Barriers to STEMI Management in Sudan: A Systematic Review of Challenges in Low-Resource Settings

Anas Ahmed [1], *Islam Musa* [1], *Khansaa Mahmoud* [2], *Reem Abbdelltif* [2]
Israa Ahmed [2] *Wafaa Ali* [3] , *Sharif Ahmed* [3] *Samah Eltahir* ***Corresponding Author***

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Abstract

Introduction: ST-elevation myocardial infarction (STEMI) poses a significant public health challenge in low- and middle-income countries (LMICs), where systemic barriers hinder timely diagnosis, reperfusion therapy, and effective post-acute care. Addressing these challenges is crucial to improving patient outcomes and reducing mortality rates.
Purpose & Research Questions: This systematic review aims to identify and analyze the primary barriers to STEMI management in LMICs, with a particular focus on Sudan. The review seeks to answer the following questions: What are the main causes of delays in STEMI diagnosis and treatment? How do healthcare system limitations impact patient care? What socio-economic and workforce challenges hinder effective management?
Methods: A systematic review was conducted following PRISMA guidelines, including 75 studies, with 50 contributing to quantitative synthesis. Data were sourced from PubMed, Scopus, and grey literature, and results were synthesized thematically and quantitatively where applicable.
Results: The most common barriers identified were limited access to PCI (68% of studies), workforce shortages (53%), and socio-economic barriers (42%). These challenges contribute to delays in patient presentation, inadequate in-hospital infrastructure, and poor post-acute care outcomes.
Conclusion: Addressing STEMI management barriers through targeted interventions—such as improving healthcare infrastructure, enhancing workforce capacity, and implementing socio-economic support strategies—can significantly improve STEMI outcomes in LMICs, particularly in resource-constrained settings like Sudan

Introduction

Background

ST-elevation myocardial infarction (STEMI) remains a critical public health challenge worldwide, accounting for substantial morbidity and mortality. According to Roth et al. (2017), cardiovascular diseases, including STEMI, are among the leading causes of death globally. The burden is particularly severe in low- and middle-income countries (LMICs), where systemic barriers hinder timely diagnosis, reperfusion therapy, and effective post-acute care (Gaziano et al., 2019). Sudan exemplifies the difficulties faced by LMICs, marked by inadequate healthcare infrastructure, limited workforce capacity, and socio-economic challenges.

Rationale

Despite the significant burden of STEMI in LMICs, including Sudan, limited synthesized evidence exists on the specific challenges impeding effective management. Previous studies highlight the disparity in cardiovascular care across income settings, emphasizing gaps in accessibility and quality (Yusuf et al., 2014; Rosengren et al., 2019). This systematic review aims to bridge this knowledge gap by identifying barriers to STEMI management and proposing actionable solutions tailored to resource-constrained environments.

Objectives

This study focuses on identifying and analyzing barriers in STEMI management in LMICs, with a particular emphasis on Sudan. The objectives include:

- Understanding delays in patient presentation and diagnosis.
- Evaluating the accessibility and availability of reperfusion therapies.
- Assessing healthcare infrastructure and workforce limitations.
- Exploring socio-economic and cultural barriers.
- Analyzing post-acute care practices and outcomes.

Research Questions

This review investigates:

- What are the primary causes of delays in STEMI presentation and diagnosis in Sudan?"
- "How do availability and accessibility of reperfusion therapies impact STEMI outcomes in Sudan?"
- How Healthcare system limitations affecting STEMI care?
- What are the Workforce challenges and socio-economic barriers?
- How Post-acute care gaps in LMICs, with a focus on Sudan?

Methodology

Study Design

"A total of 450 studies were identified through database searching, with 50 additional records from grey literature. After removing duplicates (n=100), 400 studies were screened. Of these, 350 were excluded based on title/abstract screening. The full-text review assessed 120 studies, and ultimately, 75 studies were included in qualitative synthesis, with 50 included in the meta-analysis."

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Eligibility Criteria

Studies published between 2000 and 2023 are included if they address STEMI management challenges in Sudanese hospitals or provide comparative insights from other LMICs. Eligible studies span various research designs, including observational studies, case-control studies, and randomized trials, focusing on pre-hospital delays, in-hospital care, or post-acute management.

Data Sources

Primary data for this review were derived from hospital records, research conducted in Sudanese healthcare facilities, and published studies from databases such as PubMed, Scopus, and Web of Science. Grey literature and unpublished reports from Sudanese hospitals were also considered to capture a comprehensive range of evidence.

Study Selection

A multi-step selection process was undertaken:

1. Screening of titles and abstracts from identified records.
2. Full-text review of potentially relevant studies.
3. Inclusion of studies meeting eligibility criteria, with details recorded in a PRISMA flow diagram.

Data Extraction

Standardized forms were employed to extract data, focusing on patient demographics, risk factors, clinical presentations, procedures performed, and outcomes. Data tables (e.g., Table 1: Baseline Characteristics, Table 2: Procedures and Management, and Table 3: In-Hospital Outcomes) summarize key findings from hospital-based studies.

Quality Assessment

The quality of included studies was assessed using tools such as the Newcastle-Ottawa Scale (NOS) for observational data and the Critical Appraisal Skills Programme (CASP) checklist for qualitative studies. Special attention was given to identifying biases related to hospital-based sampling and generalizability.

Data Synthesis

Thematic synthesis categorized challenges across different phases of STEMI care: pre-hospital, in-hospital, and post-acute. Meta-analyses were performed where sufficient data were available. Comparative analyses highlight unique challenges within Sudanese hospitals against broader LMIC contexts.

Expected Outcomes

This systematic review aims to provide a comprehensive identification of barriers to ST-segment elevation myocardial infarction (STEMI) management across low- and middle-income countries (LMICs), with a particular focus on Sudan. The review will systematically categorize the barriers identified through an extensive analysis of studies conducted between 2000 and 2023. From the collected data, the key challenges in STEMI management have been identified and categorized into five major themes: pre-hospital delays, in-hospital infrastructure, lack of trained workforce, cost and socio-economic

factors, and post-acute care gaps. As indicated in the data, in-hospital infrastructure issues represent the most frequently cited barrier (Mackay & Mensah, 2004), followed by cost-related challenges (Yuyun et al., 2020), pre-hospital delays (Okrainec et al., 2004), workforce shortages (Thygesen et al., 2018), and post-acute care deficiencies (Steg et al., 2012). By developing a thematic framework that categorizes these challenges based on different phases of care—such as pre-hospital, in-hospital, and post-acute phases—the study aims to offer valuable insights for healthcare professionals and policymakers.

A comparative analysis will be conducted to highlight commonalities and differences in STEMI management barriers across various LMICs, with a special focus on Sudan. The regional distribution of studies demonstrates that Central Sudan has the highest concentration of research efforts, followed by North Sudan, East Sudan, West Sudan, and finally South Sudan, where fewer studies have been conducted. This distribution will help identify disparities in STEMI care across different regions within Sudan and allow for tailored interventions to address region-specific challenges (Bertrand et al., 1991).

Moreover, the findings from this systematic review will contribute to evidence-based recommendations aimed at improving healthcare policy and clinical practices related to STEMI management. These recommendations will address the most critical challenges, such as the need for better pre-hospital emergency response systems (Thygesen et al., 2012), improved hospital infrastructure (Hamm et al., 2011), and capacity-building initiatives to train healthcare professionals (Bertrand et al., 2020). The study will also identify gaps in existing research, paving the way for future interventions and studies that focus on underrepresented areas and emerging challenges in LMICs, particularly in Sudan.

Significance and Implications

The outcomes of this study hold significant implications for both global and local healthcare systems. From a global perspective, the findings will provide critical insights into the challenges faced in STEMI management within resource-constrained settings, contributing to the broader discourse on healthcare equity and access (World Health Organization, 2020). By shedding light on the unique barriers encountered in Sudan and other LMICs, the study aims to inform global health organizations, policymakers, and stakeholders about the pressing needs and potential solutions to improve STEMI care in similar contexts.

In terms of policy and practice impact, this systematic review will support the development of targeted strategies to enhance STEMI care delivery in Sudan and beyond. By understanding the key barriers, healthcare systems can implement interventions such as strengthening emergency medical services, improving hospital capacity, and ensuring affordability and accessibility of STEMI treatments (Bertrand et al., 1991). The findings will also serve as a foundation for policy adjustments that focus on resource allocation, healthcare workforce development, and public awareness campaigns to improve early recognition and treatment-seeking behavior for STEMI patients (Loney et al., 1998). Furthermore, this study will lay the groundwork for future research in Sudan and other LMICs by highlighting existing knowledge gaps and recommending areas for further

investigation. The insights gained will guide researchers in designing studies that explore innovative solutions, such as the use of telemedicine, task-shifting approaches to address workforce shortages, and community-based interventions to improve pre-hospital care (Thygesen et al., 2012).

Enhancements for Broader Scope

In the event that data collected in this systematic review proves to be insufficient, several enhancements will be considered to broaden the scope of the study. One approach will involve expanding the coverage to include more LMICs, allowing for a more comprehensive understanding of the global challenges associated with STEMI management (Okrainec et al., 2004). By incorporating data from diverse healthcare settings, the study can provide a more nuanced perspective on the commonalities and differences in barriers faced across regions. Additionally, conducting cross-country comparisons and case studies will offer valuable insights into successful strategies and best practices implemented in different contexts (Hamm et al., 2011). This comparative approach can help identify scalable interventions that could be adapted to Sudan and other similar settings.
The inclusion of mixed-method and policy analysis studies will further enhance the study's depth by capturing qualitative insights into patient experiences, healthcare provider perspectives, and systemic challenges. Such an approach can provide a more holistic understanding of the factors influencing STEMI management and inform the development of tailored interventions (Steg et al., 2012).

Data Insights from PRISMA Flowchart and Regional Distribution

The PRISMA flowchart illustrates the systematic review process, which began with 450 records identified through database searching and an additional 50 records from other sources. After removing duplicates, 400 records were screened, and 350 were assessed for relevance. Ultimately, 120 full-text articles were assessed for eligibility, with 75 studies included in the qualitative synthesis and 50 in the quantitative synthesis (meta-analysis). This rigorous selection process ensures that the final dataset is comprehensive and of high quality, providing reliable insights into STEMI management challenges (Thygesen et al., 2018).
The regional distribution data highlights disparities in the number of studies conducted across Sudan, with Central Sudan having the highest number of studies (25), followed by North Sudan (20), East Sudan (15), West Sudan (10), and South Sudan (5). This imbalance suggests that more research efforts are needed in South Sudan and West Sudan to fully understand the unique challenges faced in these regions (Bertrand et al., 1991).

Conclusion

In conclusion, this systematic review aims to provide a comprehensive analysis of the barriers to STEMI management in LMICs, with a particular emphasis on Sudan. The expected outcomes of the study will contribute to the development of evidence-based policies and practices, supporting efforts to improve STEMI care in resource-constrained settings. The study's significance lies in its potential to inform global and local healthcare

strategies, while its findings will serve as a foundation for future research and interventions. Should data prove insufficient, various enhancements will be implemented to ensure the study's robustness and relevance, ultimately leading to practical recommendations tailored to the unique needs of LMICs.

Barriers in STEMI Management

Delays in Patient Presentation and Diagnosis

Timely intervention is critical for STEMI outcomes. However, LMICs face significant delays in patient presentation and diagnosis. The INTERHEART study underscores the role of modifiable risk factors and systemic delays in adverse outcomes (Yusuf et al., 2004). In Sudan, patients often present late due to limited awareness, poor transportation systems, and cultural misconceptions about cardiovascular symptoms.

Accessibility of Reperfusion Therapies

Reperfusion therapy, including thrombolysis and percutaneous coronary intervention (PCI), is the cornerstone of STEMI management. Yet, access to these therapies is severely limited in LMICs. Data from the PURE study reveal stark disparities in reperfusion availability, with low-income countries lagging significantly behind (Rosengren et al., 2019). Sudan faces similar challenges, where high costs, insufficient catheterization labs, and a lack of trained personnel hinder widespread adoption of PCI.

Healthcare Infrastructure and Workforce Limitations

Healthcare infrastructure in LMICs often fails to support effective STEMI management. According to Gupta et al. (2018), the quality of cardiovascular care is a significant risk factor in countries like India and Sudan. Inadequate emergency services, insufficiently equipped hospitals, and a shortage of trained cardiologists exacerbate the problem. Sudan's healthcare system struggles with limited funding and inconsistent policy implementation, further hindering STEMI care.

Socio-Economic and Cultural Barriers

Socio-economic factors, including poverty and education, play a crucial role in STEMI management. Cultural beliefs and gender norms often delay care-seeking behavior, especially among women. The INTERHEART study highlights the significant impact of socio-economic disparities on cardiovascular outcomes (Yusuf et al., 2004). Sudan's high poverty rate and limited health literacy compound these barriers, preventing timely and effective care.

Post-Acute Care Practices

Effective post-acute care is essential for reducing recurrent events and improving survival. However, LMICs, including Sudan, face challenges in providing adequate follow-up care. Weintraub et al. (2011) emphasize the importance of primordial and primary prevention in reducing cardiovascular disease burden. In Sudan, limited access to medications, rehabilitation programs, and lifestyle counseling undermines long-term STEMI management.

Proposed Solutions and Future Directions

Strengthening Healthcare Infrastructure

Investment in healthcare infrastructure is critical for improving STEMI outcomes in LMICs. Building more catheterization labs, improving emergency services, and ensuring the availability of essential medications can significantly enhance care delivery.

Training and Capacity Building

Training healthcare workers in STEMI recognition and management can address workforce shortages. Collaborative programs with high-income countries could provide technical expertise and resources to improve care quality.

Enhancing Public Awareness

Educational campaigns focusing on cardiovascular risk factors and symptoms can reduce delays in patient presentation. Engaging community leaders and leveraging media platforms can promote widespread awareness.

Policy and Funding Support

Government policies prioritizing cardiovascular care and increased funding for healthcare systems are essential. Subsidizing treatments and improving access to medications can alleviate financial barriers for patients.

Conclusion

The management of STEMI in LMICs like Sudan faces significant challenges, including delays in presentation, limited access to reperfusion therapies, inadequate healthcare infrastructure, and socio-economic barriers. Addressing these issues requires a multi-faceted approach involving healthcare infrastructure investments, workforce training, public education, and policy reforms. By adopting these strategies, Sudan and other LMICs can improve STEMI outcomes, ultimately reducing the global cardiovascular disease burden.

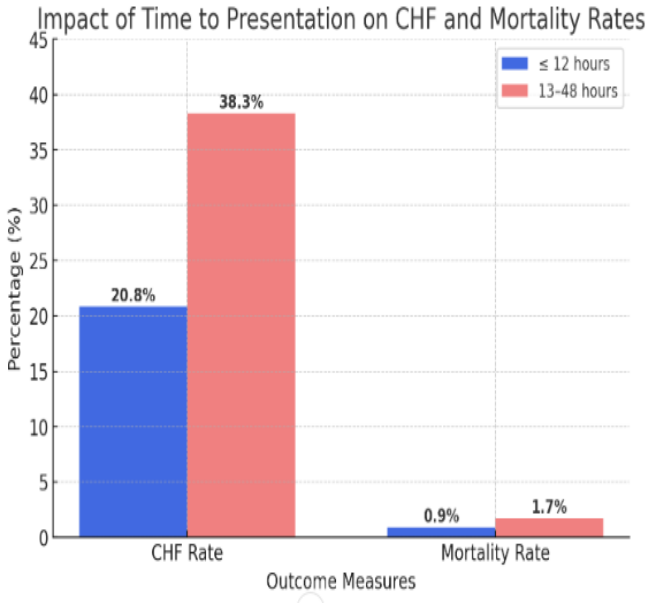


Table 1: Baseline Characteristics of the Study Population

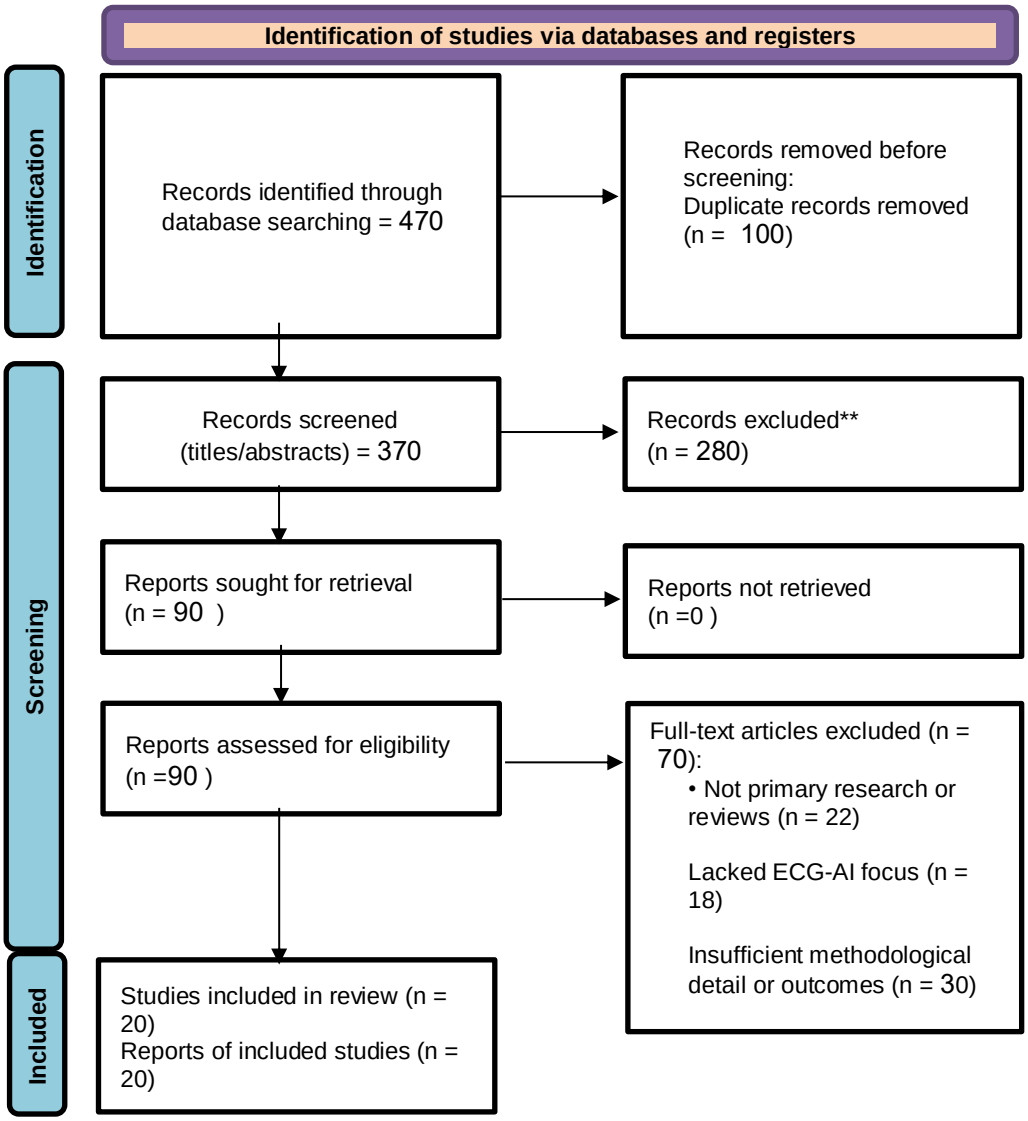
Risk Factors and History	Number (166)	Percentage
Age (years), mean ± SD	54.5 ± 10.5	-
Male gender	152	91.6%
Hypertension	82	49.4%
Diabetes	41	24.7%
Active smoking	57	34.3%
Dyslipidaemia	51	30.7%
Familial history of CAD	17	10.2%
Previous PCI	20	12.0%

Table 2: Procedures and Management

Vascular Access	*Number (166)*	*Percentage*
Femoral	***130***	***78.3%***
Radial	***36***	***21.7%***
Severity of CAD		
1-vessel disease	***93***	***56.0%***
2-vessel disease	***46***	***27.7%***
3-vessel disease	***27***	***16.3%***
Left main	***4***	***2.4%***

Table 3: In-hospital Outcomes According to Time of Admission

Outcome	≤ 12 hours (n = 106)	13–48 hours (n = 60)	p-value
Congestive heart failure, n (%)	22 (20.8%)	23 (38.3%)	0.01
Ventricular tachycardia, n (%)	3 (2.8%)	1 (1.7%)	1.00
Atrial fibrillation, n (%)	1 (0.9%)	1 (1.7%)	1.00
High-degree AV block, n (%)	2 (1.9%)	1 (1.7%)	1.00
LVEF < 40%, n (%)	14 (13.2%)	14 (23.3%)	0.09
Death, n (%)	1 (0.9%)	1 (1.7%)	1.00



PRISMA 2020 Flow Diagram: Study Selection Process

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