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HEALTH AND REHABILITATION

ARTIFICIAL INTELLIGENCE IN EARLY DETECTION OF MYOCARDIAL INFARCTION USING WEARABLE DEVICES: A SYSTEMATIC REVIEW

Original Research

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Acknowledgement: The authors sincerely acknowledge the contributions of the research and clinical experts who have advanced the field of artificial intelligence in cardiovascular diagnostics. Special thanks to the institutions and open-access databases that provided the foundational studies for this systematic review.

Conflict of Interest: None Grant Support & Financial Support: None

ABSTRACT

Background: Myocardial infarction (MI) remains a leading global cause of morbidity and mortality, with early detection being critical for improving clinical outcomes. Conventional diagnostic methods often rely on patient presentation to healthcare settings, leading to delayed intervention. Wearable devices integrated with artificial intelligence (AI) offer the potential for real-time, non-invasive, and accessible MI detection. However, there is limited consolidated evidence evaluating the diagnostic accuracy and clinical utility of these technologies.

Objective: This systematic review aims to evaluate the effectiveness and diagnostic performance of AI-driven wearable devices in the early detection of myocardial infarction.

Methods: A systematic review was conducted in accordance with PRISMA guidelines. Literature was searched across PubMed, Scopus, Web of Science, and IEEE Xplore for studies published between 2019 and 2024. Included studies evaluated adult human subjects using AI-integrated wearable or portable ECG devices for MI detection. Study designs encompassed randomized trials, cohort studies, and validation models. Risk of bias was assessed using the Cochrane Risk of Bias Tool and the Newcastle-Ottawa Scale. Data were synthesized narratively due to heterogeneity in study design and outcomes.

Results: Eight studies were included in the final review. AI algorithms demonstrated high diagnostic accuracy (sensitivity and specificity >90%) across multiple device platforms. Notably, one study reported an AUC of 0.9954 and another achieved an F-score of 88.10%. AI models were successfully integrated into real-time or embedded systems, and performance was comparable or superior to clinician-based interpretations. Study quality was moderate to high, although variations in design and small sample sizes were noted.

Conclusion: AI-enhanced wearable technologies show strong promise for the early detection of myocardial infarction, offering significant clinical benefits in timely diagnosis and intervention. While the current evidence supports their diagnostic value, further large-scale prospective trials are needed to validate performance and guide clinical implementation.

Keywords: Myocardial Infarction, Artificial Intelligence, Wearable Devices, Early Detection, ECG Monitoring, Systematic Review.

INTRODUCTION

Myocardial infarction (MI), commonly referred to as a heart attack, remains one of the leading causes of death globally, accounting for significant morbidity and mortality, particularly in individuals with underlying cardiovascular risk factors. Early detection and timely intervention are paramount to reducing myocardial damage and improving survival rates (1). Despite advances in diagnostic techniques, challenges persist, particularly in out-of-hospital settings where patients may delay seeking care. Wearable devices, integrated with artificial intelligence (AI), present a novel avenue for continuous monitoring and real-time detection of early signs of MI, potentially transforming preventive cardiology and emergency response systems (2,3). The increasing global burden of cardiovascular diseases has amplified interest in leveraging AI-enhanced electrocardiogram (ECG) interpretation through wearable technology. Recent studies have shown that AI algorithms can outperform or match cardiologists in detecting ST-elevation myocardial infarction (STEMI), with models achieving accuracies up to 99% (4). Similarly, single-lead and six-lead ECGs processed via deep learning models have demonstrated robust diagnostic capabilities suitable for mobile and wearable formats (5). Despite these advancements, there is no consensus on their clinical applicability, variability in model performance, or integration into routine care. Moreover, real-world implementation is hindered by the lack of standardized validation and limited comparative studies across different wearable platforms and populations (6-8).
Therefore, a systematic review is necessary to critically assess the accuracy, reliability, and clinical utility of AI-driven wearable devices for the early detection of myocardial infarction. This review addresses the following research question: In adults at risk of myocardial infarction (Population), how effective are AI-powered wearable ECG devices (Intervention) compared to standard diagnostic modalities or clinical evaluation (Comparison) in detecting early signs of myocardial infarction (Outcome)? The primary objective is to evaluate and synthesize current evidence on diagnostic performance metrics—such as sensitivity, specificity, and predictive value—of AI-enabled wearable tools. This review will consider both observational and interventional studies published from 2019 to 2024, incorporating global data to reflect broad applicability. The review methodology follows PRISMA guidelines to ensure transparency and reproducibility. By consolidating recent findings, it aims to guide clinicians, researchers, and device developers on the strengths, limitations, and future directions of this rapidly evolving diagnostic frontier. Ultimately, this work will contribute to the emerging field of AI-integrated wearable cardiology by clarifying whether such technologies can fulfill their promise of real-time, life-saving MI detection outside the hospital environment.

METHODS

This systematic review was conducted in adherence to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure methodological rigor, transparency, and reproducibility. An extensive literature search was performed across four major electronic databases: PubMed, Scopus, Web of Science, and IEEE Xplore. The search strategy employed a combination of Medical Subject Headings (MeSH) and free-text terms, utilizing Boolean operators to enhance specificity and sensitivity. The primary search terms included: “myocardial infarction” OR “heart attack” AND “artificial intelligence” OR “machine learning” AND “wearable devices” OR “smartwatch” OR “ECG monitoring”. The search was limited to studies published between January 2019 and April 2024. Additionally, reference lists of all eligible full-text articles were manually screened to identify any relevant studies missed in the initial search. Eligibility criteria were defined a priori. Studies were included if they involved adult human participants and investigated the application of artificial intelligence algorithms via wearable or portable devices in the early detection of myocardial infarction. Eligible study designs encompassed randomized controlled trials, prospective and retrospective cohort studies, cross-sectional studies, and systematic reviews with original data synthesis. Studies were required to report at least one diagnostic accuracy outcome (e.g., sensitivity, specificity, area under the curve, or predictive values). Only English-language publications were considered. Exclusion criteria comprised editorials, conference abstracts without full-text availability, animal studies, and papers lacking explicit outcome measures related to early MI detection.

The selection process involved two independent reviewers who screened titles and abstracts for relevance. Full-text articles of potentially eligible studies were retrieved and assessed in detail. Disagreements were resolved through discussion or, if necessary, consultation with a third reviewer. Reference management and duplication removal were conducted using EndNote software. The PRISMA flow diagram illustrates the process of study identification, screening, eligibility assessment, and inclusion. Data extraction was conducted

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independently by two reviewers using a standardized data collection form. Extracted variables included author and year of publication, study design, population characteristics, type of wearable device, AI methodology (e.g., type of algorithm used), outcome measures (accuracy, sensitivity, specificity), sample size, and key findings. To maintain consistency, ambiguous data points were clarified through consensus between reviewers or direct communication with the study authors when possible.

The methodological quality of included studies was appraised using appropriate tools based on study design. For randomized controlled trials, the Cochrane Risk of Bias Tool 2.0 was utilized. Observational studies were evaluated using the Newcastle-Ottawa Scale. Risk of bias domains assessed included selection bias, performance bias, detection bias, attrition bias, and reporting bias. Each study was independently assessed by two reviewers, with disagreements resolved through discussion. Given the heterogeneity in AI techniques, device platforms, and reported outcomes, a qualitative synthesis approach was adopted. Key results from each study were narratively summarized to highlight common findings, patterns, and variations across the evidence base. A meta-analysis was not feasible due to methodological and statistical inconsistencies among the studies. Eight studies were included in the final review. These consisted of evaluations of AI-based ECG interpretation using both 12-lead and limited-lead wearable devices. Notably, a study proposed a 1D-CNN algorithm for ECG-based MI detection deployable on microcontrollers, achieving an accuracy of 95.9% (9). Another study developed a high-performing STEMI detection algorithm with an AUC of 0.9954 (10). The ROMIAE study, a large multicenter prospective trial, reported that AI-enhanced ECG interpretation had superior diagnostic and prognostic power compared to traditional scores (11). Furthermore, a study demonstrated robust MI detection using a deep learning model on six-lead ECGs suited for wearable integration (12). A study, showed the feasibility of asynchronous ECG leads from smartwatches in detecting MI using residual networks (13). Another study reported high diagnostic performance of AI-guided algorithms using ensemble techniques for wearable STEMI detection (14). A study explored explainable AI frameworks in MRI-based MI detection, supporting clinical transparency (15). Lastly, a study provided a comprehensive review of AI methodologies for wearable MI detection and emphasized the role of hardware-efficient deep learning models (16).

RESULTS

A total of 3128 records were identified through database searches and manual reference screening. After removing 827 duplicates, 2301 studies underwent title and abstract screening. Of these, 2219 were excluded for not meeting the eligibility criteria. Full texts of 82 articles were assessed, and ultimately, 8 studies met all inclusion criteria and were included in the final synthesis. The PRISMA flow diagram was used to illustrate the study selection process. The included studies varied in design, encompassing experimental setups, retrospective analyses, validation cohorts, and one comprehensive review. Sample sizes ranged from underreported in experimental device trials to over 11,000 participants in validation studies. Most interventions involved artificial intelligence algorithms integrated with wearable or portable ECG devices for myocardial infarction detection. Demographically, participants across studies represented adult populations with suspected or confirmed cardiac events, with no specific exclusions based on gender or ethnicity, although granular demographic data were inconsistently reported. Risk of bias assessment revealed overall moderate quality. Studies using retrospective datasets had inherent risks of selection bias due to non-randomized data sampling. Three studies were judged to have low reporting bias due to complete outcome reporting and transparent methodology. Potential concerns included limited external validation in smaller experimental studies and the absence of blinding in performance evaluations of diagnostic algorithms. The Newcastle-Ottawa Scale rated most observational studies with 6–8 stars, indicating moderate to good quality, while experimental studies were evaluated with domain-specific criteria adapted from the Cochrane Risk of Bias Tool.

Regarding diagnostic performance, all studies reported favorable outcomes for AI-driven myocardial infarction detection. A study developed a 1D-CNN model deployable on a microcontroller, achieving 95.94% accuracy on ECG-derived signals from wearable devices (9). Another study demonstrated the superiority of their AI-STEMI model, reporting an AUC of 0.9954 and sensitivity of 96.75% (10). ROMIAE multicenter study confirmed that AI-ECG performed comparably or better than traditional risk scores in diagnosing acute MI, with an AUC of 0.878 and a net reclassification improvement of 19.6% (11). Furthermore, a study validated a deep learning algorithm using six-lead ECG data that achieved an internal AUC of 0.880 and external AUC of 0.854 (12). Another study explored asynchronous ECG recordings via smartwatch simulations and observed that diagnostic performance improved with the number of leads, reaching an AUC of 0.880 for full 12-lead reconstructions (13). Similarly, a study developed a convolutional neural network ensemble for wearable STEMI detection, achieving a sensitivity of 98.3% and specificity of 98.6% in a Latin American population (14). A study integrated explainable AI into MI imaging diagnostics and found ResNet50V2 to be the most robust model, with an F-score of 88.10% (15). Lastly, a study highlighted in their comprehensive review that convolutional neural networks and VLSIoptimized AI models were most effective for wearable integration (16). Collectively, these findings suggest that AI-enabled wearable ECG technologies offer highly accurate and practical solutions for the early detection of myocardial infarction, though external validation, standardization, and broader demographic testing remain areas for further study.

Table 1: Summary of Included Studies

Author (Year)	Study Design	Sample Size	Intervention	Primary Outcomes
Gragnaniello et al. (2024)	Experimental study	Not reported	1D-CNN on ARM Cortex-M4 ECG device	Accuracy 95.94%
Zhao et al. (2020)	Retrospective diagnostic study	8238	AI-STEMI diagnosis algorithm	AUC 0.9954, Sensitivity 96.75%
Lee et al. (2025)	Prospective cohort study	8493	AI-ECG risk prediction	AUC 0.878, NRI +19.6%
Cho et al. (2020)	Validation study	11,605	DLA with 6-lead ECG	AUC 0.880 (internal), 0.854 (external)
Han et al. (2021)	Retrospective study	Various sets (min 2,000)	Residual network for smartwatch ECG	AUC up to 0.880 with 12-leads
Mehta et al. (2020)	Algorithm development study	18,853	CNN Ensemble for STEMI	Accuracy 98.5%, Sensitivity 98.3%
Saleh et al. (2023)	CAD framework validation	Not specified	Explainable AI models (Grad-CAM, MRI)	F-score 88.10% with ResNet50V2
Abhijith et al. (2024)	Review with synthesis	N/A	Review of AI techniques for wearables	Algorithm classification strengths/limits

DISCUSSION

This systematic review found compelling evidence supporting the effectiveness of artificial intelligence (AI)-powered wearable technologies in the early detection of myocardial infarction (MI). Across eight selected studies, AI algorithms consistently demonstrated high diagnostic accuracy, with several models achieving sensitivity and specificity exceeding 95%. These findings indicate that AI-driven systems, particularly those embedded in wearable ECG devices, offer a promising adjunct or alternative to conventional clinical diagnostics, especially in pre-hospital or remote settings. The overall strength of evidence is robust, with consistent diagnostic metrics reported across diverse study designs and technological platforms, underscoring the reliability of AI models for MI detection when appropriately trained and validated (17,18). In comparison with existing literature, the findings align with earlier studies that recognized the diagnostic potential of deep learning in cardiology. For example, the present results mirror those of previous single-center trials that reported comparable AUC values using conventional ECGs interpreted through AI algorithms. However, this review advances prior knowledge by specifically focusing on wearable applications, such as smartwatches and portable ECG monitors, which had been underrepresented in earlier reviews. A study uniquely contributed to this evidence base by demonstrating that models could be embedded directly on low-power hardware, expanding real-world feasibility (19,20). Moreover, the ROMIAE trial offered large-scale, multicenter prospective validation, reinforcing the generalizability of AI-ECG systems. Consistency in diagnostic performance across studies suggests strong convergence in findings, although some differences in model architecture and dataset size preclude direct comparisons (21,22).

The strengths of this review lie in its comprehensive and methodologically rigorous approach. A broad database search strategy across PubMed, Scopus, Web of Science, and IEEE Xplore, combined with manual reference checks, ensured wide coverage of relevant studies. The inclusion of both prospective and retrospective designs, along with the appraisal of study quality using established tools, further strengthened the reliability of the findings. Additionally, limiting the review to human-based studies published in the past five years enhanced relevance and minimized temporal bias. Nonetheless, several limitations warrant consideration. Some included studies had small or poorly reported sample sizes, particularly in experimental and hardware-focused trials, which could limit statistical power and generalizability (23,24). There is also the possibility of publication bias, as studies with negative or inconclusive results may remain unpublished. Furthermore, heterogeneity in AI model types, ECG lead configurations, and outcome measures made quantitative

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synthesis infeasible and could obscure nuanced performance differences across models. Variability in validation strategies and lack of standardized benchmarks across studies complicate efforts to determine which models are best suited for clinical deployment.

The findings have significant implications for clinical practice and health system innovation. AI-integrated wearable devices could revolutionize MI detection by enabling real-time monitoring and earlier diagnosis, particularly in high-risk or remote populations where access to immediate care is limited. Their potential use in community settings, ambulances, and at-home monitoring may reduce treatment delays and improve patient outcomes. For researchers, this review highlights the need for large-scale, prospective trials that directly compare AI performance against clinician judgment and existing diagnostic tools. Future investigations should also explore patient-centered outcomes, cost-effectiveness, and regulatory pathways to facilitate clinical translation. In summary, this review affirms the diagnostic potential of AI-powered wearable technologies for early myocardial infarction detection and emphasizes their role in shaping future cardiovascular care pathways. Continued interdisciplinary research and real-world validation are essential to fully harness their clinical utility.

CONCLUSION

This systematic review concludes that artificial intelligence-enhanced wearable devices demonstrate strong potential for the early detection of myocardial infarction, with several studies reporting high diagnostic accuracy, sensitivity, and specificity. These technologies, particularly when integrated with real-time ECG monitoring, present a transformative opportunity in cardiovascular care by facilitating earlier diagnosis, expediting intervention, and potentially reducing mortality, especially in pre-hospital or underserved settings. The clinical relevance is underscored by the consistent performance of AI models across varied platforms and populations. While the current body of evidence is promising and methodologically sound, the reliability of these findings would be further strengthened by large-scale, multicenter prospective trials and standardized evaluation protocols. Continued research is essential to address implementation challenges, ensure equitable access, and establish regulatory frameworks that support the safe and effective integration of AI-driven diagnostics into routine clinical practice.

AUTHOR CONTRIBUTION

Author	Contribution
Muhammad Aizaz Mohsin Khan*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Javeria Niazi	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Aiza Khan	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Sana Ilyas	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Taibah Shahid	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Nauyaan Ahmed Qureshi	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Asba Riaz	Contributed to study concept and Data collection Has given Final Approval of the version to be published

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