies, such as portable biometric devices and SMS-based messaging systems, enhance the management of cardiovascular diseases (CVDs) by facilitating remote

consultations, monitoring, and treatment. (23) Telemedicine has been demonstrated to lower medical costs, improve quality of life, and boost mental health by decreasing hospitalizations and providing continuous monitoring of conditions. (24)

DIGITAL HEALTH INTERVENTIONS FOR STROKE AND HEART FAILURE MANAGEMENT

Stroke is a leading cause of death and disability, significantly affecting both individuals and society. Digital health interventions (DHIs), such as online programs and remote monitoring of vital signs, have demonstrated potential benefits in managing blood pressure and improving cardiovascular outcomes for stroke survivors. Despite these advantages, the adoption of such interventions in clinical settings remains limited, underscoring the need for thorough economic evaluations.(25)

Chronic heart failure (CHF) places a substantial strain on healthcare systems and society due to high readmission rates and associated costs.(26) Digital health interventions (DHIs) such as telemonitoring allow for daily remote monitoring, enabling early detection of clinical deterioration and prompt interventions.(27)Research has shown that telemonitoring can lead to fewer days lost to unplanned cardiovascular admissions, lower all-cause mortality, and improved self-management among CHF patients.(28) Despite these encouraging clinical results, there is a lack of comprehensive economic evaluations of DHIs for CHF management, highlighting the need for further research. (29)

The adoption of digital health technologies in managing cardiovascular diseases has the potential to significantly enhance clinical outcomes, improve patient self-management, and reduce healthcare costs.(17)However, economic evaluations of these interventions are still limited, pointing to the necessity for detailed studies to guide policy and decision-making within healthcare systems.(30)Additional research is crucial to establish the cost-

effectiveness and potential for widespread implementation of DHIs in cardiovascular disease management.

CHAPTER 5

METHODLOGY

The study conducted was a Literature based Narrative Review.

SEARCH STRATEGY AND DATA SOURCES:

Through computerised databases like PubMed, Web of Science, Cochrane Library and Google Scholar, a thorough lilterature search was carried out. The search was limited to papers that were published between January 2011 and June 2024. The structured search was done using the following keywords: digital health interventions, telemedicine, telehealth, cardiovascular diseases, heart failure, health economic evaluation, and cost effectiveness analysis. Secondary data analysis was performed using MS Excel and PRISMA. Based on the selection criteria, every study that was considered appropriate for inclusion used the PICO strategy. The study is a narrative evaluation of the literature with secondary data collection and article summaries on the cost effectiveness of digital health interventions in cardiovascular disease management.

ELIGIBILITY CRITERIA

Full-text journal articles in English will be included if they meet the following criteria:

Target Population: Patients with cardiovascular diseases.

Intervention: Digital health interventions aimed at promoting or delivering clinical interventions for cardiovascular conditions.

Comparison: Comparison with conventional care.

Outcome: Full-scale health economic evaluation conducted as a cost-effectiveness analysis, cost-utility analysis, cost-benefit analysis, or cost-consequence analysis.

STUDY SELECTION

The search results were exported to Rayyan and checked for the duplicates. After removing duplicates, titles and abstracts were screened for eligibility. Full texts of potentially eligible articles were then reviewed for verification.

DATA EXTRACTION

A data extraction form was used to collect relevant information from the included studies. Data items included general study information, study characteristics, methodology details, and a summary of findings. Primary outcomes of interest were the cost-effectiveness of DHIs.

DATA ANALYSIS

A descriptive synthesis summarized the types of DHIs, targeted cardiovascular diseases, modeling methods, perspectives, time horizons, and main cost-effectiveness outcomes. A flowchart showed the study selection. Additionally, the methodological quality and cost-effectiveness outcomes were summarized.

CHAPTER 6

RESULTS

STUDY IDENTIFICATION

The initial search retrieved 350 studies of which 26 (7.4%) duplicates were excluded. Of 324 studies left, the title and abstract screening process excluded 294 (90.7%) studies. After the full-text screening of the remaining 30 studies, we excluded 16 (53.3%), resulting in 14 (46.6%) out of 30 studies for inclusion in the analysis. The selection process and flow diagram for the identification of studies are depicted in Figure 6.1.

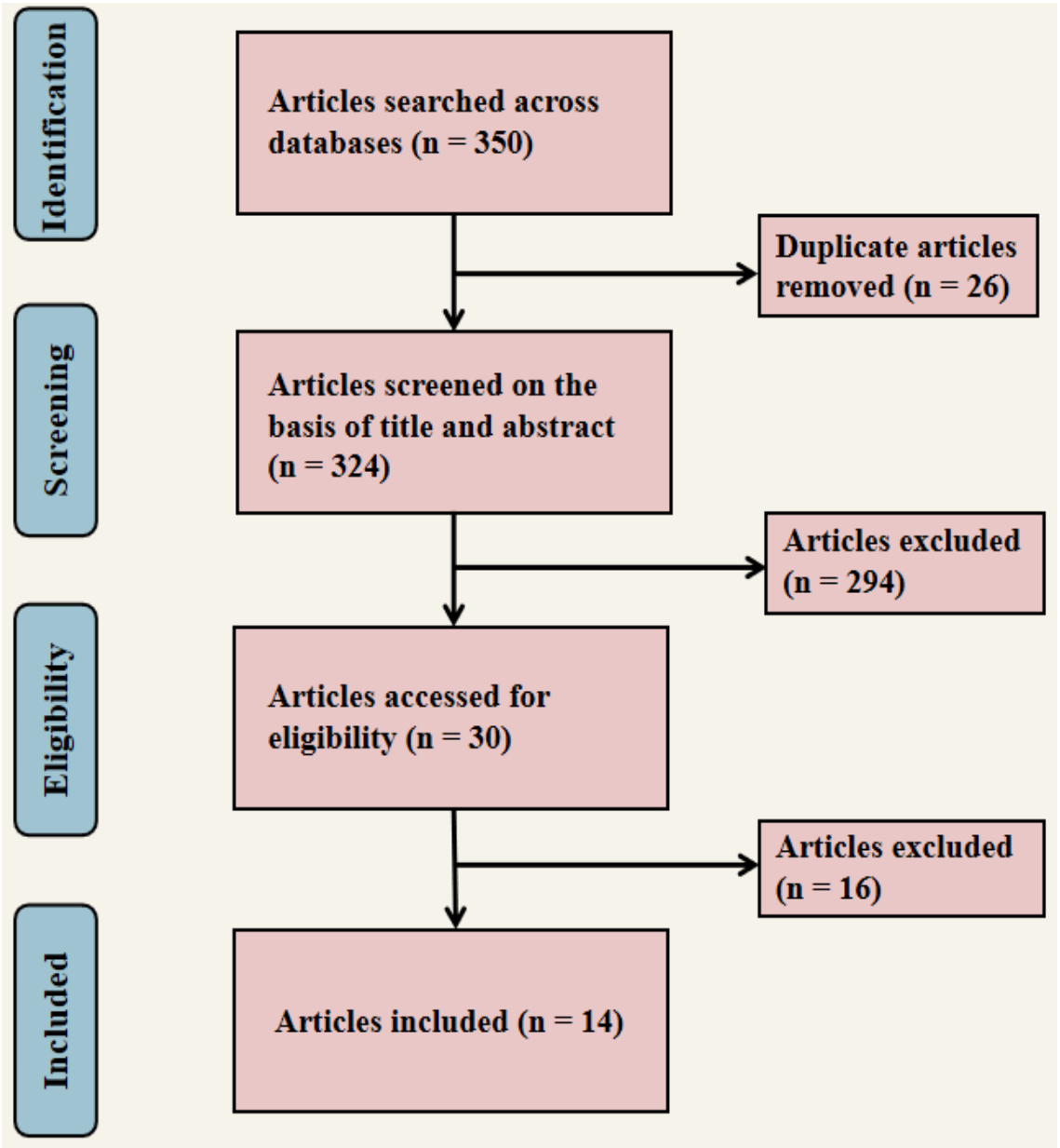

Figure 6.1: The PRISMA flowchart of the study selection process

STUDY CHARACTERISTICS AND DESIGN

Table 6.1 and 6.2 summarized the characteristics and main health economic outcomes of the included studies. The cost-effectiveness of the DHI was categorized as cost-effective if (1) the DHI was more effective and less costly than the comparator (DHI dominated the comparator), or (2) the DHI was more effective at higher cost and the ICER was less than the WTP threshold.

Reference & Year	Country	Targeted disease	Time Period	Perspective	Type of Study	Model type	Intervention vs comparator	Incremental cost effectiveness ratio	Is DHI cost effective?
Andrija et al., & 2018	Netherlands	Heart failure	20 years	Health sector	Not declared	Markov Model	Telemonitoring (HTM) and nurse telephone support (NTS) vs usual care	€ 12,479/QALY for HTM € 8,270/QALY for NTS	yes
Fernando et al., & 2022	Netherlands	Heart Failure	lifetime	Societal	Prospective observational study	Simulation model	HTM and HTM plus Diagnostic Algorithm vs usual care	€ 27,712/QALY for HTM+DA € 34,449/QALY for HTM	yes
Ines et al., & 2016	Belgium	Heart Failure, CAD	6 months	Patient	RCT	Multiple Regression Model	Telerehabilitation vs usual care	€ 21,707/QALY	yes
Ines et al., & 2017	Belgium	CAD & Heart Failure	6 months	Health sector	RCT	Not declared	Telerehabilitation vs usual care	€ 3,993/QALY	yes
Jordana et al. 2016	USA	Heart failure	5 years	Patient	RCT	Markov Model	remote monitoring vs CBM	$44832/QALY	yes
Jos et al., & 2017	Netherlands	CAD	3 months	Societal	RCT	Not declared	Telemonitoring vs centre-based CR	Cost savings insignificant	no
Padraig et al., & 2016	UK	CVD risk	12 months	Health sector	RCT	Cohort simulation model	Telehealth intervention	£11,776/QALY	yes

Table 6.1 & 6.2: Summary of the descriptive synthesis of all the included studies

Reference & Year	Country	Targeted disease	Time Period	Perspective	Type of Study	Model type	Intervention vs comparator	Incremental cost effectiveness ratio	Is DHI cost effective?
Paolo et al., & 2013	Europe	Heart failure	16 months	Health sector	RCT	Regression model	Telemonitoring vs usual care	€ 1366.30/QALY	Yes
Praveen et al. 2013	UK	Heart failure	6 months	Health sector	Cohort Study	Markov Model	remote monitoring vs usual care	£11 873/QALY	yes
Ralph et al., & 2018	Australia	CAD	3 months	Health sector	RCT	Markov Model	Remote CR vs Centre-Based CR	no Qaly change | ICER not calculated	no
Rutger et al., & 2021	Netherlands	CAD	2 years	Health sector	RCT	Regression model	Telerehabilitation vs centre-based CR	$22 840/QALY	yes
Sheena et al., & 2016	USA	Heart failure	1 year	Patient	Prospective cohort study	Markov Model	Telehealth intervention	$33,337/QALY	yes
Tianyi et al., & 2023	China	AF	6 months	Health sector	RCT	Not declared	DTx based CR vs Home-Based CR	33,572.42 CNY/QALY	yes
Vinayak et al., & 2021	USA	Acute MI	1 year	Health sector	Prospective observational study	Markov Model	Corrie DHI	$12,530/QALY	yes

Table 6.3 analyses the general characteristics of the included studies. Of the 14 studies, 6 (42.87%) were conducted using a decision analytical model, 3 (21.42%) used the regression model, 2 (14.29%) used simulation model, and 3 (21.42%) did not declare the model used. The majority of the studies were from HICs. Of the 14 studies, 4 (28.57%) from the Netherlands, 3 (21.42%) each from the United Kingdom and the United States, 2 (14.29%) from Belgium, 1 (7.15%) each from Australia and China. Of the 27 studies, 12 (85.71%) used incremental cost-effectiveness ratio (ICER) and 2 (14.29%) used cost savings for determining the economic evaluation. Types of targeted diseases included heart failure, coronary heart disease, coronary artery disease, arterial fibrillation and acute myocardial infarction. DHIs included telemonitoring, remote rehabilitation and smartphone application. 9 out of 14 studies were conducted from the perspective of the health sector, 3 were performed from the perspective of the patient and 2 adopted a societal perspective.

General Characteristics	Study (n=14), n (%)
Type of Economic Evaluation	
1. ICER	12 (85.71)
2. Cost Savings	2 (14.29)
Year of Publications	
1. Before 2016	2 (14.29)
2. Between 2016-2020	8 (57.14)
3. After 2020	4 (28.57)
Study Type	
1. RCT	9 (64.28)
2. Observational Study	4 (28.57)
3. Not declared	1 (7.15)
Region	
1. Europe	9 (64.28)
2. Asia	1 (7.15)
3. Australia	1 (7.15)
4. North America	3 (21.42)
Model Type	
1. Regression Model	3 (21.42)
2. Markov Model	6 (42.87)
3. Simulation Model	2 (14.29)
4. Not Declared	3 (21.42)

Table 6.3: Analysis of all the included studies

CHAPTER 7

DISCUSSION

The narrative review analyzed 14 studies, revealing several key trends and characteristics in the field of economic evaluations.

TYPE OF ECONOMIC EVALUATION

The majority of the studies (85.71%) utilized the Incremental Cost-Effectiveness Ratio (ICER), indicating a predominant focus on comparing the relative costs and outcomes of different interventions. In contrast, only a small fraction (14.29%) of the studies concentrated on direct cost savings, underscoring a secondary yet significant interest in the immediate financial impact of interventions.

YEAR OF PUBLICATIONS

A notable trend in the timeline of publications emerged, with only 14.29% of studies published before 2016. The bulk of research activity (57.14%) occurred between 2016 and 2020, reflecting a peak in interest and advancements in economic evaluations during this period. Post-2020, the research activity continued with 28.57% of the studies, although this slight decrease might be influenced by ongoing global events like the COVID-19 pandemic.

STUDY TYPE

In terms of study types, Randomized Controlled Trials (RCTs) were the most common, comprising 71.43% of the studies. This highlights a strong preference for high-quality, controlled data to assess economic outcomes. Observational studies accounted for 21.42%, providing real-world insights albeit with potential biases. Modelling studies

were the least common at 7.15%, suggesting that while valuable, they are less frequently employed compared to primary data collection methods.

REGION

Geographically, Europe dominated the field with 64.28% of the studies conducted there, indicating a strong focus on economic evaluations possibly driven by specific healthcare policies or research funding availability in the region. North America followed with 21.42% of the studies, reflecting a significant but less dominant interest. Asia and Australia were underrepresented, each contributing to only 7.15% of the studies, highlighting potential areas for increased research focus.

MODEL TYPE

Regarding the types of models used in the studies, regression models were the most common, featured in 42.87% of the studies, showcasing their flexibility and applicability in various economic evaluations. Markov models were used in 21.42% of the studies, reflecting their utility in modeling chronic diseases and long-term outcomes. Simulation models appeared in 14.29% of the studies, indicating their specific but less frequent application. Notably, 21.42% of the studies did not declare the model type, which may affect the transparency and reproducibility of the research.

The narrative review highlights key trends and gaps in current economic evaluation research. While there is a strong preference for ICER and a significant concentration of studies published between 2016 and 2020, there is also a noticeable dominance of RCTs and European studies. Regression models are the most commonly used analytical method, although a substantial number of studies did not declare their model type. These findings underscore the prevailing practices and suggest potential areas for future research and improvement in the field of economic evaluations.

CHAPTER 8

STRENGTHS AND LIMITATIONS OF THE REVIEW

The review includes the most recent data on the cost effectiveness of the digital health interventions in cardiovascular disease management. These findings are supported by extensive search techniques, screening, data extraction, and assessment of the available data. The strength of this review is that I have assessed various DHIs—both decision-analytic model-based and trial-based economic evaluations of DHIs in managing cardiovascular management globally—encompassing HTM, and rehabilitation.

Inevitably, this study has some limitations. Due to the variability of the methods, devices, and DHI technologies in the included studies, the comparability of studies is limited. I try to overcome this limitation by using a narrative approach; thus, the variations in methodology and study design can be observed thoroughly. In addition, although I used a broad definition of DHIs that includes genomics for personalized medicine and artificial intelligence, I did not find any studies related to these concepts. This may be attributed to the existing gaps in clinical and cost-effectiveness evidence when integrating these approaches in the context of cardiovascular diseases. Despite being robust, the methodology may have introduced a number of biases during the evaluation process. Although quality checks have been made to eliminate them, common biases like the researcher's bias may be present in the study eligibility criteria, identification of the research studies, and data extraction. The search terms were constructed using the population, intervention, comparator, and outcomes method, emphasizing a predefined set of terms related to economic evaluations, cardiovascular dieases, and DHIs. It is possible that this approach may have overlooked relevant studies that use different keywords. Thus, even if I did overlook any, I anticipate that the number would be minimal.

FUTURE RESEARCH

Considering the variability in the DHIs, modeling approaches, ICER values, and WTP thresholds, it is crucial to perform economic evaluations customized to the specific setting and country. Future research should continue to refine these models and consider the integration of emerging technologies to optimize the cost-effectiveness of telehealth solutions. Also, health economic research on CVDs in special patient groups such as pediatrics is lacking. Timely cost-effectiveness studies are essential to support the resource allocation in research and development of DHI for CVDs in low-income areas and in special populations.

CONCLUSION

The overall evidence supports the cost-effectiveness of telehealth interventions across various cardiovascular conditions and settings. These interventions often yield cost savings and improved health outcomes, particularly when evaluated over extended periods and broader societal perspectives. However, the cost-effectiveness can be influenced by factors such as the type of intervention, targeted disease, study perspective, and local healthcare cost structures. Future research should continue to refine these models and consider the integration of emerging technologies to optimize the cost-effectiveness of telehealth solutions.

CHAPTER 9

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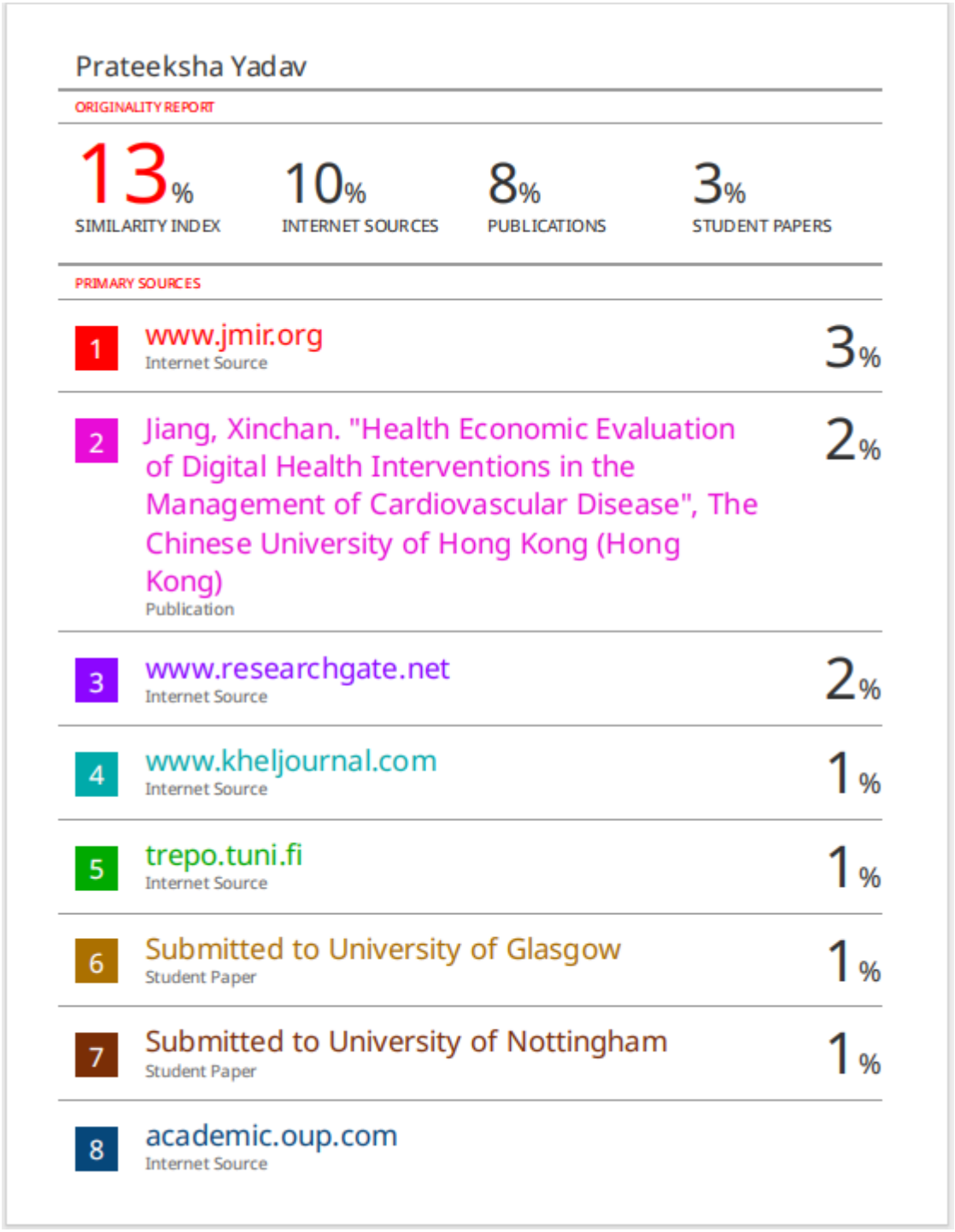
ANNEXURE



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