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Telemedicine in Acute Coronary Syndrome Management: A Literature Review on Prehospital Decision Support and Clinical Outcomes (2020-2025)

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Abstract

Background

Acute Coronary Syndrome (ACS) remains one of the leading causes of morbidity and mortality worldwide, particularly in low- and middle-income countries with geographic and structural disparities in healthcare access. Over the last decade, telemedicine has emerged as a strategic solution to support early diagnosis, risk stratification, and clinical decision-making, especially in prehospital and emergency care settings.

Objective

To review and synthesize the scientific literature published between 2020 and 2025 on the use of telemedicine in prehospital and emergency management of Acute Coronary Syndrome, focusing on clinical Interventions outcomes, system efficiency, and equity of access to specialized cardiology care.

Methods
A narrative literature review was conducted using publications indexed in PubMed, Scopus, Web of Science, and Cielo. Studies published between January 2020 and January 2025 addressing tele-electrocardiography, cardiology teleconsultation, and remote decision support in ACS were included. Both observational and interventional studies were analysed.

Results
The reviewed literature consistently demonstrates that telemedicine interventions are associated are associated with earlier diagnosis, increased adherence to evidence-based therapies, reduced treatment delays, improved referral accuracy, and lower mortality rates in ACS-particularly ST-segment elevation myocardial infarction (STEMI). Benefits were most pronounced in prehospital and resource-limited-settings.

Conclusion
Telemedicine represents a transformative tool in ACS management, enhancing clinical outcomes and reducing health system inequalities. Its integration into prehospital emergency networks should be considered a priority in cardiovascular care policies.

Keywords
Telemedicine; Acute Coronary Syndrome; STEMI; Prehospital Care; Telecardiology.

Introduction
Cardiovascular diseases remain the leading cause of mortality worldwide, representing a major burden for health systems, societies, and economies. Among these conditions, Acute Coronary Syndrome (ACS) stands out as one of the most frequent and severe cardiovascular emergencies, accounting for a substantial proportion of hospital admissions, long-term disability, and premature death. Despite significant advances in pharmacological therapy and interventional cardiology, clinical outcomes in ACS are strongly time dependent. Early diagnosis and prompt initiation of evidence-based therapy particularly reperfusion strategies in ST-segment elevation myocardial infarction (STEMI) being decisive factors for survival and myocardial preservation. The well-established principle that time is myocardium underscores the critical importance of minimizing delays across all stages of care.

Although clinical guidelines for ACS management are well established, significant disparities persist in access to timely and specialized cardiovascular care. These inequalities are especially evident in geographically extensive countries, low-and middle-income settings, and regions characterized by fragment or resource constrained healthcare systems. In such contexts, prehospital emergency services frequently constitute the first and most critical point of contact for patients with suspected ACS. Consequently, frontline healthcare professionals occupy a decisive position in early recognition, risk stratification, and initiation of appropriate management. However, limited access to cardiology expertise during the prehospital phase can compromise diagnostic accuracy, delay definite treatment, and negatively affect outcomes.

In low-and-middle-income countries (LMICs), including Brazil, these challenges are further intensified by geographic dispersion, unequal distribution of cardiology services, and shortages in specialized workforce

availability, Prehospital emergency care units often operate without on-site cardiologists, placing additional responsibility on non-specialist professionals to make complex and time-sensitive decisions, In this scenario, the absence of immediate expert support represents a critical vulnerability within the continuum of ACS care.

In recent years, telemedicine has emerged as a strategic approach to addressing these challenges. Technologies such as tele electrocardiography (tele-ECG) transmission and real-time cardiology teleconsultation enable rapid specialist support for diagnostic interpretation and clinical decision-making, often before hospital arrival. By facilitating early STEMI recognition, risk stratification, and appropriate referral to reperfusion-capable centers, telemedicine has the potential to significantly reduce treatment delays and improve adherence to guideline-directed care. The COVID-19 pandemic further accelerated the integration of telehealth solutions into emergency care pathways, consolidating telemedicine as a core component of contemporary cardiovascular practice rather than a temporary or auxiliary measure.

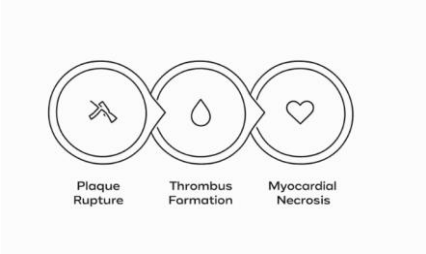
Beyond its clinical impact, telemedicine also holds important implications for health system organization and equity. By extending specialist expertise to underserved and remote areas, telecardiology contributes to the regionalization of care, optimization of resources, and reduction of avoidable transfers and overcrowding in tertiary centres. These system-level benefits are particularly relevant in public health systems, where efficiency, scalability, and equitable access are central policy objectives.

Given the rapid expansion of telemedicine initiatives and the growing body of related research, there is a need to comprehensively map and synthesize current evidence on its role in ACS management. Therefore, the objective of this article is to conduct a scoping review of the scientific literature published between 2020 and 2025 on the use of telemedicine to support clinical decision-making in prehospital and emergency care for Acute Coronary Syndrome. Specifically, this review aims to identify the main telemedicine strategies employed, examine their reported clinical and system-level outcomes, and explore their relevance across different healthcare contexts, with particular attention to low- and middle-income settings. The ultimate purpose of this review is to contribute to the understanding of telemedicine as a structural and strategic component of modern ACS care, informing clinical practice, health system planning, and future research in cardiovascular emergency medicine.

Theoretical and Clinical Foundations

Pathophysiological basis of acute coronary syndrome

Acute Coronary Syndrome (ACS) encompasses a spectrum of clinical conditions resulting from acute myocardial ischemia, most triggered by the rupture or erosion of an atherosclerotic plaque followed by thrombus formation in a coronary artery. This process leads to a sudden reduction or interruption of coronary blood flow, compromising oxygen delivery to myocardial tissue and initiating a cascade of ischemic injury that may culminate in myocardial necrosis if not promptly reversed [1,2].



The pathophysiology of ACS is intrinsically time dependent. Experimental and clinical evidence consistently demonstrates that the duration of ischemia is directly related to infarct size, left ventricular dysfunction, and mortality. The concept that "time is myocardium" underscores the urgency of early diagnosis and rapid reperfusion, particularly in ST-segment elevation myocardial infarction (STEMI), where complete coronary occlusion is more frequent [3,4].

Electrocardiography plays a central role in the early identification of ACS, especially STEMI, enabling immediate risk stratification and activation of reperfusion strategies. Delays in ECG acquisition, interpretation, or specialist confirmation are associated with prolonged ischemic time and worse clinical outcomes [5]. In this context, tele-electrocardiography (tele-ECG) emerges as a clinically sound strategy, allowing rapid transmission of ECG data for expert interpretation during the prehospital phase. By anticipating diagnostic confirmation, tele-ECG facilitates earlier therapeutic decisions, including initiation of antiplatelet therapy and direct referral to reperfusion-capable centers [6].

Beyond STEMI, patients with non-ST-segment elevation ACS and complex arrhythmias also benefit from early expert evaluation. Accurate differentiation between ischemic and non-ischemic presentations, as well as timely identification of high-risk features, is essential to guide appropriate management and avoid both undertreatment and unnecessary interventions. Telemedicine-supported decision-making contributes to reducing diagnostic uncertainty in these scenarios, reinforcing its pathophysiological relevance across the ACS spectrum [7].

Cardiovascular Care Networks and System-Level Integration

From a clinical systems perspective, the management of ACS increasingly relies on the organization of structured cardiovascular care networks. These networks aim to integrate prehospital services, emergency departments, and tertiary referral centers to ensure timely access to reperfusion therapies and specialized care. International guidelines emphasize the importance of coordinated regional systems to reduce treatment delays and improve outcomes in ACS [4].

In geographically extensive countries and health systems with heterogeneous resource distribution, the effectiveness of cardiovascular care networks is highly dependent on communication and coordination mechanisms. Telemedicine serves as a critical enabler of these networks by linking frontline providers to cardiology specialists in real time, regardless of physical distance. Through teleconsultation, clinical protocols can be activated earlier, referral pathways optimized, and unnecessary interhospital transfers reduced [8].

In low- and middle-income countries, including Brazil, telecardiology networks have demonstrated relevance. Public prehospital emergency services often operate in environments with limited availability of cardiologists, especially outside major urban centers. Telemedicine compensates for these workforce limitations by extending specialist expertise to remote and underserved areas, contributing to more equitable access to high-quality cardiovascular care [6,10].

Furthermore, the integration of telemedicine into cardiovascular care networks supports health system efficiency. By improving diagnostic accuracy and referral appropriateness, telemedicine reduces overcrowding in tertiary centers, optimizes resource utilization, and enhances the overall performance of emergency care systems. These benefits align telemedicine not only with clinical objectives but also with broader health policy goals related to sustainability and equity [12].

Early Diagnosis	Optimized Referral	Resource Efficiency	Equity of Access
Rapid ECG transmission and specialist interpretation	Direct routing to appropriate reperfusion centres	Reduced unnecessary transfers and overcrowding	Extended specialist expertise to underserved regions

Taking together, the pathophysiological imperatives of early ischemia management and the organizational demands of contemporary cardiovascular care networks provide a strong theoretical and clinical foundation for the use of telemedicine in ACS. Telecardiology is therefore not merely a technological adjunct but a structural component of modern cardiovascular emergency care, capable of influencing outcomes at both the patient and system levels.

Methods (Scoping Review)

This study was conducted as a scoping review, following the methodological framework originally proposed by Arksey and O'Malley and subsequently refined by the Joanna Briggs Institute (JBI). The choice of scoping review methodology was deliberate and appropriate given the complexity, heterogeneity, and evolving nature of telemedicine applications in Acute Coronary Syndrome (ACS) management. Unlike systematic reviews, which focus on narrowly defined questions and effect size estimation, scoping reviews aim to map the breadth, characteristics, and key concepts of a body of literature, identify knowledge gaps, and clarify how research has been conducted in each field [14,15].

The methodological process followed the five core stages proposed by Arksey and O'Malley: (1) identification of the research question; (2) identification of relevant studies; (3) study selection; (4) data charting; and (5) collating, summarizing, and reporting the results. These stages were operationalized in accordance with the JBI Manual for Evidence Synthesis, ensuring methodological transparency and reproducibility [15].

1. Research Question Identification of the research question
2. Study Identification Identification of relevant studies
3. Study Selection Application of eligibility criteria
4. Data Charting Structured data extraction
5. Synthesis & Reporting Collating, summarizing, and reporting results

Research question

The guiding research question for this scoping review was: What is the scope and nature of scientific evidence published between 2020 and 2025 regarding the use of telemedicine to support clinical decision-making in prehospital and emergency management of Acute Coronary Syndrome? This question was designed to capture both clinical and system-level dimensions of telemedicine use, including diagnostic strategies, therapeutic decision support, and integration within cardiovascular care networks.

Information sources and search strategy

A comprehensive literature search was conducted in four major scientific databases: PubMed (MEDLINE), Scopus, Web of Science, and Cielo. These databases were selected to ensure broad coverage of international biomedical literature, with particular attention to cardiovascular medicine, emergency care, and telehealth research. The search period was limited to studies published between January 2020 and January 2025, reflecting the rapid expansion of telemedicine initiatives and the acceleration of digital health adoption during and after the COVID-19 pandemic. The search strategy combined controlled vocabulary terms and free-text keywords related to telemedicine and ACS. Core search terms included combinations of telemedicine, telecardiology, tele-electrocardiography, acute coronary syndrome, ST segment elevation myocardial infarction, prehospital care, and emergency medical services. Boolean operators ("AND", "OR") were used to refine the search and ensure sensitivity across databases.

Eligibility criteria

Studies were considered eligible for inclusion if they met the following criteria: (1) addressed the use of telemedicine or telecardiology to support clinical decision-making in ACS; (2) involved prehospital or emergency care settings; (3) reported clinical outcomes, process indicators (e.g., treatment delays, referral accuracy), or system-level impacts; and (4) were published in peer-reviewed journals between 2020 and 2025. Both observational and interventional study designs were included, reflecting the real-world implementation of telemedicine systems. Exclusion criteria comprised: studies focused exclusively on chronic coronary syndromes; editorials, opinion pieces, and narrative commentaries without original data; and studies addressing telemedicine applications unrelated to cardiovascular emergencies. No restrictions were applied regarding geographic location, allowing inclusion of evidence from high-, middle-, and low-income settings.

Data charting and synthesis

Data from included studies were charted using a structured extraction framework developed a priori. Extracted variables included author and year of publication, country, study design, telemedicine intervention characteristics, care setting, and main clinical or system-level outcomes. The extracted data were synthesized descriptively and presented in narrative form, complemented by a synthesis table to facilitate comparison across studies.

Consistent with scoping review methodology, no formal quality appraisal or risk-of-bias assessment was performed, as the primary objective was to map the extent and nature of the evidence rather than to assess intervention effectiveness. The findings were organized thematically to highlight recurring patterns, gaps, and implications for clinical practice and health systems.

Results

The analysis of the literature published between 2020 and 2025 reveals a consistent expansion in the use of telemedicine to support clinical decision-making in Acute Coronary Syndrome (ACS), particularly within prehospital and emergency care settings. Most of the included studies were observational or quasi-experimental in design, reflecting real-world implementation of telemedicine systems rather than controlling experimental environments. This characteristic is particularly relevant, as it provides insight into the effectiveness of telemedicine under routine clinical conditions.

Author/ Year	Country	Design	Strategy	Key Outcomes
[6].	Brazil	Multicentre	Telecardiology Network	Reduced mortality
[7]	South Korea	Quasi-experimental	Teleconsultation	Reduced ischemic time
[11]	Brazil	Observational	Tele-ECG + protocols	Improved guideline adherence
[16]	Spain	Cohort	Prehospital tele- ECG	Shorter door-to-balloon time

Table 1: Synthesis of Key Studies (2020-2025).

Across different healthcare contexts, tele-electrocardiography (tele-ECG) emerged as the most frequently employed intervention, often integrated with real-time cardiology teleconsultation. The primary reported outcome was earlier identification of ST-segment elevation myocardial infarction (STEMI), allowing faster activation of reperfusion pathways and more appropriate triage to percutaneous coronary intervention capable centres. Several studies demonstrated significant reductions in first medical contact to reperfusion time and door-to-balloon time when telemedicine support was available, reinforcing the time-sensitive benefits of early specialist involvement [4,3].

In addition to improvements in process indicators, a subset of studies reported clinically meaningful outcomes, including reduced in-hospital and short-term mortality among STEMI patients managed with telemedicine-supported decision-making. These findings were particularly pronounced in regions with limited baseline access to cardiologists, suggesting that telemedicine exerts a proportionally greater impact in underserved settings [6,7]. Beyond STEMI, telemedicine was also associated with improved diagnostic accuracy in non-ST-segment elevation ACS and complex arrhythmias, reducing unnecessary transfers and inappropriate admissions.

The synthesis table (Table 1) integrates these findings by mapping study characteristics, telemedicine strategies, and key outcomes. When interpreted collectively, the evidence indicates that telemedicine consistently improves early diagnostic accuracy, optimizes referral pathways, and enhances adherence to guideline-directed medical therapy. Importantly, the convergence of findings across heterogeneous health systems strengthens the external validity of the observed benefits.

Discussion

The findings of this scoping review reinforce telemedicine as a structurally transformative and evidence-based component of contemporary Acute Coronary Syndrome (ACS) care, rather than a merely

supplementary technological tool. The clinical and systemic benefits identified across studies published between 2020 and 2025 are strongly aligned with the most recent international guidelines, particularly the 2024 European Society of Cardiology (ESC) and the 2025 American Heart Association/American College of Cardiology (AHA/ACC) recommendations for ACS management. From a cardiological perspective, the observed benefits of telemedicine are mechanistically coherent with the pathophysiology of myocardial ischemia and the well-established relationship between ischemic time and clinical outcomes. Both ESC and AHA/ACC guidelines emphasize that early diagnosis, rapid electrocardiographic confirmation, and timely initiation of reperfusion strategies are decisive determinants of prognosis in ACS, especially in ST-segment elevation myocardial infarction (STEMI). The ESC 2024 guidelines explicitly highlight the role of prehospital ECG acquisition and early expert interpretation as critical elements for reducing total ischemic time and improving survival. In this context, tele-electrocardiography and real-time cardiology teleconsultation emerge as operational mechanisms that directly enable guideline adherence in real-world settings. The evidence synthesized in this review demonstrates that telemedicine-supported decision-making consistently shortens diagnostic and therapeutic delays, improves referral accuracy to percutaneous coronary intervention capable centers, and enhances adherence to guideline-directed medical therapy. These findings are concordant with the AHA/ACC 2025 guideline, which recognizes telehealth solutions as effective tools for optimizing prehospital triage, streamlining system activation, and reducing inequities in access to specialized cardiovascular care. By enabling early ECG interpretation and specialist consultation, telemedicine directly influences infarct size, myocardial salvage, and left ventricular function outcomes that are central to long term prognosis and repeatedly underscored in contemporary guideline documents. A key contribution of telemedicine lies in its capacity to standardize clinical decision-making across heterogeneous care settings. Variability in ACS management often driven by differences in clinician experience, resource availability, and geographic location has long been recognized as a contributor to outcome disparities. Telecardiology mitigates this variability by providing real-time access to specialist expertise, promoting consistent application of evidence-based protocols regardless of where the patient first enters the health system.

Importantly, this standardization effect extends beyond STEMI to include non ST-segment elevation ACS and complex arrhythmias, where early risk stratification and appropriate escalation of care are essential to avoid both undertreatment and unnecessary interventions. Beyond individual patient outcomes, telemedicine demonstrates a profound system-level impact, increasingly recognized within contemporary guideline frameworks. Both ESC 2024 and AHA/ACC 2025 advocate for the organization of regionalized systems of care, particularly in settings characterized by heterogeneous resource distribution. The studies included in this review illustrate that telecardiology functions as a key enabler of such systems by integrating prehospital services, emergency departments, and tertiary centers into coordinated care networks. These integrations translate into improved referral appropriateness, reduced overcrowding in tertiary hospitals, and more efficient use of specialized cardiovascular resources.

Clinical Impact	**System Impact**
Earlier diagnosis	Optimized referral pathways
Reduced ischemic time	Reduced overcrowding
Lower mortality rates	Enhanced resource utilization

Improved myocardial salvage	Improved care coordination

Notably, the relative benefits of telemedicine appear to be amplified in low- and middle-income countries and public health systems, where shortages of cardiologists, geographic barriers, and infrastructural limitations are more pronounced. In these contexts, telemedicine acts as a compensatory mechanism that extends specialist expertise to underserved regions, aligning local clinical practice with international standards of care. This dual impact simultaneously improving clinical outcomes and addressing systemic inequities positions telemedicine not merely as an efficiency-enhancing intervention, but as a cornerstone of equitable cardiovascular emergency care. Taken together, the strong alignment between empirical evidence and contemporary international guidelines supports the interpretation that telemedicine is no longer optional or experimental in ACS management. Instead, it should be regarded as an essential and structural component of modern cardiovascular emergency systems, capable of simultaneously improving clinical outcomes, enhancing health system efficiency, and advancing equity in access to life-saving interventions.

The evidence synthesized in this review carries significant implications for both clinical practice and health policy. At the clinical level, telemedicine supports earlier risk stratification, timely initiation of antiplatelet and reperfusion therapies, and more accurate differentiation between high- and low-risk ACS presentations. For frontline healthcare professionals, particularly those working in prehospital emergency services, telemedicine enhances clinical confidence and decision-making capacity during the most critical phases of care.

From a health policy perspective, the integration of telemedicine into regional ACS networks represents a cost-effective strategy to improve outcomes without proportionally increasing specialist workforce requirements. Investments in telecardiology infrastructure, standardized protocols, and workforce training have the potential to reduce avoidable mortality, decrease unnecessary interhospital transfers, and improve overall system efficiency. These benefits align closely with broader policy goals related to universal health coverage, equity, and sustainability of health systems.

Clinical Practice	**System Integration**	**Health Policy**
Enhanced decision-making, earlier risk stratification, improved confidence for frontline providers	Structured care networks, standardized protocols, coordinated referral pathways,	Universal coverage, equity of access, sustainable cardiovascular care systems

Furthermore, the findings support the inclusion of telemedicine as a formal component of national and regional cardiovascular care strategies. Rather than being implemented as isolated pilot projects, telemedicine initiatives should be embedded within structured care networks, supported by regulatory frameworks, performance monitoring, and continuous quality improvement processes. In doing so, telemedicine can fulfil its potential as a scalable and resilient solution for improving ACS care across diverse healthcare contexts.

Conclusion

This scoping review provides a comprehensive synthesis of contemporary evidence demonstrating that telemedicine is no longer a peripheral or auxiliary strategy in the management of Acute Coronary Syndrome (ACS), but rather a foundational element of modern cardiovascular emergency care. The body of literature published between 2020 and 2025 consistently supports the role of telemedicine particularly tele-electrocardiography and real-time cardiology teleconsultation, improving the timeliness, quality, and equity of care delivered to patients with suspected or confirmed ACS.

From a clinical perspective, the integration of telemedicine directly addresses the time-sensitive pathophysiology of myocardial ischemia. By enabling early diagnostic confirmation, rapid risk stratification, and timely activation of reperfusion pathways, telemedicine contributes to reductions in ischemic time, preservation of myocardial function, and lower mortality rates, especially among patients with ST-segment elevation myocardial infarction. These effects are not incidental but mechanistically coherent with established principles of cardiovascular pathophysiology and guideline-directed care.

At the system level, telemedicine demonstrates a capacity to reshape the organization of cardiovascular care networks. By extending specialist expertise to prehospital and resource-limited settings, telecardiology mitigates geographic and structural disparities, enhances referral appropriateness, and optimizes the use of high-complexity resources. The evidence suggests that these system-level gains are particularly pronounced in low- and middle-income countries and public health systems, were constraints in workforce distribution and infrastructure pose persistent challenges to equitable access.

Telemedicine represents a robust, evidence-supported, and scalable solution for improving outcomes in Acute Coronary Syndrome

Importantly, the findings synthesized in this review indicate that telemedicine should not be implemented as isolated technological interventions or temporary pilot initiatives. Instead, telemedicine must be embedded within structured regional ACS networks, supported by standardized clinical protocols, continuous professional training, performance monitoring, and regulatory frameworks that ensure quality and accountability. When integrated in this manner, telemedicine functions as a strategic enabler of both clinical excellence and health system sustainability.

In conclusion, telemedicine represents a robust, evidence-supported, and scalable solution for improving outcomes in Acute Coronary Syndrome. Its incorporation into prehospital and emergency cardiovascular care pathways should be prioritized by clinicians, health system planners, and policymakers as part of a comprehensive strategy to reduce avoidable mortality, promote equity, and strengthen the resilience of cardiovascular care systems in diverse healthcare contexts.

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