ORIGINAL RESEARCH PAPER
Volume - 15 | Issue - 04 | April - 2026 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

HOME-BASED CARDIAC REHABILITATION VS. CENTER-BASED CARDIAC REHABILITATION – A SYSTEMATIC REVIEW AND META-ANALYSIS

Cardiology

Ankit Sodani	Consultant and In-charge, Department of Neuro Rehabilitation, Vishesh Jupiter Hospital, Indore, Madhya Pradesh, India
Chetan Gharat*	Head Medical Affairs, Department of Medical Services, Lupin Digital Health, Mumbai, India*Corresponding Author
Ishita Dhadhha	Medical Service Manager, Department of Medical Services, Lupin Digital Health, Mumbai, India
Roshan Verma	Medical Service Manager, Department of Medical Services, Lupin Digital Health, Mumbai, India
Ashwin Prabhughate	Medical Writer, Department of Medical Services, Lupin Digital Health, Mumbai, India

ABSTRACT

The global prevalence of cardiovascular diseases (CVDs) continues to escalate, contributing substantially to morbidity, mortality, and hospital admissions, with CVDs accounting for a significant proportion of global mortality. Cardiac rehabilitation (CR) remains a cornerstone in the management of CVD; however, its adoption remains suboptimal worldwide. Home-based cardiac rehabilitation (HBCR), facilitated through digital health platforms, has emerged as a promising alternative to traditional center-based cardiac rehabilitation (CBCR), offering improved accessibility and the potential for reduced healthcare expenditure. This systematic review aims to critically evaluate the comparative effectiveness of HBCR versus CBCR with respect to key clinical outcomes, including hospital readmissions, mortality, morbidity, quality of life (QoL), peak oxygen uptake (PVO2), body mass index (BMI), and modifiable cardiovascular risk factors. Twenty-five studies, encompassing a cohort of 7400 patients, were included in the analysis. The findings suggest that HBCR and CBCR yield comparable outcomes across major clinical endpoints, with no significant disparities in hospital readmissions, mortality, or QoL scores. However, HBCR demonstrated a marginal advantage in PVO2 improvements. Despite these promising findings, challenges remain in the areas of patient engagement, technological accessibility, and long-term adherence. In conclusion, HBCR presents as a feasible, cost-effective alternative to CBCR in the management of CVD, though further investigation is required to optimize its implementation and fully elucidate its long-term efficacy within the cardiovascular care continuum.

KEYWORDS

Cardiac rehabilitation, home-based cardiac rehabilitation, center-based cardiac rehabilitation, cardiovascular outcomes, digital health

INTRODUCTION

The global incidence of cardiovascular diseases (CVDs) has been escalating, contributing significantly to the rising burden of morbidity, mortality, and hospital admissions, with CVDs accounting for approximately 30% of all global mortality. [1, 2] In response to this growing epidemic, the healthcare community has directed efforts towards optimizing the delivery and implementation of cardiac interventions, with an emphasis on enhancing research and clinical outcomes. Cardiac rehabilitation (CR), a multifaceted and intricately designed intervention tailored for individuals with CVD, encompasses physical rehabilitation, stress management, baseline biometric monitoring (e.g., weight, blood pressure, diabetes, smoking and alcohol cessation), and risk reduction strategies, alongside promoting long-term health awareness. [3,4]

The primary therapeutic goals of CR are to mitigate CVD-related hospital admissions, reduce morbidity and mortality, and enhance overall quality of life (QoL). Despite its well-documented efficacy in improving cardiovascular health, CR remains underutilized globally, necessitating novel strategies to increase accessibility. [5] Home-based cardiac rehabilitation (HBCR), as an alternative to traditional center-based CR (CBCR), has emerged as a promising model for remotely delivering CR interventions, potentially reducing hospitalizations, mortality rates, and the economic burden of healthcare. [6-8] Furthermore, telerehabilitation offers a viable modality for remotely facilitating CR, enabling patient management within the comfort of their homes, in contrast to the logistical constraints of CBCR. [7]

However, telerehabilitation is not without its challenges, including concerns related to patient data security, potential for social isolation, and the requisite digital health literacy to mitigate risks associated with fraudulent activities. A systematic review by Stefanakis et al. [9] has demonstrated superior outcomes in patients undergoing HBCR, particularly regarding adverse event profiles, corroborating evidence from the American College of Cardiology (ACC) and American Heart Association (AHA). Notwithstanding these promising results, critical gaps persist in understanding the full impact of HBCR on CVD patients, particularly regarding its role in reducing hospital admissions, mortality, and enhancing QoL. Therefore, this systematic review aims to critically appraise and compare the outcomes of HBCR versus CBCR, examining their respective effects on hospital admissions, mortality, and overall QoL, while delineating the current challenges and potential future directions for optimizing CVD management.

METHODS

This systematic review was performed by following the PRISMA (Preferred Reporting Items for Systematic review and Meta-Analyses) guidelines. [10] This review is registered with PROSPERO with the PROSPERO ID: CRD42024629685.

For this review, definition of HBCR intervention is elaborated as the CR interventional home-care delivered remotely to a patient via smartphone applications, wearable devices or the internet. For each study, we dissected and analyzed the components of HBCR and differentiated each study as either HBCR or CBCR. HBCR was assumed to be prescribed to CVD patients with first in-person visit for baseline assessments.

Study selection and search strategy

A comprehensive literature search was performed using the key words – Home-based Cardiac Rehabilitation, Center-based Cardiac Rehabilitation, Cardiovascular diseases, Digital Health and Tele-rehabilitation. This was performed on the following search engines -

a. PubMed
b. Scopus (Elsevier).
c. Springer Link
d. Google Scholar
e. Embase

The selected tenure for this review was 10 years (12th Sept 2014 to 13th Sept 2024). The starting date was selected based on the initiation of this review. Patient data was gathered from Clinical Trials Registry of India and examined for its completion before being included in this review.

 PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

Inclusion and exclusion criteria
An independent screening was performed to establish the inclusion and exclusion criteria for this review. This was to keep the focus streamlined and avoid deviations.

Inclusion Criteria
A. Only English studies were included.

B. Articles focusing on HBCR for CVD patients were included; articles analyzing CBCR for CVD patients were also included for comparison; Articles involving Lupin's LYFE application (Palshikar et.al [11] and Podtar et.al [12]) were excluded in order to avoid reporting and/or information bias. These studies are cited in the discussion for supporting this review's hypothesis.

C. No bar placed on the patient's age and gender.

D. No bar placed on geography (global studies were included)

Exclusion Criteria
A. All studies before 12th Sept 2014 were excluded. Exception was made for Kraal et.al (2017) [13] published on 5th Sept 2014 which was included in this review since it fitted the inclusion criteria.

B. Studies focusing on solely mobile/smart-phone-based applications were excluded; attempt was made to include diversity of digital interventions to compare the efficacy of individual implementation.

C. Studies reporting incomplete data and scarcity of evidence were excluded.

D. Case series and reports, Comments, Review and systematic review were excluded, with an exception of reference test.

Outcome of the study
The main outcome of this study was to analyze the effectiveness and comprehensiveness of HBCR in comparison to traditional CBCR for CVD patients

Index test
The index test in this review is HBCR vs. CBCR for CVD patients

Risk of bias assessment
Authors separately conducted the assessment of the selected studies by using the QUADAS 2 (Quality Assessment of Diagnostic Accuracy Studies). Mutual understanding was implemented for any discrepancy in study analysis. There were four main domains covered in assessing risk of bias namely flow of patients, patient selection, index test with time and reference standard with time. Since this was a diagnostic accuracy review, funnel plots were unreliable and hence, were excluded from this review.[10]

Statistical analysis
MS Office Excel (version 6.2.14 2019) was used for statistical pooling of the included studies. Studies with high risk of bias assessment were removed using statistical analysis. P value <0.05 was considered as significant. Forest plots were designed using meta-analysis online software incorporating the 95% confidence interval (CI) cluster for data pooling.

RESULTS
Study inclusion strategy
A total of 2749 articles were obtained using the keywords Home-based Cardiac Rehabilitation, Center-based Cardiac Rehabilitation, Cardiovascular diseases, Digital Health and Tele-rehabilitation (Figure 1). 751 duplicate records were removed amongst which 542 records were assessed to be ineligible using automation tools. At the final stage, 39 and 73 reports were excluded due to non-English articles and incomplete data respectively.

Overall, 25 reports with a total of 7405 patients were included this review and analyzed to test the efficacy of HBCR in comparison to CBCR. Three studies were excluded due to high risk of bias. Five studies and 20 studies showed moderate and low risk of bias respectively, and were included in the review.

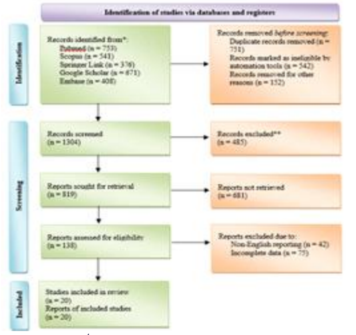


Figure 1: Inclusion strategy using the study criteria

Risk of bias assessment
Majority of the studies reported sufficient quantitative values altering the risk of bias assessment (Figure 2). Overall, the loss of follow-up was inconsistent in both HBCR and CBCR treatment groups. The pattern and intensity were variable between HBCR and CBCR groups, although it was challenging to precisely quantify the application of CR interventions. Majority of the studies reported low risk of bias in terms of outcomes reported and selective reporting.

Out of the included studies, majority of reports focused on improvement in QoL (n=12; 60%), followed by peak oxygen uptake (PVO2) (n=7; 35%), followed by assessment of lab parameters including HbA1c and Lipid profile (n=10; 40%) and BP (Systolic BP, Diastolic BP and Heart Rate) (n=6; 30%). [13-36] One study reported high risk of bias in terms of outcomes measured and were excluded from this review. [33] Majority of the HBCR programs delivered care via tele-health and tele-monitoring with assistance of smartphone or web-based algorithms.

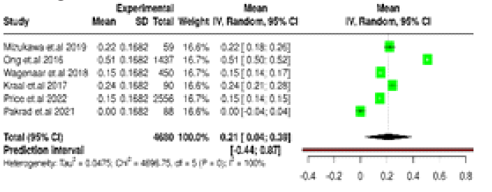
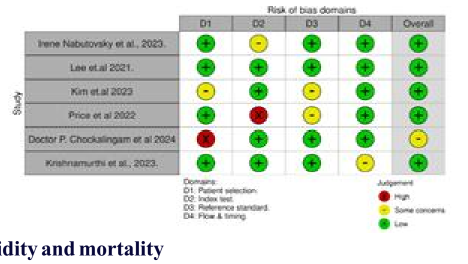


Figure 2: Risk of bias assessment summary for non-RCTs using the MINORS QUADAS-2 scale

Hospital readmissions
Hospital readmissions with a follow-up tenure of 2 years were reported in 5 of the 25 included studies. [23,24,28,33,34]. The pooled analysis of the hospital admissions showed no major difference in hospital readmissions (Figure 3) in the HBCR group after the treatment.

Four studies reported less hospital readmission rates in HBCR group in comparison to the CBCR. [23,29,34,35] On average, the HBCR and CBCR groups showed 13% and 16.9% hospital readmission rates respectively. However, Ong et.al. [24] and Kraal et.al. [13] reported 50.8% and 24.2% readmission rate in the HBCR group, as compared to the 49.2% and 8.7% in the CBCR group respectively.



Morbidity and mortality
Four studies (Figure 4) reported mortality rate of the patients in the HBCR and CBCR groups. [25,26,30,37] Mizukawa et al. [25] and Lee et al. [33] analyzed mortality rates of patients who were assigned a combination of center-based program in collaboration with home-based intervention reporting 15% and 27% mortality rate respectively. Overall, the pooled mortality rate of HBCR patients was significantly similar to those in CBCR patients. Two studies reported lower mortality in HBCR patients, [25,37] whereas two studies showed lower mortality in CBCR patients. [26,30]

Morbidity was only reported by Wagenaar et al. [30] who used two major platforms for HBCR group namely e-health (E-vita with telemonitoring) and website (Heartfailurematters.org) in comparison to the CBCR group; morbidity was reported to be higher in HBCR group (29.6% for Website and 30.2% for E-Vita platform) in comparison to CBCR (29%).

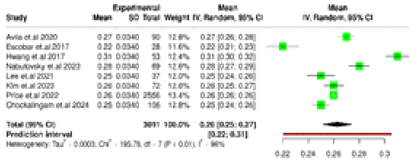


Figure 4: Forest plot depicting mortality rate of HBCR patients post treatment

Health-related quality of life

Due to variations in the measurement methods for QoL in CVD patients in the HBCR and CBCR treatment groups, it was challenging to precisely interpret which group depicted better QoL amongst CVD patients. Hence the analysis is plotted in a tabular format for better clarity (Table 1). Overall, there was no difference observed between the HBCR and CBCR patients with respect to the QoL as reported by their individual scale-based scoring (Figure 5). 20% (n=4) of the included studies measured QoL using the Minnesota Living with Heart Failure Questionnaire (MLWHFQ) scale, and Short Form-36 (SF-36) health survey (n=4; 20%) each, followed by EQ-5D (n=1; 5%) and The World Health Organization Quality of Life – BREF (WHOQOL-BREF) (n=1; 5%).

Overall, average follow-up period for measuring QoL was 10.7 months (SD: 6.9).

TABLE-1 AVERAGE SCORES QOL ANALYSIS AS PER THE INCLUDED STUDIES

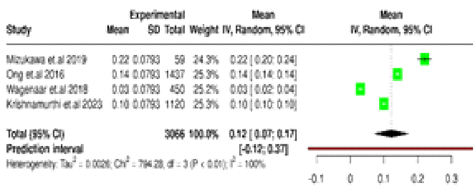


Figure 5: Forest Plot depicting QoL for HBCR patients post treatment

Peak oxygen uptake (PVO$_2$)

Seven studies reported peak oxygen uptake (PVO$_2$) with an average follow-up of 10 months. [13,15,23,33,34,37,38] The average PVO$_2$ was 22.9 mL/kg/min amongst HBCR patients in comparison to CBCR with 22.4 mL/kg/min (Figure 6).

Avila et al. [15] and Lee et al. [33] reported major difference between HBCR and CBCR groups in terms of PVO$_2$ uptake; however, higher oxygen uptake was recorded to be higher in HBCR patients (27.1 mL/kg/min) than CBCR patients (24.5 mL/kg/min) by Avila et al., [15] whereas lower oxygen uptake was witnessed by HBCR than CBCR patients as reported by Lee et al. [31] Kim et al. [13] reported the lowest PVO$_2$ uptake (7.1 ± 0.3 mL/kg/min) for HBCR patients.

Overall, higher oxygen uptake was witnessed in HBCR group, although not extremely variable in comparison to the CBCR group.

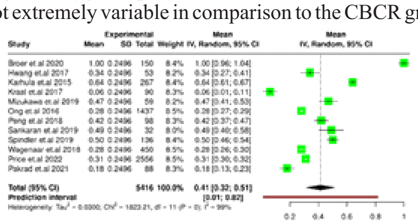


Figure 6: Forest plot depicting peak oxygen uptake (PVO2) in HBCR patients post treatment

Risk factors

Six studies assessed the blood pressure [15,19,25,30,33,35] for the HBCR and CBCR patients, amongst which 5 studies assessed the SBP and DBP, [15,19,30,33,35] and 4 studies assessed the HR [15,19,25,35] of the included CVD patients. Overall, the SBP, DBP and HR rates of HBCR patients were similar to those of CBCR patients with minor differences. It was difficult to predict the precise SD between the values since a few studies report a range. Two contradictions were witnessed in terms of HR was by Peng et al. [25] who reported lower HR (77.52) in HBCR group than the CBCR group (80.54). Nabutovsky et al. [31] failed to depict the CBCR group blood pressure, but values of HBCR group are similar to those of other studies.

Four studies reported primary lab parameters (Low-density lipoprotein (LDL), high-density lipoprotein (HDL), total cholesterol (TC), total glucose (TG) and HbA1c). [15,31-33] Meta-analysis revealed no significant difference observed between HBCR and CBCR groups in terms of LDL, HDL and TC. HbA1c was reported be lower in HBCR group in comparison to CBCR (SD: 0.25; 95% CI <7.0-7.5). Avila et al. [15] reported fasting blood glucose in HBCR and CBCR treatment groups (SD: 0.41; 95%CI 5.36-5.96), showing no significant gulf between HBCR and CBCR patients in terms of fasting glucose.

Body mass index (BMI)

Eight studies covered BMI as one of the endpoints for HBCR and CBCR CVD patients. [15,17,19,31-33,35] The mean BMI was 26.9 kg/m² (SD: 2.25 kg/m²; 95% CI 24.9-31) (Figure 7). Overall CBCR patients reported similar BMI (27.35 kg/m²; SD: 2.5 kg/m²) in comparison to HBCR patients. However, Nabutovsky et al. [31] did not report BMI CBCR patients; however, the HBCR patients had similar BMI (27.8 kg/m²). All studies reported slightly lower BMI in HBCR groups except Kim et al. [32] who showed higher BMI in HBCR group (26 kg/m²) as compared to CBCR (25.5 kg/m²). Overall, no major difference was witnessed in BMI values amongst the HBCR and CBCR groups.

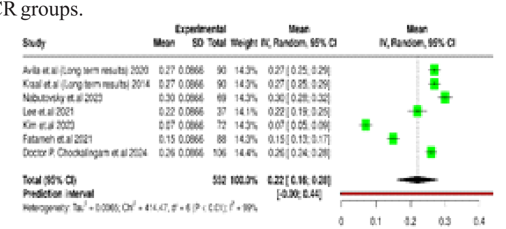


Figure 7: Forest plot depicting BMI in HBCR patients post treatment

TABLE-1 AVERAGE SCORES QOL ANALYSIS AS PER THE INCLUDED STUDIES

Study	HBCR	CBCR/SoC	Follow-up Period	Scale for QoL
Broer et.al; 2020	100.2	98.2	6 months	WHO QoL-BREF
Hwang et.al; 2017	34	33	6 months	MLWHFQ
Karhula et.al; 2015	64.31	60.93	12 months	SF-36 Health Survey
Kraal et.al; 2014	6	5.9	12 months	SF-36 Health Survey
Mizukawa et.al; 2019	47.5	32.2	24 months	MLWHFQ
Ong et.al; 2016	28.5	32.63	6 months	MLWHFQ
Peng et.al; 2018	42.32	49.63	4 months	MLWHFQ
Sankaran et.al; 2019	Not mentioned	Not mentione	Not mentioned	EQ-5D and Heart QoL
Spindler et.al; 2019	49%	31%	12 months	SF-36
Wagenaar et.al; 2018	28.3% (Website); 25.5% (e-health)	26.50%	12 months	MLWHFQ
Fatemeh Pakrad et al; 2021	PCS (Physical Component Summary): 11.5% improvement; MCS (Mental Component Summary): 24.8% improvement	PCS: 6-7% improvement; MCS: 8-9% improvement	4 months	Short Form-36 (SF-36) version 1.0

DISCUSSION:

This systematic review sought to critically assess the comparative efficacy of HBCR versus CBCR in the management of CVD. As evidently elaborated by Kerkar et al., [39], overall implementation of CR is significantly scarce in low-income countries like India, which could be triggered by socio-economic factors including lack of essential resources, inaccessibility to cardiac care, constraints related to finance and inadequate referrals. Assessment of the HBCR for CVD patients enters the equation which triggers the need for holistically assessing the current pillar balancing the bridge between technology and medical application in the cardiac care regime.

The analysis revealed no statistically significant divergence in outcomes between the two interventions post-treatment, suggesting that both modalities confer equivalent benefits in terms of clinical endpoints. This is consistent with findings from the meta-analysis by Imran et.al [38], which indicated comparable improvements in functional capacity between HBCR and CBCR cohorts, albeit with a superior enhancement in QoL observed in the HBCR group. Our data corroborated this observation, with the HBCR group demonstrating consistently elevated QoL scores across all measured domains relative to CBCR.

Geographically, the studies included in the review were predominantly disseminated across Belgium and the United States (16% each), followed by the Netherlands (13%), and smaller contributions from China, Korea, New Zealand, Spain, and other nations. A preponderance of studies (32%) focused on heart failure (HF), followed by coronary artery disease (CAD) (24%) and myocardial infarction (MI) (12%). Notably, Zwiesel et al. [37] provided a comprehensive analysis of HBCR in HF patients, observing analogous outcomes in QoL and functional capacity between HBCR and CBCR, with no significant variation in risk factor modulation between the two cohorts.

A diverse array of digital interventions was employed in the studies, encompassing online coaching, tele-health/tele-monitoring, educational websites, and smartphone-based applications for the delivery of CR. This was in agreement with the real-world evidence study by Palshikar et al. [11] which assessed the digital therapeutic intervention called LYFE, which reported positive outcomes in coronary artery disease (CAD) patients who underwent percutaneous coronary intervention (PCI). Tele-monitoring and smartphone applications yielded the most substantial efficacy outcomes. Podtar et al. [12] reported similar outcomes of LYFE group in terms of medication adherence, blood pressure control, and overall QoL compared to the standard of care (SoC), supporting the integration of DTx with conventional therapies for improved patient prognosis. In both studies, secondary prevention in patients with CAD and ACS, involves addressing risk factors such as hypertension, elevated cholesterol, and diabetes, with LYFE DTx showing enhanced effectiveness in managing these factors through personalized coaching and continuous monitoring [11,12]. Wagenaar et al. [28] reported that the E-Vita health platform (tele-monitoring) and heartfailurematters.org (website) led to superior clinical outcomes in HF patients, including reductions in hospital readmissions, enhanced self-care, and improved health status when compared to CBCR.

Following are the interventions implemented with primarily aimed at improving outcomes in patients undergoing cardiac rehabilitation (CR), employing diverse technological, behavioral, and physical strategies. These interventions incorporate a variety of remote monitoring devices, telehealth systems, personalized coaching, and exercise protocols to improve cardiovascular health, with a focus on both short-term and long-term outcomes for patients.

1. Avila et al., 2020 [15] focused on the long-term effects of physical activity by utilizing the Sensewear® Mini Armband, a wearable device that measured physical activity levels over at least five consecutive days. The use of objective data collection helped evaluate the efficacy of physical activity interventions over extended tenures.

2. Broer et al., 2020 [16] introduced a behavior change program known as DSD, designed to modify unhealthy habits by promoting behavioral flexibility. This intervention spanned three months and was coupled with wearable devices that provided real-time, objective data on physical functioning, thus enabling data-driven adjustments to the rehabilitation process.

3. Escobar et al., 2017 [18] explored home-based exercise regimens, where patients followed a walking program aimed at achieving 70% of their heart rate reserve during the first month and 80% in the second month. This program was monitored remotely using a Bluetooth-enabled electrocardiographic device (NUUBO), allowing continuous tracking of the patient's heart rate during exercise.

4. Hwang et al., 2017 [19] adopted the Telehealth in Chronic Disease (TECH) model, which emphasized effective engagement between patients and clinicians for chronic disease management. The intervention involved a 12-week group-based exercise program that was delivered to patients' homes via online videoconferencing platforms like Adobe Connect. This approach ensured that patients could participate in both physical activity and education remotely, promoting long-term engagement.

5. Karhula et al., 2015 [20] integrated mobile health technology into CR by assigning each patient a personal health coach who provided regular coaching calls every 4 to 6 weeks. Patients were equipped with a mobile personal health record (PHR) app that connected to Bluetooth-enabled devices, such as a blood pressure meter, which automatically transferred data to the PHR. This system supported self-monitoring and remote tracking of vital signs, facilitating personalized care.

6. Kraal et al., 2014 [21] focused on the long-term effectiveness of home-based CR. Patients in this intervention received three supervised training sessions in an outpatient clinic, with heart rate monitors (Garmin FR70) used to track exercise intensity. The data from these monitors were uploaded to a web application (Garmin Connect), enabling both patients and clinicians to monitor progress remotely.

7. Rawstorn et al., 2018 [22] implemented the REMOTE-CR program, which combined individualized exercise prescriptions, real-time physiological monitoring, and behavioral strategies. The program was delivered via a bespoke telerehabilitation platform, incorporating wearable sensors, mobile applications, and web-based platforms. This multimodal approach aimed to improve both physical fitness and behavioral outcomes in patients.

8. Mizukawa et al., 2019 [23] utilized a notebook-based self-management approach for monitoring vital signs, such as blood pressure, and incorporated nurse calls for tele-monitoring. This system allowed patients to track their health data independently, while healthcare providers offered support to ensure adherence to management protocols.

9. Ong et al., 2016 [24] combined predischarge education, telephone coaching, and home-based telemonitoring in a comprehensive intervention. Patients received regular monitoring of their weight, blood pressure, heart rate, and symptoms, with scheduled phone calls from registered nurses to guide management and provide education.

10. Peng et al., 2018 [25] employed a telehealth-based CR program that consisted of 32 exercise training sessions over 2 months, along with printed educational materials, and a 4-month follow-up period. This program aimed to enhance patient engagement in physical activity while offering continued support and monitoring.

11. Sankaran et al., 2019 [26] developed HeartHab, a comprehensive patient-tailored app that supported various aspects of CR, including physical activity, medication management, risk factor monitoring (such as blood pressure and glucose levels), and symptom tracking. The app also provided e-coaching through specially designed videos.

12. Wagenaar et al., 2019 [26] utilized the e-Vita platform, which provided telemonitoring services to guide patients in recording key health parameters, such as weight, blood pressure, and heart rate. Regular consultations with a heart failure nurse helped patients navigate challenges related to monitoring, ensuring adherence to health management routines.

13. Wong et al., 2016 [29] implemented the e-HEI website, which applied the Health Belief Model to deliver a personalized 35-minute educational intervention. This intervention aimed to increase patient awareness and foster behavioral changes through individualized education administered by a trained research assistant.

14. Irene Nabutovsky et al., 2023 [30] developed a comprehensive CR

 PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

program involving regular exercise monitored by a smartwatch that transmitted data to a central operations center. A stress test was conducted before the program and repeated after 3 months to assess cardiovascular improvements.

15.Jeong Jae Lee et al., 2021 [31] compared center-based CR (CBCR) and home-based CR (HBCR), with participants performing supervised exercise regimens either at a rehabilitation center or at home, under similar guidelines. Cardiovascular evaluations were conducted at baseline and after 6 months to assess the impact of each program.

16. Chul Kim et al., 2023 [32] further differentiated between HBCR and CBCR, emphasizing self-exercise at home for the HBCR group and electrocardiogram-monitored exercise for the CBCR group. This study aimed to assess the outcomes of both approaches in terms of patient adherence and overall health improvements.

17. Price et al., 2022 [33] employed a technology-enabled CR program consisting of unsupervised exercise sessions, weekly nurse calls, and health education. Participants used a mobile phone application linked to a wearable smartwatch, ensuring comprehensive monitoring and support.

18.Pakrad et al., 2021 [34] offered traditional CR during the first month, followed by additional education and care delivered both in person and through small discussion groups. The program adhered to the Chronic Care Model (CCM), supporting long-term patient engagement.

19.Dr. Chockalingam et al., 2024 [35] employed a multidisciplinary team, including physicians, physiotherapists, dietitians, and counseling psychologists, to provide in-person or telehealth-based CR. This intervention highlighted the importance of a holistic, team-based approach to patient care.

20. Krishnamurthi et al., 2023 [36] focused on HBCR, providing patients with up to 9 telephonic coaching and motivational interviewing sessions over 12 weeks. This program emphasized sustained engagement and support through personalized interactions.

These studies demonstrate the successful integration of technology, personalized care, and behavioral interventions in CR, offering scalable solutions for improving patient outcomes across different settings, whether at home or in clinical environments. Through wearable devices, mobile applications, telehealth platforms, and individualized coaching, these programs enable continuous monitoring and support, fostering long-term health improvements in cardiac patients.

In colder countries, particularly in parts of North America, Northern Asia, and Europe, the seasonal and environmental constraints often impact patients' ability to engage in outdoor physical activities, a key CR component. The cold weather and shorter daylight hours during the winter months could limit outdoor exercise, prompting reliance on indoor activities. In this context, HBCR programs could focus on alternative, indoor-based exercises (e.g., treadmill walking, resistance training) that can be conducted safely within the home environment. In contrast, in warmer climates, patients may benefit from more consistent outdoor exercise opportunities year-round. The mild weather and extended daylight hours in many regions reduce PA barriers, allowing patients to more easily engage in aerobic exercises such as walking, jogging, or cycling. As a result, HBCR programs could focus less on indoor alternatives and instead leverage the natural environment to enhance patient motivation and physical activity levels. Despite these regional differences, this review suggests that the efficacy of HBCR programs is not inherently compromised by colder climates. With appropriate adaptation of exercise protocols, technological support, and patient education, HBCR can be an effective intervention for cardiac patients in both western and colder countries.

Another pivotal aspect often underexplored in digital health research—healthcare costs—was addressed by Shields et.al [40] who conducted a systematic review on the cost-effectiveness of HBCR versus CBCR during the COVID-19 pandemic. Their findings indicated that HBCR was more cost-effective for CVD patients, with reductions in hospital visits, travel expenditures, laboratory tests, and associated cost burdens due to remote monitoring and digital health interventions. Collectively, the evidence from this review substantiates the efficacy of HBCR as a viable alternative to CBCR, offering comparable or superior clinical outcomes while concurrently reducing the economic burden associated with traditional rehabilitation modalities. Singh et al. [41] addresses this point while assessing the impact of digital therapeutics on heart failure patients in India; cost-cutting is a critical factor which needs to be considered while analyzing the CR realm in low-middle income counterparts. HBCR allows not only the patients to access the treatment regime remotely, but also the physicians to provide high-quality care. [42]

LIMITATIONS:

There are few limitations of this review; Firstly, due to the diversity of the digital interventions implemented in the included studies, it is challenging to assess the overall efficacy of HBCR over CBCR, although reported health outcomes are optimistic and show good potential.

Second, since the overall intervention details were poorly reported, it is difficult to assess whether interventions meet the global innovation framework for digital health technology-based interventions. [43] It would be more clarifying if individual studies are performed in the framework shadow, with a goal to report a focused outline on application of HBCR in CVD management.

Third, although HBCR depicts positive outcome in comparison to CBCR, several pitfalls are hidden, potentially leading to framing effect. [44] Remote monitoring can be beneficial for patients in reducing hospital visits and travel, but could also negatively affect patient's psychological health since lack of interaction could lead to isolation. Included studies fail to report a few related issues which could mislead the efficacy rate of HBCR in CVD patients.

CONCLUSION:

In conclusion, this systematic review demonstrates that home-based cardiac rehabilitation (HBCR) provides comparable clinical outcomes to center-based cardiac rehabilitation (CBCR) across key parameters, including quality of life (QoL), functional capacity, peak oxygen uptake (PVO2), body mass index (BMI), risk factor management, hospital readmission, morbidity, mortality. These findings suggest that HBCR is a promising and cost-effective alternative to traditional rehabilitation approaches for cardiovascular disease (CVD) patients, offering enhanced accessibility, better clinical outcomes and potential healthcare cost reductions. Despite these positive outcomes, several limitations persist in the current HBCR framework, including concerns regarding technology access, awareness among HCPs, limited referral for CR, patient engagement and long-term adherence. HBCR using technology can improve uptake of CR and help HCPs achieve better outcome for patients across cardiology continuum. As such, further research is essential to refine the implementation of HBCR and establish its definitive role within the broader continuum of CVD management, ensuring its sustained impact on patient outcomes and healthcare systems.

Funding: This study was funded by Lupin Digital Health.

Conflict of Interest: Dr. Chetan Gharat, Dr. Ishita Dhadhha, Dr. Roshan Verma, and Ashwin Prabhugate are associated with Lupin Digital Health. Dr. Ankit Sodani has no conflict of interest to declare.

Acknowledgments: None

REFERENCES:

[1] Lin S, Luo M, Walker RJ, Liu X, Hwang SA, Chinery R. (2009), Extreme high temperatures and hospital admissions for respiratory and cardiovascular diseases. Epidemiology. 20(5):738-46.
[2] WHO methods and data sources for global burden of disease estimates 2000-2019. Available at: https://www.who.int/docs/default-source/gho-documents/global-health-estimates/ghe2019_daly-methods.pdf.
[3] Mampuya WM. (2012), Cardiac rehabilitation past, present and future: an overview. Cardiovascular diagnosis and therapy. 2(1):38.
[4] Dalal HM, Doherty P, Taylor RS. Cardiac rehabilitation. BMJ. 2015 Sep 29;351:h5000. doi: 10.1136/bmj.h5000.
[5] Khadanga S, Gaalema DE, Savage P, Ades PA. (2021), Underutilization of cardiac rehabilitation in women: barriers and solutions. Journal of cardiopulmonary rehabilitation and prevention. 41(4):207-13.
[6] Lear SA. (2018), The delivery of cardiac rehabilitation using communications technologies: the "virtual" cardiac rehabilitation program. Canadian Journal of Cardiology. 34(10): S278-83.
[7] Piotrowicz E, Piotrowicz R. (2013), Cardiac telerehabilitation: current situation and future challenges. Eur J Prev Cardiol. (2 Suppl):12-6.
[8] Maddison R, Rawstorn JC, Stewart RA, Benatar J, Whittaker R, Rolleston A, et al. (2019), Effects and costs of real-time cardiac telerehabilitation: randomised controlled

non-inferiority trial. Heart. 105(2):122-9.
[9] Stefanakis M, Batalik L, Antoniou V, Pepera G. (2022), Safety of home-based cardiac rehabilitation: a systematic review. Heart & Lung. 55:117-26.
[10] Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. (2021), The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 372:n71.
[11] Palshikar A, Gharat CH, Patel K. (2023), A real-world evidence study to evaluate the efficacy of software-driven digital therapeutics on major adverse cardiovascular events, vitals, adherence to medication and lifestyle changes among patients with coronary artery disease or post-coronary interventions. Int J Res Med Sci. 11:1541–8.
[12] Potdar A, Gharat C, Patel K. (2024), Comparing effects of smartphone application based standard of care vs. standard of care in acute coronary syndrome and coronary artery disease patients: a real-world study. J Clin Exp Cardiolog. 15(5):884.
[13] Kraal JJ, Van den Akker-Van Marle ME, Abu-Hanna A, Stut W, Peek N, Kemps HM. (2017), Clinical and cost-effectiveness of home-based cardiac rehabilitation compared to conventional, centre-based cardiac rehabilitation: Results of the FIT@ Home study. European journal of preventive cardiology. 24(12):1260-73.
[14] Avila A, Claes J, Goetschalckx K, Buys R, Azzawi M, Vanhees L, Cornelissen V. (2018), Home-based rehabilitation with telemonitoring guidance for patients with coronary artery disease (short-term results of the TRiCH study): randomized controlled trial. Journal of medical Internet research, 20(6):e225.
[15] Avila A, Claes J, Buys R, Azzawi M, Vanhees L, Cornelissen V. (2020), Home-based exercise with telemonitoring guidance in patients with coronary artery disease: does it improve long-term physical fitness?. European journal of preventive cardiology, 27(4):367-77.
[16] Broers ER, Widdershoven J, Denollet J, Lodder P, Kop WJ, Wetzels M, et al. (2020), Personalized eHealth program for life-style change: results from the “do cardiac health advanced new generated ecosystem (do CHANGE 2)” randomized controlled trial. Psychosomatic Medicine, 82(4):409-19.
[17] Duan YP, Liang W, Guo L, Wienert J, Si GY, Lippke S. (2018), Evaluation of a Web-Based Intervention for Multiple Health Behavior Changes in Patients With Coronary Heart Disease in Home-Based Rehabilitation: Pilot Randomized Controlled Trial. J Med Internet Res, 20(11):e12052.
[18] Bravo-Escobar R, González-Represas A, Gómez-González AM, Montiel-Trujillo A, Aguilar-Jimenez R, Carrasco-Ruíz R, et al. (2017), Effectiveness and safety of a home-based cardiac rehabilitation programme of mixed surveillance in patients with ischemic heart disease at moderate cardiovascular risk: A randomised, controlled clinical trial. BMC Cardiovasc Disord, 17(1):66.
[19] Hwang R, Bruning J, Morris NR, Mandrusiak A, Russell T. (2017), Home-based telerehabilitation is not inferior to a centre-based program in patients with chronic heart failure: a randomised trial. Journal of Physiotherapy, 63(2):101-7.
[20] Karhula T, Vuorinen AL, Rääpysjärvi K, Pakanen M, Itkonen P, Tepponen M, et al. (2015), Telemonitoring and mobile phone-based health coaching among Finnish diabetic and heart disease patients: randomized controlled trial. Journal of medical Internet research, 17(6):e153.
[21] Kraal JJ, Peek N, Van den Akker-Van Marle ME, Kemps HM. (2014), Effects of home-based training with telemonitoring guidance in low to moderate risk patients entering cardiac rehabilitation: short-term results of the FIT@ Home study. European journal of preventive cardiology, 21(2_suppl):26-31.
[22] Rawstorn JC, Gant N, Rolleston A, Whittaker R, Stewart R, Benatar J, Warren I, et al. (2018), End users want alternative intervention delivery models: usability and acceptability of the REMOTE-CR exercise-based cardiac telerehabilitation program. Archives of physical medicine and rehabilitation, 99(11):2373-7.
[23] Mizukawa M, Moriyama M, Yamamoto H, Rahman MM, Naka M, Kitagawa T, et al. (2019), Nurse-led collaborative management using telemonitoring improves quality of life and prevention of rehospitalization in patients with heart failure a pilot study. International heart journal, 60(6):1293-302.
[24] Ong MK, Romano PS, Edgington S, Aronow HU, Auerbach AD, Black JT, et al. (2016), Effectiveness of remote patient monitoring after discharge of hospitalized patients with heart failure: the better effectiveness after transition–heart failure (BEAT-HF) randomized clinical trial. JAMA internal medicine, 176(3):310-8.
[25] Peng X, Su Y, Hu Z, Sun X, Li X, Dolansky MA, et al. (2018), Home-based telehealth exercise training program in Chinese patients with heart failure: a randomized controlled trial. Medicine, 97(35):e12069.
[26] Sankaran S, Dendale P, Coninx K. (2019), Evaluating the impact of the HeartHab app on motivation, physical activity, quality of life, and risk factors of coronary artery disease patients: multidisciplinary crossover study. JMIR mHealth and uHealth, 7(4):e10874.
[27] Dinesen B, Nielsen G, Andreasen JJ, Spindler H. (2019), Integration of rehabilitation activities into everyday life through telerehabilitation: qualitative study of cardiac patients and their partners. Journal of medical Internet research, 21(4):e13281.
[28] Wagenaar KP, Broekhuizen BD, Jaarsma T, Kok I, Mosterd A, Willems FF, et al. (2019), Effectiveness of the European Society of Cardiology/Heart Failure Association website 'heartfailurematters. org'and an e-health adjusted care pathway in patients with stable heart failure: results of the 'e-Vita HF'randomized controlled trial. European Journal of Heart Failure, 21(2):238-46.
[29] Wong EM, Chair SY, Leung DY, Sit JW, Leung KP. (2018), Home-based interactive e-health educational intervention for middle-aged adults to improve total exercise, adherence rate, exercise efficacy, and outcome: a randomised controlled trial. Hong Kong Med J, 24Suppl 2(1):34-38.
[30] Nabutovsky I, Breitner D, Heller A, Levine Y, Moreno M, Scheinowitz M, et al. (2024), Home-based cardiac rehabilitation among patients unwilling to participate in hospital-based programs. Journal of Cardiopulmonary Rehabilitation and Prevention, 44(1):33-9.
[31] Lee JJ, Ko JY, Lee S. (2021), An observational study substantiating the statistical significance of cardiopulmonary exercise with laboratory tests during the acute and subacute phases of center and home-based cardiac rehabilitation. Medicine, 100(31):e26861.
[32] Kim C, Lee SH. (2023), The effect of home-based cardiac rehabilitation on cardiovascular risk factors management. Annals of Rehabilitation Medicine, 47(4):272-81.
[33] Nkonde-Price C, Reynolds K, Najem M, Yang SJ, Batiste C, Cotter T, et al. (2022), Comparison of home-based vs center-based cardiac rehabilitation in hospitalization, medication adherence, and risk factor control among patients with cardiovascular disease. JAMA network open, 5(8):e2228720-.
[34] Pakrad F, Ahmadi F, Grace SL, Oshvandi K, Kazemnejad A. (2021), Traditional vs extended hybrid cardiac rehabilitation based on the continuous care model for patients who have undergone coronary artery bypass surgery in a middle-income country: a randomized controlled trial. Archives of Physical Medicine and Rehabilitation, 102(11):2091-101.
[35] Chockalingam P, Natarajan V, Sekar T, Anantharaman R, Yusuf MM, Gunasekaran S, Nayar PG, et al. (2022), Effectiveness of a home-based cardiovascular disease prevention program during the COVID-19 pandemic. Journal of Clinical and Preventive Cardiology, 11(2):37-43.
[36] Krishnamurthi N, Schopfer DW, Shen H, Rohrbach G, Elnaggar A, Whooley MA. (2023), Association of home-based cardiac rehabilitation with lower mortality in patients with cardiovascular disease: results from the veterans health administration healthy heart program. Journal of the American Heart Association, 12(5):e025856.
[37] Zwisler AD, Norton RJ, Dean SG, Dalal H, Tang LH, Wingham J, et al. (2016), Home-based cardiac rehabilitation for people with heart failure: A systematic review and meta-analysis. International journal of cardiology, 221:963-9.
[38] Imran HM, Baig M, Erqou S, Taveira TH, Shah NR, Morrison A, et al. (2019), Home-based cardiac rehabilitation alone and hybrid with center-based cardiac rehabilitation in heart failure: a systematic review and meta-analysis. Journal of the American Heart Association, 8(16):e012779.
[39] Kerkar P, Harikrishnan S, Sawhney JP, Kapoor A, Gharat C. (2024), Implementing Remote Cardiac Rehabilitation: Strategic Framework. Heart Failure Journal of India, 2(3):156-69.
[40] Shields GE, Rowlandson A, Dalal G, Nickerson S, Cranmer H, Capobianco L, et al. (2023), Cost-effectiveness of home-based cardiac rehabilitation: a systematic review. Heart, 109(12):913-20.
[41] Singh B, Hazra P, Roy S, Garg R, Bhat S, Patki N, et al. (2023), Exploring the Need and Benefits of Digital