ST-Elevation Myocardial Infarction Systems of Care in Africa

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Acknowledgements

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This thesis is further dedicated to Mother Africa and all her beautiful people. May you continue to prosper and find solutions to all your challenges.

Abbreviations

ACC – American college of cardiology

ACS - acute coronary syndrome

ACTION - acute coronary treatment and intervention outcomes network

AHA - American Heart Association

ALS - advanced life support

AMI - acute myocardial infarction

BLS - basic life support

Cath-lab – catheterisation lab

CCU – coronary care unit

CPU - chest pain unit

CVD - cardiovascular disease

D2B - door-to-balloon

D2N - door-to-needle

DIDO - door-in-door-out

ECG - electrocardiogram

ED - emergency department

EMS - emergency medical service

ESC - European society of cardiology

FMC - first medical contact

GP – general practitioner

HEMS - helicopter emergency medical service

HIC – high-income country

ICU – intensive care unit

IFT - interfacility transfer

IHC - Iowa Heart Centre

IHD - Ischaemic Heart Disease

INR – Indian Rupee

IQR – Interquartile range

LATIN - Latin America Telemedicine Infarct Network

LVEF - left ventricle ejection fraction

LMIC - Low-and-middle-income-country

MACE - major adverse cardiac events

MHI - Minneapolis Heart Institute

NCD - non-communicable disease

PHF - prehospital fibrinolysis

PHT - prehospital thrombolysis

PI - pharmaco-invasive

PPCI - primary percutaneous coronary intervention

PPV - positive prediction value

QA – quality assurance

QI – quality improvement

S2B - symptom-onset-to-balloon

SSA - Sub-Saharan Africa

SOAR - symptom-onset-to-arterial-reperfusion

STEMI - ST-elevation myocardial infarction

STEMI SOC - ST-elevation myocardial infarction system of care

TIT - total ischaemia time

TT - thrombolytic therapy

USA – United States of America

USD – United States Dollar

WHO - World Health Organisation

Part A

Literature Review

Introduction

Globally, cardiovascular disease (CVD) is the leading cause of death. [1] Ischaemic Heart Disease (IHD) is one of the leading causes of CVD, others include ischaemic and haemorrhagic strokes, peripheral artery disease, aortic aneurysm, and several other CVD complications. [2] The implementation of evidence- and guideline-based treatment recommendations over the last few decades has seen high income countries (HIC) markedly reduce their IHD related mortality. [1] Contradictory to this success, data shows a concerning increase in IHD related deaths in low-and-middle-income-countries (LMIC). [3,4] ST-Elevation Myocardial Infarction (STEMI) is a life-threatening condition of IHD that requires early timeous intervention to decrease mortality and morbidity. The age-old adage of time is muscle is well renowned in the medical society. As time to treatment of STEMI increases, more heart muscle death occurs worsening the outcome of the patient. Several studies have shown that early treatment of STEMI can greatly reduce death and disability. [1,5–7]

A functional Emergency Medical Service (EMS) system, pre-hospital electrocardiogram (ECG) diagnosis, telemedicine, early access to the appropriate reperfusion strategy, inter-agency cooperation, emergency department (ED) bypass and several other interventions can be used to decrease the time delays to treatment. The challenges in LMICs are different to those faced in HICs, but by implementing regional specific STEMI systems of care, policy makers can contribute greatly to decreasing treatment times in STEMI.

Ischaemic Heart Disease

IHD represents a group of clinical conditions that relates to myocardial ischaemia, or inadequate oxygenation of the heart muscle. This can be chronic and not acute (such as the case of angina pectoris, anaemia, cyanotic congenital heart disease, or advanced lung disease); or sudden and more critical (such as unstable angina, STEMI, and non-STEMI). [8] This acute phase is known as acute coronary syndrome (ACS), of which STEMI is the most alarming condition. ACS is caused by an occlusion or narrowing of a coronary artery. This can be caused by a blockage, spasm, or rupture, subsequently blocking oxygen to the heart muscle. This blockage leads to ischaemia and subsequently infarction of the heart muscle depending on a number of aspects such as the duration and extent of the blockage and the myocardial oxygen demand. [9]

For the sake of immediate treatment strategies, such as reperfusion therapy, patients with continuous chest discomfort or symptoms suggestive of ischaemia, and new ST-segment elevation (STEMI) in at least two contiguous leads or new bundle branch blocks with ischaemic changes on ECG, can be classed

as having a myocardial infarction. [1] In contrast, some patients can present with continuous chest pain but without ST-segment elevation, known as non-STEMI requiring a different treatment approach. [1]

Low-and-middle-income countries constitute 80% of the world's population, or roughly 5,86 billion people. [3] As mentioned, IHD and STEMI is increasing at an unprecedented rate in these countries, therefore, this should be a cause for great concern and should prompt prevention and control strategies, public and clinical education, in addition to treatment guidelines standardisation. It is estimated by the World Health Organisation (WHO) that up to 80% of all cardiovascular deaths now occur in LMICs. [3] Data on STEMI incidence in LMICs are scarce and limited, but estimations are well beyond 3 million cases a year in India alone. [10] If one looks at the global burden of CVD, it is noted that LMICs has seen an increase of 66% in CVD deaths from 1990 to 2013, also concerning is that these deaths occur in younger populations than those seen in HICs. [3,11] This has a substantial direct and indirect economical effect with estimated losses in the region of USD 3.76 trillion to LMICs between 2011 and 2025. [3]

Yusuf, et al, has found that major cardiovascular events and fatal cardiovascular rates are significantly higher in LMICs compared to HICs by six- and seven-fold respectively. [12] Additionally, the case fatality rates are also higher for cardiovascular diseases. Further, Yusuf also states that the usage of secondary prevention medication such as statins, beta-blockers, ace-inhibitors, and anti-platelet agents are dismally low in LMICs compared to HICs between seven- and twenty-fold. [13] The usage of these inexpensive drugs could substantially reduce the CVD burden in LMICs.

Within Sub-Saharan Africa (SSA), cardiovascular diseases are the leading cause of non-communicable disease (NCD). [4] SSA, as witnessed in other LMICs, is experiencing a rapid epidemiological transition in disease burden-profile, from infectious diseases and childhood illnesses, to more chronic NCDs. WHO estimates NCDs to overtake communicable diseases as the leading cause of death in Africa by 2030. [14] This "double whammy" disease burden will require effective health service planning and prioritisation in the near future.

The United Nations through its Sustainable Developmental Goals (Goal 3) has set a target of 25% reduction in premature mortality due to NCDs by 2025. [15]

STEMI Treatment

ST-elevation myocardial infarction (STEMI) is an urgent condition of IHD. STEMI requires early identification and rapid intervention to prevent further myocardium damage and to reduce morbidity and mortality.

Figure 1 shows the association between early reperfusion and saving of myocardium, thereby decreasing morbidity and mortality. [16] On the first part of the curve, time to treatment is critical to preserve myocardium. Any delay will impact on myocardium salvage. On the flat part of the curve, opening the infarct-related artery is more important, and PCI will be superior during this time.

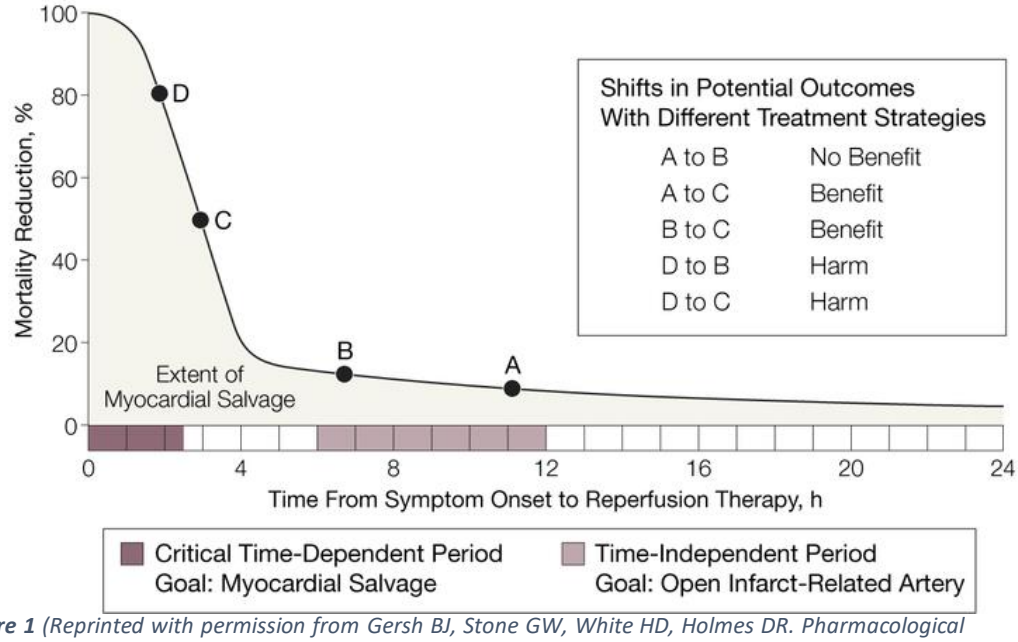

Figure 1 *(Reprinted with permission from Gersh BJ, Stone GW, White HD, Holmes DR. Pharmacological facilitation of primary percutaneous coronary intervention for acute myocardial infarction: Is the slope of the curve the shape of the future? Vol. 293, Journal of the American Medical Association. 2005p. 979–86: https://jamanetwork.com/journals/jama/fullarticle/200421*

The goal of reperfusion therapy should be to administer treatment as quickly as possible to reduce morbidity and mortality, whereas the goal of a STEMI SOC is to make this repeatable to treat the most people. [16] Primary Percutaneous Coronary Intervention (PPCI) is the treatment modality of choice for STEMI if it can be performed within 120min of First Medical Contact (FMC). [1] FMC is the first time a healthcare worker has contact with a presenting patient. PCI is the insertion of a wire-meshed tube used to stent and unblock the obstructed coronary artery and should be performed by an experienced team. However, if PCI cannot be performed within 120min of FMC, fibrinolysis is an alternative option. [1] Fibrinolysis is the administration of medication to break down the fibrin clot that is blocking the blood flow in the coronary artery. In addition to this, there is the pharmaco-invasive strategy. Pharmaco-invasive strategy entails a STEMI patient receiving fibrinolysis, followed by emergency PCI for unresolved STEMI, or routine angiography at 3-24 hours after fibrinolysis. [1,3] Several studies have shown that the pharmaco-invasive approach achieves at least similar outcomes to timely primary PCI with no differences in bleeding risks. [17–19] A pharmaco-invasive strategy is also endorsed by the

American Heart Association (AHA), European Society of Cardiology (ESC), and task groups involved with STEMI management. [3,10,20] In the majority of settings, especially in LMICs, this is a feasible and

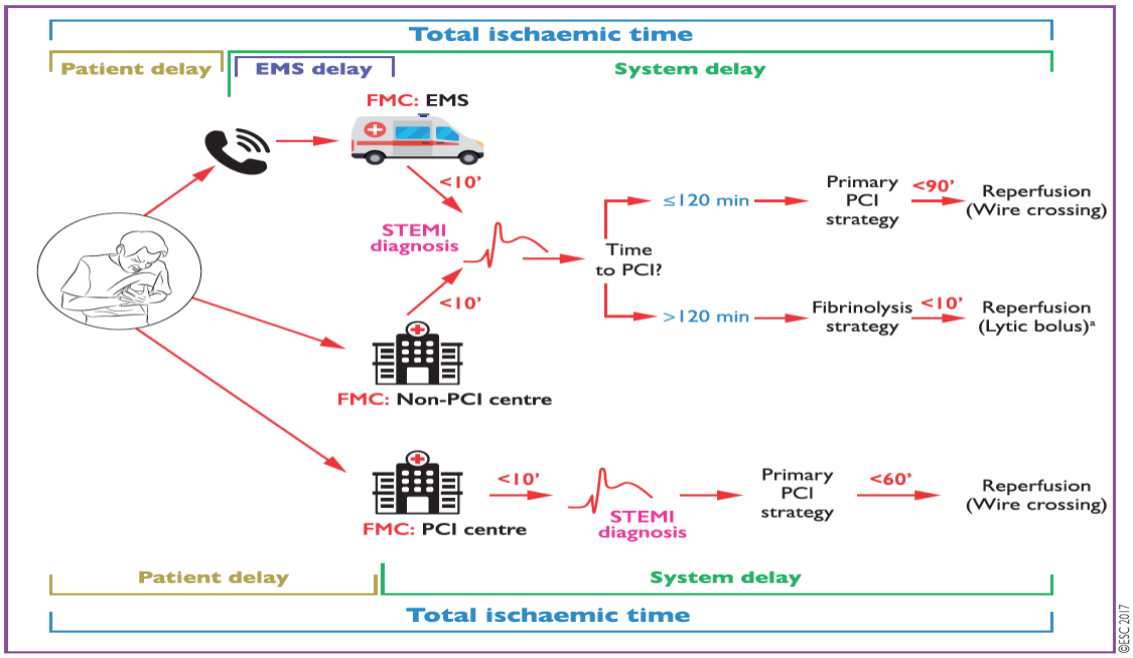

Figure 2 *(Reprinted with permission from Ibanez B, James S, Agewall S, Antunes MJ, Bucciarelli-Ducci C, Bueno H, Caforio ALP, Crea F, Goudevenos JA, Halvorsen S, Hindricks G, Kastrati A, Lenzen MJ, Prescott E, Roffi M, Valgimigli M, Varenhorst C, Vranckx P, Widimský P; ESC Scientific Document Group. 2017 ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation: The Task Force for the management of acute myocardial infarction in patients presenting with ST-segment elevation of the European Society of Cardiology (ESC). Eur Heart J. 2018 Jan 7;39(2):119-177. doi: 10.1093/eurheartj/ehx393. PMID: 28886621.*

practical option as access to PCI centres are inadequate and concentrated in urban areas. Figure 2 demonstrates these timelines. [1]

Resources and infrastructure can be combined to create a STEMI pathway, or a STEMI System of Care (SOC). This has been implemented in HIC and some LMICs with a reduction shown in long term mortality and morbidity. [3] A cost analysis done in India also indicated that the implementation of a STEMI SOC leads to an economical benefit and cost-cutting based on lives saved as well as the program's effectiveness. [21] Further, STEMI SOC is a Class 1, Level B recommendation by ESC and a national initiative by AHA known as Mission Lifeline. [1,22].

STEMI Systems of Care

Regional STEMI systems of care were created by integrating different healthcare facilities and healthcare agencies to optimise the best reperfusion strategy of STEMI patients, aiming for safe, effective, timeous, high-quality care, and optimising resources and reducing disparities in healthcare. [23]

STEMI SOC in HICs has led to a decrease in total ischaemia times and subsequent decreases in mortality. [3,23] Some LMICs have also seen meaningful improvement in reperfusion timelines by

implementing a STEMI SOC. India has seen a significant reduction in one year mortality in addition to its previously mentioned cost benefit. [24] Brazil also reported lower mortality as well as increased compliance with evidence-based therapies. [25] Similar outcomes have been observed in the Latin America Telemedicine Infarct Network (LATIN) model in Central- and South America, as well as Indonesia. [23] Generally regional STEMI SOCs are basically non-existent in LMICs. [3] Several challenges exist that are regional specific and will be discussed in more detail later in this dissertation.

An effective STEMI SOC should be tailored to the local and regional resources and needs. As mentioned, a pharmaco-invasive strategy should form an important core of the STEMI SOC. [3] Geographical mapping and situational analysis should be performed to determine what are the needs, resources, and travel times in the setting.

A hub-and-spoke model has been proposed by ESC, AHA, and focus groups concerned with implementing STEMI SOCs. [1,3] A PCI facility will serve as a hub, supported by outlying spokes, i.e., non-PCI facilities. STEMI patients who can avail PCI within 120min should be transported to the hub directly. STEMI patients outside of this 120min window should be transported to non-PCI facilities where thrombolysis can be initiated promptly. [3,23] Patients can then be transferred to a PCI facility depending on successful (3-24hrs for transfer) or unsuccessful (immediate transfer) reperfusion, i.e., the pharmaco-invasive approach. The possibility of prehospital fibrinolytic therapy should also be explored as significant benefits are observed in HICs to reduce FMC to treatment times. [3] Electrocardiogram (ECG) telemetry should be utilised to assist in ECG diagnosis and patient disposition. [1,3]

In LMICs streptokinase is still the thrombolytic of choice due to its widespread availability and low cost. [3] Fibrin specific agents like tenecteplase has been used in HICs due to its safer profile and ease of administration and should also be explored by LMICs. [1,26]

Further, STEMI SOCs should be built on accurate data and feedback loops should be used to identify treatment gaps and support quality assurance and quality improvement initiatives. This can be achieved by investing in STEMI Registries. [27]

This literature review will further explore STEMI SOCs, with an emphasis on their benefits, barriers, facilitators, and the steps taken to implement them. In an effort to include as much information on STEMI SOC as possible, this review will discuss both high-income-countries (HICs) and low-to-middle-income-countries (LMICs).

Literature Review

STEMI Systems of Care Benefits

The early reperfusion of an occluded artery remains the cornerstone in the management of an acute myocardial infarction. [1] As much emphasis has been placed on the in-hospital processes to decrease times, several out of hospital factors can also be aligned to decrease the overall Total Ischaemia Time (TIT).

These out-of-hospital factors led to the design and evolution of systems-of-care, the idea that STEMI management involves factors outside of the hospital context and how to adapt and align all of them. Since 2009 the ACC / AHA and ESC prioritised STEMI SOCs as a Class-I recommendation. [1]
A multitude of literature reported on STEMI SOC in HICs. Delli Fraine, et al, found that integrating a system of STEMI protocols and procedures, along with feedback of performance metrics to hospitals and EMS agencies, reduced door-to-balloon (D2B) and symptom-onset-to-balloon (S2B) times in Dallas County. [28]

A report from the AHA's Mission: Lifeline Program, concluded that quality of care for patients with STEMI improved once a STEMI SOC was in place, reflected through an increased use of reperfusion therapy and faster times to treatments. Overall, 147 466 patients were admitted to a total of 485 USA hospitals, that were part of 656 different systems. Additionally, STEMI SOC implementation witnessed the increased usage of prehospital ECGs, PPCI rates, as well as the PI approach. [29]

Green, et al, also compared patients from the acute coronary treatment and intervention outcomes network (ACTION) -Registry. They matched states without hospital destination policies to states with hospital destination policies and reported that prehospital ECG use was more likely, and treatment times were shorter in the latter group. [30] Similarly, Le May, et al, also found a decrease in mortality for STEMI patients transported by EMS directly to PCI facilities compared to non-PCI facilities in Ontario, Canada. [31]

In a manuscript by Huber, et al, reference is made to the concept that STEMI networks in North America and Europe has led to expanding the pool of eligible STEMI patients receiving reperfusion therapy, a reduction in transportation times, guiding transport decisions to the most appropriate facility, prehospital catheter lab activations, and a reduction in interhospital transfer delays, as well as D2B times. [32] STEMI Networks evaluated included city-, state-, and regional-wide networks all over Europe, the United Kingdom, and North America.

A policy statement from the AHA, reports that >85% of the US population is now covered in the Mission: Lifeline STEMI System of Care. Several benefits have been seen since the introduction of the STEMI SOC back in 2008. Increase in prehospital ECGs, EMS FMC-to-device time <90min has been reached in 80.1% of cases compared to 65%, ED Dwell time is down from 37 to 31min, and unnecessary patient transfers are down from 11 468 to 7 404. There is still room for improvement, as several parameters have not seen such advancements, i.e., door-in-door-out (DIDO) times from 2012 onwards are still similar, financial constraints remain, and there is no single US STEMI registry. [33]

Jollis, et al, reported on their experience within the Mission: Lifeline STEMI-SOC implementation. They enrolled 16 regions (comprising of 484 hospitals, and 1253 EMS agencies), and hypothesized that by organising leadership, data collection, common protocols, and ongoing data review with timely feedback, they could increase the percentage of patients receiving primary PCI within guideline goals. Over a period from July 2012 to December 2013 they enrolled 23 809 patients who presented with STEMI to their networks. Patients transported by EMS had shorter "Symptom onset to FMC times" (114min vs 47min), decreases in FMC to device times, increases in portion of patients presenting directly to PCI centres, and ultimately an increase in the proportion of patients treated within guideline goals. [34]

In a rural region with limited PCI facilities, Langabeer, et al, set out to implement the Mission: Lifeline STEMI SOC in the state of Wyoming, USA. They developed a standardised treatment and transfer protocol for STEMI patients. Investigators recognised that their state has a large geographical area, low population density, and limited interventional capabilities. After the interventions, total symptom-onset-to-arterial-reperfusion (SOAR) time decreased from a median of 307 minutes to 215 minutes. D2B times decreased from 53minutes to 42 minutes. Additionally, there was a greater utilisation of PPCI, from 47% to 60%, and lower fibrinolysis only rates, from 8% to 4%. [35]

However, an analysis of databases from 2006-2015 in Californian counties by Shen, et al, found that even though STEMI-regionalisation was associated with increased PCI access and lower 7-day mortality, no difference was seen in long-term mortality. A limitation, and possible reason for this finding, is that mortality data was only available till 2012, prior to the completion of regionalisation of all counties. This might explain the absence the of long-term mortality effects. [36]

Recently, Fordyce, et al, assessed in a pre- and post-implementation survey the results between the uptake of four key steps in 167 hospitals that form part of the Mission: Lifeline SOC. These were

prehospital cath-lab activation, single call PPCI transfer protocol for non-PCI facility presenters, ED bypass for direct presenters, and ED bypass for patients arriving from non-PCI facilities. The implementation of these key processes was associated with improved reperfusion times. [37]

Smith, et al, has shown in a database review that a STEMI SOC can be replicated in two different geographical regions with similar results. The Minneapolis Heart Institute's (MHI) Abbot North-Western Hospital introduced their STEMI SOC program in 2003, and the Iowa Heart Centre (IHC) introduced theirs in 2004, based a priori on that of the MHI. Both networks used similar protocols and transfer guidelines. The indistinguishable outcomes suggest the simplicity of implementing the same STEMI SOC in different regions. [38]

Similar results were witnessed in LMICs. Alexander, et al, showed in a multicentre prospective study that the introduction of a hub-and-spoke model in India increased rates in both the PI strategy as well as PPCI. [39]

Findings from a Brazilian STEMI Registry in Salvador indicated that implementation of their STEMI network in Salvador improved the use of evidence-based therapies and 30-day survival. [25] In another part of Brazil, the city of Belo Horizonte, a retrospective observational study by Marcolino, et al, also showed a reduction in AMI-mortality, from 12.3% in 2009, to 7.1% in 2011. [40]

Notably, especially for LMICs with their limited resources, Mohan, et al, have shown, in their landmark TN STEMI program, that investments in STEMI care yielded economic benefits to society. They calculated a benefit of USD 233 per life-year saved. For every INR 1.00 they spent, there was INR 3.58 gained by the economy. [21] Guy, et al, was also able to show a $2.80 saving for every $1.00 spent during a quality improvement initiative in their STEMI SOC in a small interventional study in British-Columbia, Canada. [41] An increase in prehospital lytic therapy and decreased perfusion time meant shorter hospital and coronary care unit length of stay reducing costs.

In conclusion, a review article published in the Global Heart Journal by Dharma, summarised different STEMI SOCs, their challenges, and success shows the following: PPCI increased in France from 12% to 76%; China was able to increase PCI access from 10.6% to 28.1%; an increase in PPCI from 28% to 56% was witnessed in Indonesia. Symptom onset-to-balloon times decreased from 257min to 189min in South Korea; and Singapore reported that patients using EMS transport were associated with higher reperfusion rates and subsequent shorter median symptom onset-to-balloon times. [42]

STEMI SOC Barriers and facilitators

To be able to introduce a STEMI SOC, it is essential for policymakers and planners to understand their local setting, the resources available, as well as the multitude of challenges it's likely to face.

Sørensen, et al, describes in their review how several studies have shown the relationship between treatment delay and morbidity / mortality in STEMI patients. They further distinguish between patient-related delays and system related delays. Patient-related delays refers to the time from symptom onset to presentation to EMS or GP (First Medical Contact FMC). System delays constitute a multitude of factors, these include geographical challenges, EMS delays, on-scene delays, transportation time, Door-In-Door-Out (DIDO) delay, interfacility transfer (IFT) delay, and D2B times. [43] Other barriers and facilitators to be discussed include gender, health insurance, and data collection challenges.

Patient Delay

One of the biggest challenges in STEMI management is late presentation to healthcare services of AMI patients. George, et al, assessed symptom onset to hospital presentation times in a descriptive, cross-sectional study in India. It was found that the median prehospital delay time was 4.8hours, and most patients (59%) arrived within 6h of symptom onset. Additionally, 62% of patients did not arrive via ambulance. [44] Solla, et al, also demonstrated in the RESSIST registry from Brazil that median pain-to admission times were 180minutes (IQR 90 – 473min). [45] These trends are also displayed in Cape Town, as Uys, et al, revealed 46% of patients presented >12 hours from symptom onset. [46] Recommendations were made to focus on public education, measures to improve prehospital care, patient flow in the ED, and healthcare workers education.

Chandrashekar, et al, additionally recommends public service announcements and educational campaigns educating the public on STEMI awareness. Social media, the entertainment industry, community theatres, and platform's such as "Whatsapp" and "WeChat" should also be utilised as is being done with smoking prevention campaigns. [3] Mehta, et al, concludes in their opinion paper that for the educational message to be effective, it needs to be targeted at the right group, be written in simple words, comprehensible to all levels of education, and be clear and concise. They suggested building the message into stories of movies and TV shows as it might have a bigger impact. [47]

Geographical

Another challenge in STEMI SOC is geographical area and access to reperfusion treatment. GIS and systematic mapping of geographical areas can assist in guiding reperfusion strategies and transport

decisions as shown by Ranasinghe, et al, Stassen, et al, as well as Mathew, et al, in surveys of PCI facilities and their respective transport times. [48–51] Sepehrvand, et al, demonstrated that further distance from hospital increased EMS usage during their GIS spatial data analysis in Canada. [52] PCI centres, intensive care unit (ICU) beds, healthcare workers, and interventional teams are unequally concentrated in urban areas as compared to rural settings. [23] Cole, et al, describes in their computer-based modelling how prehospital environmental variables, existing and altered healthcare resources, and health statistics can be continuously used to predict the ideal STEMI transfer protocol. Their model integrates regional infrastructure, medical infrastructure, transportation times depending on the time of day, and STEMI prediction models (based on population age), to best predict the most effective PCI pathway in a STEMI SOC containing more than one PCI-facility. [53]

The pharmaco-invasive (PI) approach has been advocated to overcome geographical barriers as part of a STEMI SOC. Fazel, et al, conducted a systematic review and meta-analysis comparing different reperfusion strategies for STEMI patients. They concluded that a PI approach is safer and more effective than facilitated PCI and fibrinolytic therapy alone. [54] A review of the literature by Rangel, also supported this finding. PI showed no difference in the occurrence of major adverse cardiac events (MACE), when compared to PPCI. [26] PI is also recommended by AHA, ESC, and several other bodies involved in STEMI management, in settings where PPCI is not possible in a timely manner. [1,3]

Prehospital fibrinolysis has been advocated to reduce reperfusion delays by several authors, policymakers, and focus groups. [1,3,23,55] Guy, et al, and Khan, et al, both demonstrated in their respective remote locations in Canada and Australia, that prehospital thrombolysis is feasible, safe, and decreases reperfusion times. [41,56] Chandrashekhar, et al encourages countries to continuously evaluate their policies and resources to include prehospital thrombolysis (PHT) once feasible. [3] However, in the South African setting, Lynch, et al, reported that PHT has not been implemented in South Africa, with several perceived barriers to its usage noted during their qualitative single-case study. [57] Nascimento advocates the use of a checklist and adequate interpretation of the 12 Lead ECG for successful PHT. The use of telemedicine can aid in STEMI diagnosis and management. [23] Other challenges in expanding PHT to the wider population in Canada, as cited by Welsh, et al, include costs, physician oversight, and disparate emergency medical resources. [58] Additional recommendations for an effective PHT system include bolus dose thrombolytics, EMS availability, trained paramedics, telemedicine availability, organised prehospital fibrinolysis (PHF) program with feedback and monitoring, and legal support. [23] Streptokinase is mostly still used in LMICs and almost phased out completely in HICs. Streptokinase is an attractive agent due to its lower cost, however, it is associated

with higher mortality rates and lower perfusion success rates when compared to the fibrin specific alternatives. Tenecteplase is easy to administer as a weight adjusted bolus and safer compared to tissue Plasminogen Activator in preventing non-cerebral bleeds and blood transfusions. [1,26]

Prehospital 12 Lead ECG and Telemetry

Prehospital 12 Lead ECG and telemetry is advised by several associations. [1,3,33] A literature review by Hemsey, et al, concluded that prehospital ECG is instrumental in emergency cardiac care and assists in identifying ACS patients early, leading to shorter reperfusion times. [59] Recommendations are that a 12-Lead ECG should be performed within 10 minutes of FMC, this will guide the EMS transportation decision. Waisman, et al, endorses STEMI networks equipped with ECG Telemetry in their editorial as it can provide remote STEMI diagnosis, enable prehospital thrombolysis in remote areas, permit rapid activation and immediate transfer to PCI facilities, and avoid costs of unnecessary transfers. [60]

Clemmensen, et al, reported on a 10-year review of the Danish STEMI SOC. The System has reported an all-time low 30-day mortality rate of 5.7%. Prehospital 12-Lead ECGs has been fully implemented by law since 2008. The 12-Lead ECG is transmitted via GSM to the receiving PCI unit where it can be assessed by a cardiologist, allowing for remote diagnosis. This also serves as early notification as required, direct admission, and decreases false-cath-lab activations. [61] Telemedicine, and prehospital 12 Lead ECG was also introduced to the RESSIST STEMI SOC and the city of Belo Horizonte in Brazil demonstrating a reduction in D2B times and mortality. [25,40] Mehta, et al, reported on the LATIN-Network that incorporated ECG-Telemetry in Brazil, Colombia, and Chile. A cardiologist at a hub hospital, telemedicine centre, or at home would remotely interpret ECGs and the STEMI protocol gets activated, either through thrombolysis or transfer to PCI facility depending on location. This strategy provides global STEMI care and helps to bridge the gaps of STEMI care. [62] Tanguay, et al, reported in their interventional study on the effectiveness in implementing 12 Lead ECG telemetry in their STEMI regionalisation network in Canada. They were able to meet the recommended <90 min interval for PPCI's consistently, as well as expanding their catchment area after the introduction of ECG telemetry and redirection to a cath-lab from rural and suburban areas. [63] Kleinrok, et al, also demonstrated through introducing ECG telemetry to their STEMI SOC in Poland a decrease in system delays. [64]

A challenge with prehospital cath-lab activation is the unavoidable toll of false cath-lab activations. Barrabés, et al, writes in their editorial that an acceptable rate for false positives can be around 10-20%. The authors recommend an array of strategies to limit these false-positive activations, including professional training, clear coordinated protocols, automated ECG analysis, medical personnel and

paramedical training, and ECG transmission. [65] Garvey, et al, found in the Mission Lifeline Project that EMS (24.7%) had a greater inappropriate cath-lab activation rate compared to physicians (7.9%) and deemed it as acceptable for the two groups. [66] Contradictory, Regueiro, et al, reported on their findings from an observational, multicentre study, within the Catalonian STEMI network in Spain that EMS activation was more accurate compared to non-PCI facilities. Additionally, they described left-bundle branch blocks, women, older patients, and previous AMIs as indicators for inappropriate activations. The authors also commented that there were no significant differences in outcomes for true-positive and false-positive STEMI diagnosis patients treated within the network. [67] Forberg, et al, demonstrated that an Artificial Neural Network can be programmed to assist in ECG diagnosis and reducing the number of unnecessary ECG transmissions. [68] Tolles, et al, implemented a "PreAct Algorithm" to decrease the rates of false positive activations. After implementation of the algorithm, the authors found that there was an increase in the Positive Predictive Value (PPV) of prehospital cath-lab activations for suspected STEMI patients. [69] Further recommendations are made by Stengaard, et al, to focus on optimisation of prehospital diagnosis of selected NSTEMI patients who also require a STEMI-like strategy. The authors hypothesize that biomarker measurements will be expected to play a role in the future. [70]

EMS Infrastructure

Several authors advocate for the organisation of the EMS network. [3,32,71] EMS needs to be integrated to optimise resources and access. Public-private partnerships can be explored. Lack of equipment, ECGs, and absence of telemetry is evident in many LMICs according to Mehta, et al. The authors additionally advocate for investment in paramedic training to assist in early diagnosis and management of STEMI. [3,32,71] Zurowska-Wolak, et al, found in their retrospective chart review that delays in the prehospital phase lowered Left Ventricle Ejection Fraction (LVEF) and increased rates of death. The authors recommended investing in ECG interpretation training, ECG telemetry, and interagency communication between EMS and PCI facilities. [72] Borowicz, et al, was able to show that there were no differences in prehospital delays or survival outcomes for STEMI patients when comparing physician to paramedic staffed ambulances in their retrospective observational study with both groups meeting Polish and European standards. [73]

Helicopter EMS (HEMS)

Helicopter Emergency Service (HEMS) has also been incorporated in STEMI SOCs with good success in decreasing treatment times. Clemmensen, et al, showed in the Danish STEMI-network that patients up to 150km from PCI centres, and those on islands away from the mainland, can be treated within

the 120min timeframe. [61] This was also shown in an article by Raval, et al, who compared their STEMI SOC HEMS in Wisconsin to that of a Polish system, where both found that HEMS and EMS coordination showed favourable outcomes. [74] Additionally, Schneider, et al, introduced changes to a HEMS STEMI transfer protocol which led to decreased DIDO times. These included allowing transferring facilities to request HEMS prior to finalising a PCI facility, limiting continuous infusions to those necessary for the flight, and training of flight crews to minimise time spent at bedside. [75] Contrary to these findings, Nicholson, et al, found in their chart review of data submitted to the Action-Registry, patients transported by HEMS had longer DIDO times and modest decreases for distances more than 40miles. Reasons indicated are possible delays in requesting HEMS and higher rates of HEMS activation for heart failure and cardiogenic shock patients. The authors recommend streamlining of the HEMS activation process, non-PCI facility bypass, or the initiation of fibrinolysis in cases where transport delays are expected. [76]

In-hospital delays

Several in-hospital changes can be implemented to assist in decreasing reperfusion times in STEMI SOC. George, et al, reported median door-to-needle times in India as 75 minutes whereas the current recommendation is 30 minutes. [1,3,44]

Chauhan, et al, implemented a fast-track protocol during a non-randomised controlled interventional trial to reduce door-to-needle (D2N) times in a rural hospital in India. Steps taken included early recognition of STEMI patients, early transfer to the hospital coronary care unit (CCU), and advanced communications to the CCU to prepare the thrombolytic medication for patient's arrival. They managed to reduce reperfusion delays with up to 60 minutes. [77] In a rural hospital in Pakistan, Rizvi, et al, demonstrated how they reduced total time to treatment by 3h05min in an interventional study. The utilisation of EMS was introduced, interagency communication improved, streptokinase made available, and a chest pain unit (CPU) was introduced to the existing ED. The implementation of a CPU decreased D2N times to 28 minutes, compared to 78 minutes in the hospital's CCU. [78]

Camp-Rogers, et al, outlined several other hospital-based strategies in a review to decrease perfusion times. [79] These included Emergency Physician activation of the cath-lab, single call to a central paging system, pre-hospital activation, cath-lab personnel arrival within 20 minutes, attending cardiologist on site, real-time data feedback, senior management commitment, and a team-based approach. Mehta, et al, suggests empowering EDs to directly activate the cath-lab, no insisting on upfront payments, and not waiting on administration formalities to be completed prior to initiating management. [47]

Non-PCI facility by-pass

Both Bennin, et al, and Bagai, et al, was able to show that EMS bypassing the ED and non-PCI facilities and taking the patient directly to the catheter lab decreases FMC2D times. Bagai revealed a median of 30 minutes is spent in the ED. [80,81] Minha, et al, showed similar reperfusion times for patients transferred >25 miles (median 36 miles) compared to <25 miles (median 13 miles) as times constantly trended lower after the implementation of a STEMI SOC in Washington. [82] Langabeer, et al, found in a rural STEMI SOC that high transfer rates were significantly associated with longer TITs. These transfer times were significantly reduced when EMS was used as the mode of transport directly to PCI capable facilities. Prehospital use in rural areas were reported to be lower compared to their urban counterparts, accordingly public education was advocated. [83] Similar results were noticed by Won Choi, et al, in South Korea, and Nippak, et al, in Canada. [84,85] EMS use significantly improved the odds to timely transportation to PCI facilities, while delays were noted during interhospital transfers, prompting the authors to recommend the implementation of policies to expedite interhospital transfers and invest in EMS infrastructure. [84,85]

Gender Challenges

It has also been reported by several authors that women experience longer delays in treatment compared to men. Alexander, et al, found in a sub-group analysis of the Tamil-Nadu STEMI Program that females had a 1.8 times increased likelihood of higher mortality. [86] Langabeer, et al, also described that women had longer SOAR times, during their interventional study of a rural STEMI SOC in Wyoming. [35] Jacobs, et al, advocates for campaigns targeting women in STEMI management as ischaemic symptoms may vary in women. [33] In addition, Jäger, et al, also reported on longer call-to-door times in the Vienna STEMI network. Female patients tending to be older, with more comorbidities and hemodynamic instability, leading to prolonged prehospital transportation times. [87] Rayner-Hartley, et al, compared reperfusion timelines and in-hospital outcomes during a retrospective analysis in a Canadian STEMI SOC pre- and post-STEMI Network implementation. Their results suggested that compared to men, women presented with more comorbidities, had longer perfusion times, and worse outcomes, but no mortality difference was observed. The authors conclude that regionalisation alone is not enough to ensure equal care, and that gender-specific strategies should also be introduced to mitigate these challenges. [88]

Health Insurance

Chandrashekar and colleagues, argue in the White Paper that government, non-governmental organisations, and other stakeholders should find ways to cover healthcare costs for STEMI patients. [3]

Funding should be directed to cover all patients, regardless of their ability to pay. Policymakers should negotiate costs and minimal pricing for drugs and devices. [3] Mehta, et al, also makes the argument, in their opinion paper in India, in favour of government support to cover expenditure as the costs to the patient has been revealed as one of the major contributors towards patient-related delay. The authors suggest a small contribution should come from the patients themselves, as it promotes awareness and co-participation in their own well-being [47]

Hospital competition

In a for-profit healthcare system, having multiple hospitals in a region can hamper the implementation of a network, as these hospital groups compete for profitable insured STEMI patients. Additionally, non-PCI hospitals might not want to enrol in STEMI SOC as by-passing them for PCI-facilities will mean a loss in revenue. Investment in EMS is also needed as this is the first point of contact for many STEMI patients into the STEMI SOC pathway. Bagai, et al, advocates in their Project: Mission Lifeline set-up design, the creation of a single prospective payment plan to be in place so all agencies involved in the STEMI SOC, including EMS and hospitals, receive remuneration. [22] Jollis, et al, found in a questionnaire to role-players in the Mission-Lifeline STEMI-network that the most common challenges were competition amongst hospitals and cardiology groups, as well as lack of funding to EMS.[89]

Data Collection and Reporting

Data collection and reporting has been shown to be another challenge in STEMI SOCs. Both Bagai-, and Fordyce, et al, state that even well-developed systems in the USA have difficulties in capturing all data concisely and in a central registry. [22,90] Comprehensive data collection into a single registry can aid in quality improvement programs. As Mehta et al, states: *"If you don't measure, you cannot improve."* Therefore, it is essential to measure all metrics and times in STEMI SOC management. Involving of all the stakeholders is also essential and can be achieved through regular interaction between ED personnel, admin, and cardiologists. [47] Scholz, et al, were able to demonstrate in a multicentre prospective interventional trial that regular data assessment and interactive feedback sessions with local STEMI management teams over a 10-year period improved performance which contributed towards a reduction in mortality. [91] STEMI registries have been introduced in other LMICs like China, Latin-America, Mexico, and India. Registries aided countries to identify and improve gaps within their respective STEMI SOCs. [92]

Mission Lifeline Challenges

In an AHA Policy Statement Jacobs, et al, categorised barriers into nonmodifiable, modifiable with difficulty, and modifiable groups as tabled below. [33]

***Table 1** – Barriers to Implementing STEMI SOC*

Non-Modifiable	Modifiable with difficulty	Easily modifiable
Distance to STEMI receiving facility	Public knowledge of STEMI symptoms and use of EMS	Lack of triage protocols specific to identifications of patients with STEMI
Local Geography	Denial of symptoms	Lack of pre-planned reperfusion strategy
Local adverse weather conditions (air transport)	Preferred provider IFT agreements	Lack of IFT plans
Traffic	PPCI cardiology on-call schedule	Unfamiliarity with fibrinolytic therapy
	Clinical staffing structure and cardiac cath-lab response	Prolonged ED dwell time
	Budget issues	Lack of back-up transfer plan
	EMS resources	Lack of back-up plans for simultaneous presentation of STEMI patients
	EMS variability	Unclear minimum expectations for IFT response and transport
	Air medical transport availability	Lack of pre-planned automatic acceptance agreements between hospitals
	Corporate loyalty / market share	Lack of QI program
	24/7/365 PCI capability	Lack of or incomplete participation in regularly scheduled multidisciplinary reviews
		Staff STEMI education

The authors recommend ways of improving STEMI SOC by focusing on community education initiatives, developing regional protocolised inter-agency collaboration, prehospital cath-lab activation and direct transfer, staff engagement and STEMI training, EMS investment, EMS protocols, EMS QI initiatives, STEMI facility pre-planned reperfusion strategies, IFT protocols, active participation of STEMI referring- and receiving facilities, prompt cath-lab activation on STEMI diagnosis, minimal ED delays, guideline-based secondary prevention initiatives, use of telemedicine, and global reimbursement to cover STEMI treatment costs. [33]

Global STEMI SOC challenges

Dharma summed up the barriers in a review of all the global STEMI SOCs as the following: geographic, logistics, administration process, ambulance equipment, traffic control, ECG transmission system, catheterization laboratory facilities, human resources, local culture, health insurance reimbursement policy, and health technology. [42] Recommendations are made to focus on system-related delays: comprising DIDO times from non-PCI facilities, through healthcare worker education, ECG transmission, rapid transfer decisions, EMS coordination, and the PI approach in suspected delays. Another delay as mentioned by other authors are the patient related delays, with again an emphasis on public education through campaigns. And lastly, the author argues for investing to increase the number of interventional cardiologists to improve overall patient care. [42]

A systematic review by Chan, et al, explored barriers in the Asia-Pacific Region. They found a decreased emphasis on long-term STEMI management outcomes, geography, patient – and healthcare worker education, lack of hospital policies, lack of guideline-recommended pharmacotherapy, and continuity of care were some of the main themes in this region. [93] Further, the authors recommend longer-term patient surveillance, greater patient education, overcoming of geographical challenges, and the adoption of value-based over cost-based healthcare systems.

Stassen, et al, assessed the barriers and facilitators to implement a STEMI SOC in South Africa, and summarised the findings thematically. STEMI SOCs in South Africa are perceived to be fragmented, under-resourced, not prioritised by policymakers, and characterised by substantial variation. It's further plagued by delays at different entry points to the system. Legislation, quality assurance / quality improvement (QA/QI), and guideline directed thrombolysis were endorsed by participants to assist in overcoming these barriers in South Africa. [94] A small cross-sectional observational pilot study in Pretoria suggested EMS is poorly utilised, and cath-lab activation times did not meet global standards, 9h20min and 20h11m respectively for direct admission and inter-facility-transfers. [92]

STEMI SOC Set-up

Optimal organizational STEMI Networks has been advocated by ACC/AHA and ESC STEMI guidelines to be implemented as Class I Indications. Their aims should be to:

- Offer PPCI to the greatest proportion of patients within recommended timespans.
- Provide optimal care to STEMI patients in the prehospital setting, this entails early diagnosis, cath-lab activation, and initiation of prehospital thrombolysis if PPCI timelines are not met.
- To bypass non-PCI facilities to maximise PPCI-appropriate admission rates. [1,95]

Additionally, Huber, et al, advocates that STEMI networks should have well-articulated goals, be evidence-based, and to enhance the speed and delivery of reperfusion to all eligible patients. A network should be adjustable to local conditions, easy to follow, accepted by all stakeholders, constantly audited and malleable to new lessons learned. [95]

Several authors and policymakers have reported extensively in papers on the creation of STEMI SOCs. One such a document by Chandrashekhar, et al, is a White Paper that has been created specifically for LMICs and will be used for the foundation on which this following Chapter will be built on. [3]

The authors recommend the following steps during the creation of a STEMI SOC:

Government Support

For any STEMI SOC to be successful, government support and buy-in is crucial.

Investments in social insurance or universal health insurance, should be prioritised to ensure equal access to care to all, irrespective of their abilities to pay. Examples can be seen in India's Tamil Nadu Social Insurance Scheme. All the hospitals in the STEMI SOC were covered by the state government insurance scheme, this ensured equal access to all social classes, regardless of their ability to pay. Thrombolysis, catheterisation and PCI, hospital stay, and medications were all covered under this scheme. [96] Brazil also offers completely free medical care to STEMI patients through the Brazilian Unified Health System. [45]

Government should push through legislation to accredit STEMI hospitals, prescribe minimum training requirements, medication stock, and manpower requirements to manage STEMI patients. [3]

Minimum standards should be introduced outlining the training and equipment requirements for ambulance services. [3,47]

Transfer protocols should be established to allow EMS to bypass non-PCI facilities directly to STEMI-accredited hospitals. New STEMI-accredited hospitals can be regulated to ensure an even distribution of PCI-facilities. A similar "Certificate of Need" legislation was introduced in the USA. [3] This can potentially encourage newer centres in underserved areas.

Coordination of dedicated or shared ambulance networks and integration to allow them to be optimised and reprioritised where needed. Public-private partnerships could also be explored by

government if needed. Minimum requirements for ambulance system should include paramedics trained in performing and basic analysis of ECGs; Protocols for STEMI management; Emergency Medications; ECG equipment, preferably with telemetry capabilities; multifunctional monitoring devices; and defibrillators. [3,23,47]

Government should coordinate with technology companies for innovation in supplying low cost 12 Lead ECGs. This helps in overcoming manpower and infrastructure constraints. Alexander, et al, refers to their model, a low-cost 12 Lead ECG device that was developed, capable of ECG transmission, vital sign monitoring, and data storage to assist in analysis and quality improvement purposes. This device can be used in the patient's home, in an ambulance, or any hospital facility. [24,96] Jacobs, et al, advocates for readily available 12-Lead ECG technology in their AHA Mission Lifeline Policy Statement as it serves as the first diagnostic test to be performed for all chest pain patients in the ED or EMS environment. [33]

Granger, et al, also echoes the sentiment to focus on the prehospital system as has been the case in Mission Lifeline. Prehospital delays account for a large majority in the STEMI pathway. Additionally, there should be an emphasis on DIDO times to meet the global standard of 30minutes. [29]

As the government will be investing heavily into STEMI care, they should opt to negotiate minimal essential drug and device pricing. Locally sourced methods and products can be sourced and with bulk purchasing prices can be reduced.

Policy-Makers

A dedicated team consisting of STEMI SOC role-players should be gathered to coordinate and set up the network. This team should consist of government liaisons, statisticians, cardiologist groups, EMS representatives, information technology, health related NGO's, policymakers, and hospital management. [3,24,47] The team should be responsible for program administration, STEMI protocol implementation, identifying local challenges, data collection, and reporting. Geographic mapping (through GIS) along with resources and manpower mapping can be done to determine resources and travel times. [23]

The STEMI-India model showed that a dedicated team ensured collaboration amongst hospitals, EMS, and insurance agencies. [24]

This team should also endeavour to set up a STEMI registry. The STEMI registry should ideally be securely cloud based, give real-time feedback, enable data collection and analysis. Facilities should be able to input their data and be able to access various parameters to allow data analysis, audit, and quality checks. Countries should aim to build these live registries, as seen in STEMI-India, AHA's Mission Lifeline, Brazil's RESSIST registry, and others as they allow for regular feedback and monitoring of outcomes. [3,24,25]

Additionally, The STEMI SOC role-players should also advise on STEMI management algorithms, transportation decisions, and discharge or post-discharge management. This includes efforts to ensure smoking cessation, ongoing management of diabetes mellitus, encouraging of regular physical activity, and advice on dietary changes. [3]

Patient and Healthcare worker Education

As seen earlier, late presentation to hospital for STEMI patients is common in LMICs. STEMI SOC role-players should focus on education campaigns to make the community aware of the signs and symptoms. Additionally, the general public should be made aware of treatment modalities in STEMI management, the use of EMS, and which hospitals to present to in cases of chest pain. [3] In the Mission Lifeline system, policymakers advocate for increased public awareness of the advanced capabilities of EMS and their role in the STEMI SOC and how it affects STEMI patient outcomes. [33]

General practitioners and community healthcare centres are generally the first point of entry in a STEMI SOC for a large portion of patients. [3] It is therefore advisable that these entities should attempt to procure some sort of subsidised or low-cost ECG machine. It is essential that established protocols are in place for these ECG's to be sent off for remote diagnosis if required. [3,47] Efforts should be made for rapid triage of patients presenting with chest pain to facilitate early reperfusion. This can be achieved through continuous medical education programs which should be low-cost or no-cost to the healthcare worker. [3,23,47]

Nascimento, et al, additionally advocates for task shifting of healthcare workers in addition to non-medical workers. Examples of task shifting include greater EMS responsibility, telemedicine and regulatory staff, quality assurance, data collection, data maintenance, and continuity of care. [23]

AHA recommends all advanced life support EMS practitioners to have readily available 12-Lead ECG capabilities, and all BLS personnel to be able to obtain an ECG on chest pain patients. [33] The Canadian

Cardiovascular Society advises regional networks to have predetermined EMS transport protocols when advanced life support ALS is required in place. These should be based on geography, resources, and other system factors. Primary Care Paramedics (Similar to Emergency Medical Technician Paramedics) should be able to safely transport the majority of chest pain patients to PCI facilities. Should patient condition deteriorate, crews should divert to the closest ED facility should an ALS practitioner not be available. [97] Sørensen, et al, reports recommendations from ESC for ambulance / helicopters be staffed with personnel skilled in recognising AMI; administering oxygen; relieving pain, and basic life support (BLS). In addition, at least one person on board should be skilled in ALS, 12-Lead ECG acquisition and diagnosis, and a healthcare worker skilled in advanced airway management and pharmacological therapy to manage cardiogenic shock and / or malignant arrhythmias. [43]

Clinicians should be well versed with AMI or STEMI definitions and clinical diagnosis. [3] Periodic training should be done, with an emphasis on spoke hospitals, especially those that will be newly introduced to being thrombolytic centres. [24]

Therapeutic Options

The end-goal in STEMI treatment is restoring blood flow to the heart. PPCI is the preferred option if it can be delivered in a timely fashion by an experienced team as it restores coronary flow more completely compared to fibrinolysis, and with fewer adverse events. [1,3] However, fibrinolysis is most commonly used in LMICs for the treatment of STEMI due to the lack of PCI facilities. [3] Relative and absolute contraindications should be excluded prior to administration. Fibrinolysis has the best effects if given within the first two hours of symptom onset, it is also the preferred option if PCI therapy is not available or cannot be delivered in a timely fashion. [1,3] Prehospital fibrinolysis should also be explored and introduced if feasible. [1] Governments should consider bulk purchasing and pursue active negotiations to lower prices for the more expensive fibrin specific agents. [3] Further, as LMICs have a scarcity in PCI facilities, the pharmaco-invasive approach is suggested. [3,23] This involves early fibrinolysis, followed by either transfer to a PCI facility for rescue PCI in the case of failed fibrinolysis, or routine angiography 3-24 hours later for those successfully reperfused. Similar outcomes were seen compared to PCI alone in the CAPTRIM trial, PRAGUE-2 trial, STREAM, and STEPP-AMI trials. [99–102] . 3 PPCI should be permitted without the need for surgeon standby. Drug-eluting stents generally have better long-term results and safety data, however their costs might limit their availability in LMICs. If practical, they should be considered in certain population groups, i.e., smaller vessels (<3.0mm), longer lesions (>20mm long), and diabetes mellitus patients. [3] Once again, Chandrashekhar, et al, argues for governments to pursue bulk buying and negotiations to decrease these prices. Policymakers

in India were able to decrease prices of stents by up to 85% this way. [103] During the index-procedure, operators can elect revascularization of both the culprit and non-culprit vessels. This will aid in limiting the need for repeat procedures and improve outcomes. [3] The Canadian Cardiovascular Society (CCS) recommends thoughtful consideration and individualisation of each case separately. [97]

AHA Mission Lifeline recommends non-PCI facilities should have algorithms in place prescribing the step-by-step procedures during STEMI management. Pre-approved guidelines should be in place depending on the transportation time to a PCI centre. Should a PI approach be implemented, facilities should still be prepared to refer those in whom the primary strategy cannot be implemented. DIDO times should be <30minutes. Administration of conjunctive medications should be standardised and protocolised in fibrinolytic therapy cases. [33]

STEMI SOC Models

Figure 3 illustrates the STEMI care model by Chandrashekhar, et al, explaining each entry point to the STEMI SOC and the transport pathways each should be taking. In the event of a patient presenting to a Level 1 facility (Local GP, PHC facility without ECG), the clinician should examine whether the patient is high-risk, or low risk. High risk patients will be transported directly to the nearest reperfusion centre for confirmation and definitive treatment, this can be either PCI Facility if <30 min, or a non-PCI facility with thrombolytic therapy (TT) availability >30minutes / 30miles. Low risk patients can be transferred to a Level 2 facility (ECG available, but no TT). All facilities should transfer patients to the Level 5 PCI capable facility once STEMI has been diagnosed and transport times are within 30 minutes / 30 miles. If transport times are more than 30 minutes / 30 miles, they should be transported directly to the Level 3 facility where TT is available. [3]

In figure 4, Chandrashekhar, et al, illustrates the Ideal Reperfusion algorithm to follow once a patient has been diagnosed with STEMI, depending where in the STEMI SOC the patient has presented. The authors recommend the global standard that Primary PCI be performed within 120minutes. This entails patients close to cath-labs, like those in urban areas, or within 30minutes transport time to facilities equipped with 24/7 PPCI capabilities. For those more than 30minutes transport times, such as rural areas, or if fibrinolysis can be given >60minutes earlier than PPCI, the PI approach is recommended (fibrinolysis, followed by catheterisation and PCI if indicated, within 3 – 24 hours of fibrinolysis). [3]

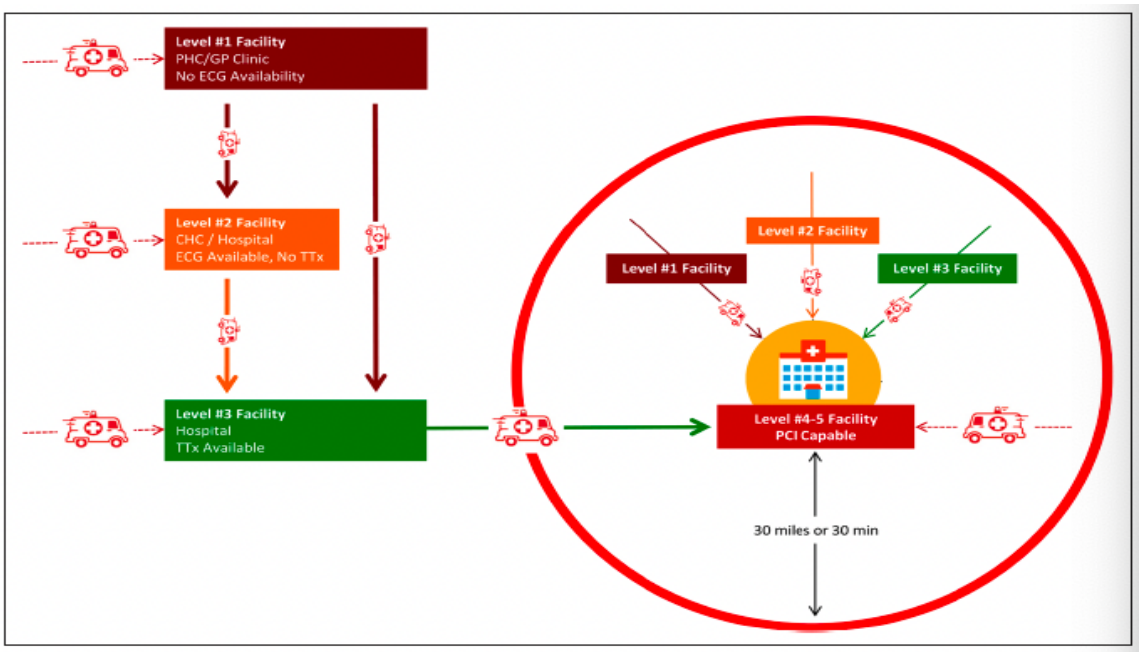

Figure 3 *(Reprinted with permission from Wolters Kluwer Health Inc. Chandrashekhar Y, Alexander T, Mullasari A, Kumbhani DJ, Alam S, Alexanderson E, et al. Resource and infrastructure-appropriate management of ST-segment elevation myocardial infarction in low- And middle-income countries. Circulation. 2020 Jun;141(24):2004–25.)*

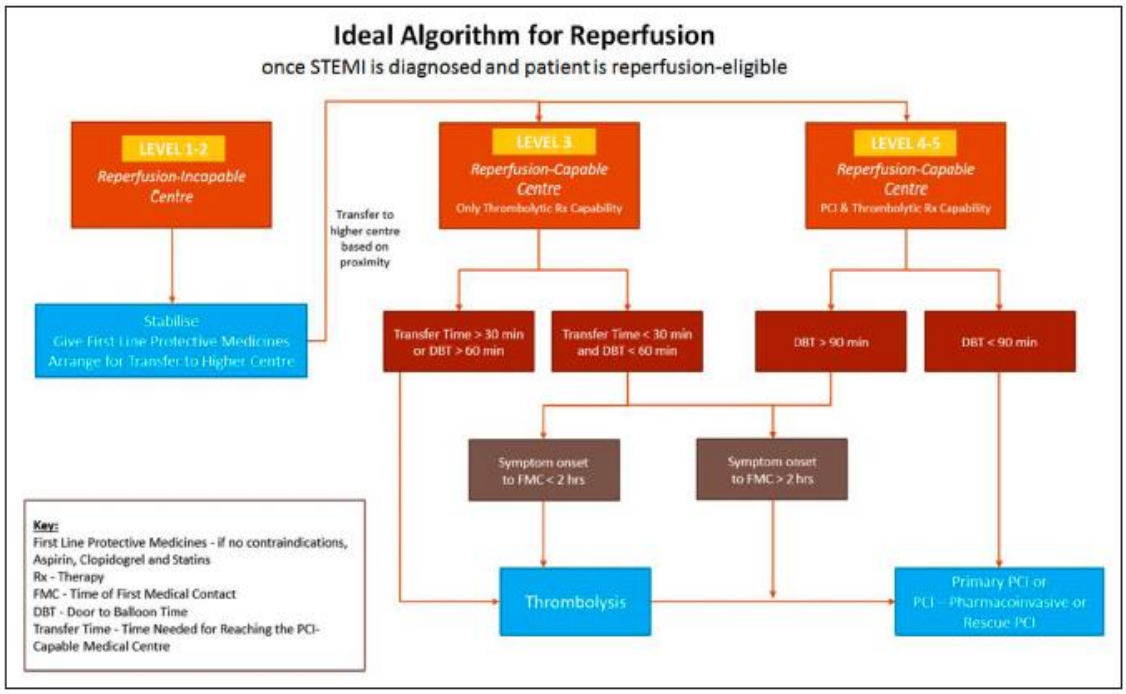

Figure 4 *(Reprinted with permission from Wolters Kluwer Health Inc. Chandrashekhar Y, Alexander T, Mullasari A, Kumbhani DJ, Alam S, Alexanderson E, et al. Resource and infrastructure-appropriate management of ST-segment elevation myocardial infarction in low- And middle-income countries. Circulation. 2020 Jun;141(24):2004–25.)*

Alexander, et al, proposes a hub-and-spoke model as seen below. This is similar to "levels" created by Chandrashekhar, et al. In the STEMI India model, Hub hospitals (PCI facilities) are "teamed-up" with Spoke hospitals (non-PCI facilities), and based on transportation times, a reperfusion strategy is implemented. Hub A (Public Hospital / or 24/7 PCI capable facility) and Hub B (Private hospital / PCI capable facility that is not 24/7) would have an agreement, should one of the Hubs be overburdened, the other hub will assist and handle the overflow as needed. Public-private partnerships should be explored, and payments could be made via social insurance schemes. [24,96,104,105]

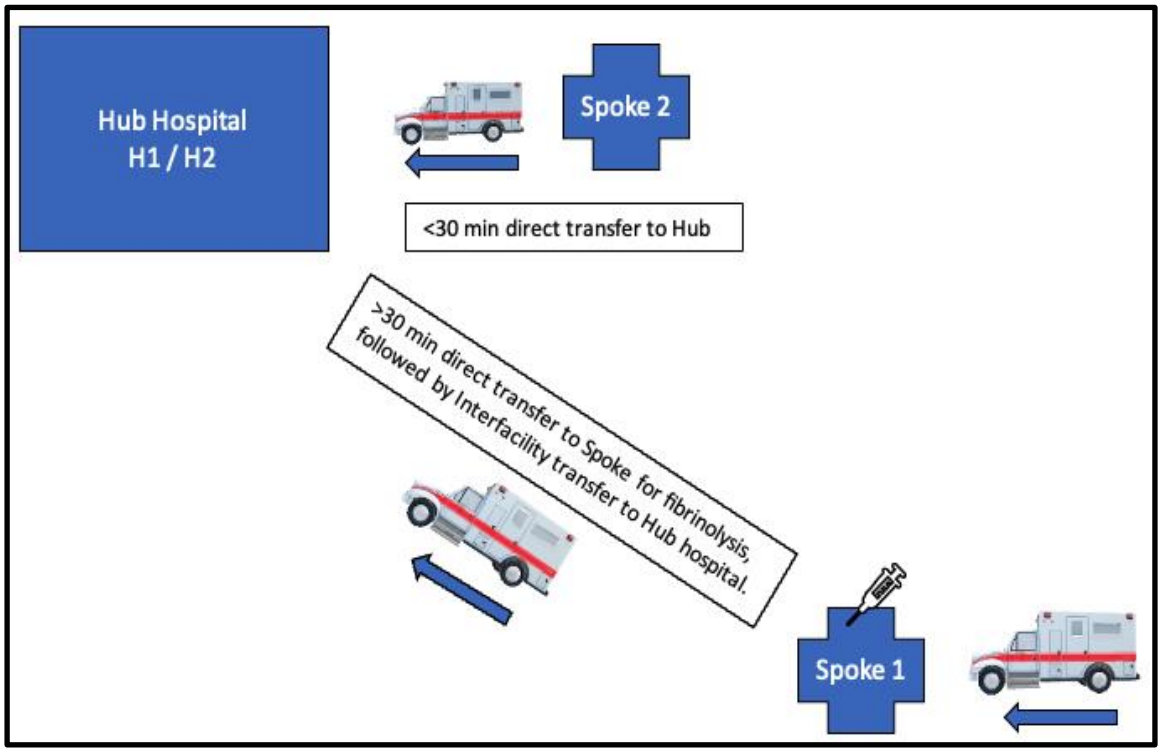

Figure 5, *STEMI India model.*

Alexander, et al, recommends legislation and regulatory measures be used to accredit hospitals to manage STEMI. Additionally, "marketing" these hospitals as "Heart Attack Accredited Centres" enables patients within the region to present directly, further reducing unwanted delays. [24]

AHA and CCS policies also supports the 120minutes FMC2D times. Recommendations are made that non-PCI facility DIDO times to be <30minutes and transport times for IFT to be <60minutes. PCI facilities should strive for <30minutes D2B time for patients arriving from a non-PCI facility. [33,97]

Data Collection and Quality Assurance / Quality Improvement (QA/QI)

A secure cloud-based IT platform, with real-time access from any device, would assist in data collection and sophisticated analytics. An administrator should be able to log on to a live dashboard, input their respective data, and allow for quick data analysis, audit, and quality checks. Hospitals generally improve their performance by having continuous feedback systems in place. [3,23,24] STEMI data collection and reporting initiatives such as AHA Mission Lifeline and ACC's ACTION registry provides regular feedback on patient characteristics, process measures, and outcomes achieved for their respective sites compared to local and national data. Some LMICs have explored such registries and future efforts should build on these experiences. [3]

Data from these registries should be used to assess and implement quality control metrics in the STEMI SOC. Key performance indicators (KPIs) should be identified and measured. These KPIs should be contextualised to each country and jurisdiction, but generally consist of STEMI care use rates, actual reperfusion times, choke points in achieving internationally accepted goals for timely reperfusion, and a detailed data base of outcomes. This captured data, could become instrumental and form an integral part where LMICs are introducing social insurance schemes and whereby facilities can receive reimbursement. [3]

Conclusion

In conclusion, it is therefore clear that the coordination and introduction of STEMI Systems of Care potentially has great advantages especially for LMICs. A myriad of barriers as well as facilitators exist in the implementation of these networks. Each setting will be unique and will require interagency liaison, government support, infrastructure investment, legislation, and quality assurance programs, amongst others to contribute towards the successful implementation of a STEMI System of Care.

The so-called double whammy of expected increase in prevalence of IHD in Africa, along with the traditional communicable disease epidemic, should trigger African countries to find innovative solutions to deal with these expected challenges. STEMI SOC holds great potential to overcome inadequate access to care for ACS patients while being cost effective, reducing treatment delays, allowing more people to access PCI, and essentially reducing morbidity and mortality. As it is hypothesised that studies relating to STEMI SOC in Africa is scarce, a scoping review will be proposed to explore the literature to determine the current state, barriers, and facilitators to implementing STEMI SOC in African countries. This can serve as a foundation to inform research and implementation priorities.

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Part B

Manuscript

ST-Elevation Myocardial Infarction Systems of Care in Africa: A Scoping Review

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Abstract

Objectives: The aim of the study is to describe and summarise the body of literature pertaining to ST-Elevation Myocardial Infarction Systems of Care (STEMI SOC), as well as barriers and solutions to STEMI SOC implementation in the African context.

Methods: The Scoping Review has been designed following the PRISMA-ScR Guidelines. The search strategy consisted of three elements: STEMI Systems of Care, STEMI, and Africa. These three elements were combined to compile a comprehensive search strategy to answer the main research question. EbscoHost, Medline via PubMed, and Google Scholar databases were searched. All study types that collected primary data or that ran an analysis on an existing data set, conference abstracts, reports, and unpublished 'grey' literature were included. Studies not in English and where a full text was not available were excluded. Two reviewers independently assessed the studies for eligibility based on title, abstract, and full text. Included full-text articles were interrogated in the same manner. Data was extracted from the included literature and were subjected to descriptive analysis to develop a summary description of the main themes.

Results: A total of 656 articles were identified through the database search, 607 articles were excluded after duplications removal and full text screening. A total of 49 articles met the inclusion criteria for full review. The articles originated from studies conducted in South Africa 39%, Egypt 12%, Kenya 10%, Tunisia 10%, Ethiopia 8%, Ivory Coast 6%, Cameroon 4%, and one study each from Sudan, Tanzania, Libya, Nigeria, and the combined Maghreb Region. The literature on STEMI systems of Care in Africa is scarce with only Egypt, Tunisia, and South Africa reporting some information on their systems. STEMI patients in Africa are generally younger than their Western counterparts, present late to healthcare facilities, have low education levels, insufficient healthcare insurance, and are non-adherent to discharge medication. Emergency Medical Services are lacking, there's a shortage of PCI-facilities, EDs are disorganised, STEMI reperfusion times are delayed, data collection and quality assurance initiatives are inadequate, and STEMI-referral networks and -registries are left wanting. In addition, there's a deficiency of ECG and telemetry, a shortage of healthcare workers, a lack of adherence to guideline recommended therapy, and a perceived hesitancy of medical personnel to administer fibrinolytics, suggestive of a need for more clinical education.

Conclusion: A myriad of barriers has been reported in this review, as well as potential facilitators in the implementation of these networks. The coordination and introduction of a STEMI Systems of Care in African settings potentially holds great advantages as has been witnessed in other LMICs and HICs.

Introduction

Ischaemic heart diseases (IHD) are the leading cause of death and disability globally. [1] It accounts for more than 1 out of every 10 premature deaths caused by non-communicable diseases. [2]

High-income countries (HICs) have seen a decrease in cardiovascular disease (CVD) mortality, whereas low-and-middle-income countries (LMICs) are experiencing a rise. [3,4] It is estimated that 80% of CVD deaths now occur in LMICs, consequently impacting the younger working age population with significant direct and indirect economic consequences. [5] This phenomenon is due to better care and prevention in HICs; in comparison to urbanisation, lifestyle changes, population growth, aging, and changing health epidemiology in LMICs. [4] Furthermore, it is predicted that the incidence of CVD will double in Sub-Saharan Africa and is projected by the World Health Organisation to overtake communicable, maternal, perinatal, and nutritional diseases as the leading cause of death within the next two decades. [3,6]

ST-elevation myocardial infarction (STEMI) is an urgent condition of IHD. STEMI should be treated early to prevent further myocardial damage and to reduce morbidity and mortality. Primary Percutaneous Coronary Intervention (PPCI) is the treatment modality of choice if it can be performed within 120min of First Medical Contact (FMC). [1] However, if PPCI cannot be performed within 120min of FMC, fibrinolysis is an alternative option. [1] Fibrinolysis might be a viable option in LMICs with limited resources. [5]

The European Society of Cardiology (ESC) as well as American Heart Association (AHA) endorses STEMI Systems of Care (STEMI SOC) to enhance the efficacy of STEMI management. [1,7] STEMI SOC organises the healthcare system's approach to STEMI to decrease time delays and improve outcomes. [1,5,7] In several systems, including LMICs, the introduction of regional STEMI SOCs has had positive results in reducing treatment delays as can be seen in India, Brazil, and rural America. [8–11]

Along with Africa's dire shortage of PCI facilities, significant delays to reperfusion, and poor access to PCI based on geography and socio-economic status is also observed. [6,12–14] System delays in STEMI management is multifactorial and the implementation of well organised STEMI SOCs integrate prehospital and in-hospital STEMI management to decrease these delays. [9]

Aim

The aim of the study is to describe and summarise the body of literature pertaining to STEMI SOC, as well as barriers and solutions to STEMI SOC implementation, in the African context.

Methods

The Scoping Review has been designed following the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Guidelines. [15]

Search Strategy

The search strategy consisted of three elements:

1. STEMI Systems of Care
2. STEMI
3. Africa

These three elements were combined to compile a comprehensive search strategy to answer the main research question. EbscoHost, Medline via PubMed, and Google Scholar databases were searched respectively on 17, 18, and 19 October 2023. For Google Scholar the first 10 pages were reviewed. The search strategy was refined with a librarian to improve its appropriateness and accuracy and is contained in Appendix A.

Inclusion / exclusion criteria

All study types that collected primary data or ran an analysis on an existing data set, conference abstracts, reports, and unpublished 'grey' literature were included. Literature published in any language were initially included, though the search strings were in English. Only studies published between 1 August 2003 and 31 August 2023 were included in the study. Studies where a full text was not available or not in English were excluded.

Duplicate studies were manually eliminated by AP. AP and PS independently assessed the studies for eligibility based by first reviewing the title, then abstract and thereafter full text. The reference lists of the included full-text articles were interrogated in the same manner. Discrepancies were handled by WS as the supervisor and independent reviewer. Screening and data management were conducted in Rayyan. [16]

Data extraction and analysis

Data was extracted by AP from the included literature into an Excel spreadsheet (Microsoft Corporation, Redmond, Washington, U.S) which summarised the title, country of origin, purpose,

sample, methodology, and information relating to STEMI SOC. The Extraction sheet is available as Appendix B. After extraction, data were subjected to descriptive analysis to develop a summary of the main themes contained in the literature. This is supported by the extraction table and accompanied by a descriptive summary. A formal risk of bias assessment was not undertaken in this scoping review.

Ethical Considerations

The study did not pose any direct risks or benefits to any persons as there were no direct contact with participants. Furthermore, the literature included in the review is accessible in the public domain. A waiver of ethical review was obtained from the Human Research Ethics Committee of the University of Cape Town.

Results

Overview

A total of 656 articles (EbscoHost n = 310, PubMed n = 246, Google Scholar n = 100) were identified through the database search. A total of 28 duplicates (manual n = 15, Rayyan n = 13) were removed. Hereafter, 628 records were screened through title and abstract of which 545 were excluded. The remaining 83 articles were transferred to Rayyan. A further 6 articles could not be retrieved. Full-text screening was conducted whereby a further 29 articles were excluded (not focussing on Africa (n = 10); Article in French (n = 8); Not relating to STEMI SOC (n = 4) Prospective study (n = 4); Other (n = 2)). A total of 49 articles were therefore included in this scoping review. Figure 1 outlines the PRISMA diagram for article selection.

The articles originated from studies conducted in South Africa (39%), Egypt (12%), Kenya (10%), Tunisia (10%), Ethiopia (8%), Ivory Coast (6%), Cameroon (4%), and one study each from Sudan, Tanzania, Libya, Nigeria, and the combined Maghreb Region as seen in Figure 2, depicting each article's originating country. Eight studies were from the Sub-Saharan and North African area but excluded due to not being in English.

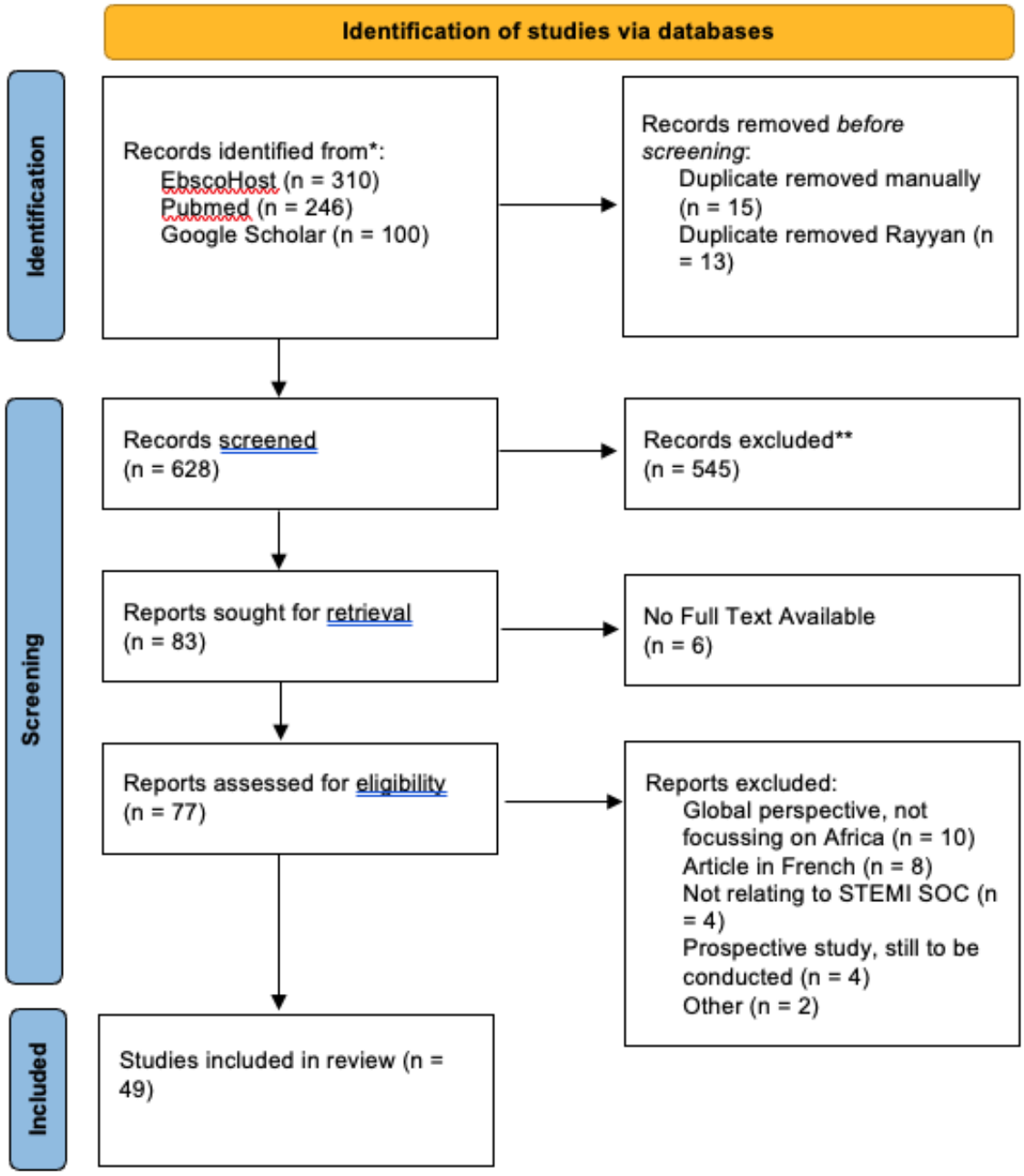

Figure 1: *Prisma Flow Diagram of database searches conducted.*

Most of the studies were facility based (69%), followed by both in- and out-of-hospital (14%), and out-of-hospital accounting for 6% of the studies. Methodologically, most of the articles were made up of quantitative literature (81%), followed by qualitative (8%), mixed methods (6%), one editorial, and one conference consensus statement. Retrospective- (40%), and prospective observational studies (37.5%), accounted for the majority of the quantitative studies. In addition, qualitative studies occurred through interviews (50%), and focus-group discussions (50%).

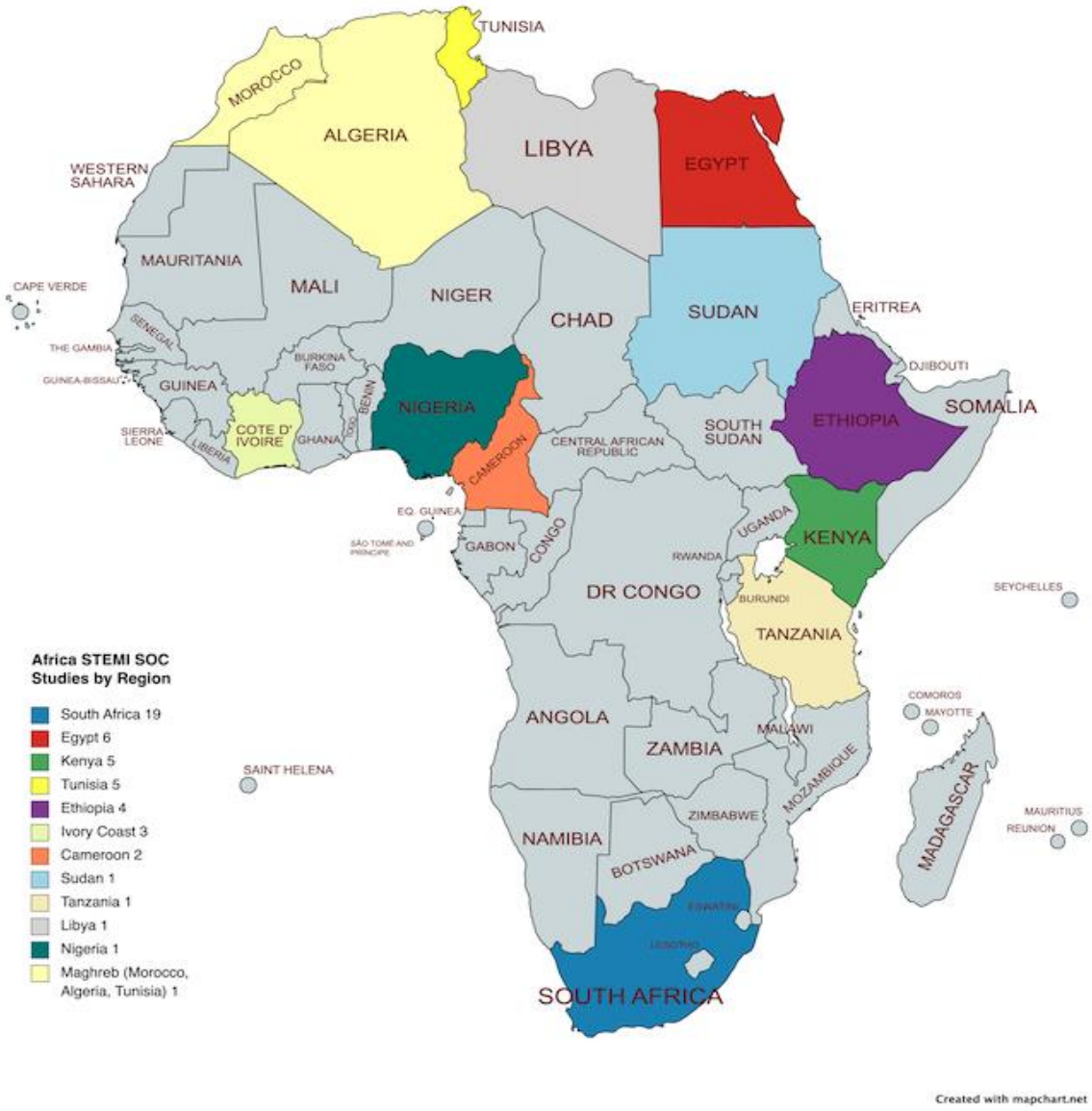

Figure 2: *Article's originating countries*

Results were grouped into seven themes. These were patient related challenges; healthcare funding challenges; prehospital challenges; policy and quality assurance; healthcare facility challenges; technology gaps; and healthcare worker challenges. Articles have been presented along with the thematic framework in the extraction sheet, Appendix B.

Patient Related Challenges

A common theme reported in every country is delayed presentation of ACS patients to healthcare facilities as depicted in Figure 3 and Table 1. It is considered as one of the biggest challenges in South Africa. [17,18] Data from the ACCESS registry (mostly private facilities) reported that 64% of STEMI

patients arrived within 6 hours of the symptom onset.[14] Public facilities reported 49.5% and 46% of patients presenting at 6- and 12 hours after symptom onset. [19,20] The mean time from symptom onset to call for help was reported in two different studies as 35 and 60 minutes (IQR 5 to 1,185min). [13,21] The median symptom onset to hospital arrival times in South Africa ranged from 3.2 - 3.6hrs. [12,14] In Egypt only 29% of patients arrive at a hospital within 2 hours of symptom onset. [22] Median presentation times were reported as 3hrs, 4hrs, 4.3hrs, and 5.3hrs respectively. [23–26] Tunisian STEMI-registry data shows that 49.5% of all cases has an initial late presentation. [27] Further, two prospective observational studies documented median times of symptom onset to arrival at emergency department (ED) as 2 hours, and 43% of calls for help were made within two hours of chest pain onset. [28,29] Earlier data from the combined Maghreb region (Tunisia, Morocco, and Algeria) from the ACCESS register reported median delays of 7 hours. [30] Kenyan data, where less than 10% of patients arrive at EDs from symptom onset, reveals times of 12 and 13 hours for STEMI presentation. [31,32] Fortunately, in younger STEMI patients aged <50, median arrival times were shorter in Kenya, Senegal, and Tunisia. [28,33,34] In Ethiopia, where no patients presented within 1 hour of symptom onset, and nearly two thirds of patients arrived with heart failure symptoms, median arrival times are reported to be 26 hours, and average times 91.7 hours or 3.8 days. [35–37] Median symptom onset to hospital admission times in Ivory Coast is reported as 20 hours. [38,39] In other African countries, 32.2 % present within 4 hours in Libya, 11.9 % within 12 hours in Nigeria, and a disappointing 61% of patients present after 24 hours to facilities in Sudan. [40–42]

Reasons for these delays include inability of patients recognising the signs and symptoms of STEMI, [13,19,21,23,25,31,35,42–46] education levels, and socio-economic status. [23,41,44,47] In Nigeria, STEMI patients in the lower socioeconomic class were 3.1 times more likely to die than those in the upper socioeconomic class. [41] Egyptian investigators reported a decrease from 230 minutes in 2011 to 60 minutes in 2016-2017 in FMC to balloon time attributed in part to a large educational campaign using social media, TV advertisements, press releases, and “Meet the Experts” public sessions. [48] In addition, policy makers advocate for the inclusion of family members in education programs, as family members increased the likelihood of patients acting early on. [23] Other challenges include patient’s reluctance to seek medical help, [21,22] long travel distances, [22,33,42,44] hospital resource (ECG’s, diagnostics) limitations, [19,31] EMS resources, [19,44] patients self-medicating, [21] and prolonged hospital triage times. [19]

Other themes that emerged includes patient’s long-term non-adherence to their discharge medications after an ACS event, [19,46,49] younger age presentations of HIV-positive STEMI patients, [50,51] and delayed treatment times worsening outcomes in the elderly as well as women. [28,42,52] One

significant finding that was universal was that STEMI patients in Africa are generally younger than those in Western countries. [14,19–21,24,26,30,31,34,35,39,41,44,48–50,53,54]

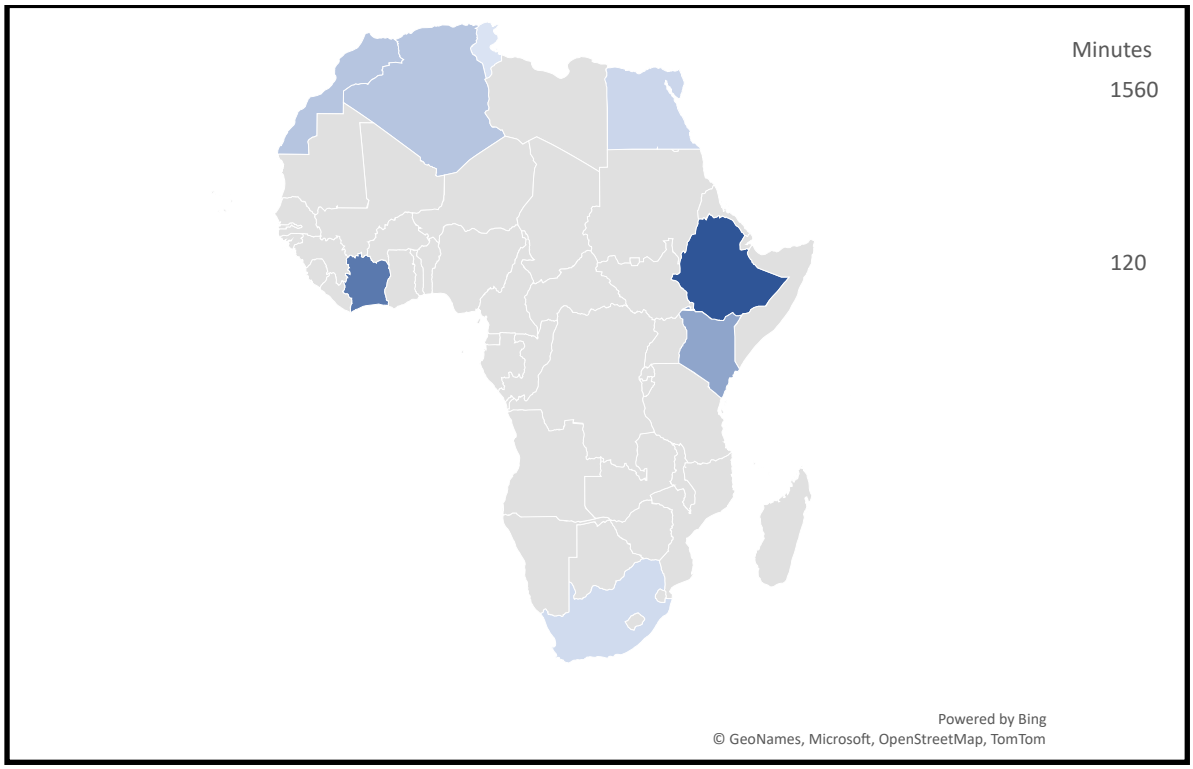

***Figure 3**: Median ACS symptom onset to hospital arrival time*

***Table 1**: Median symptom onset to hospital arrival times*

Median symptom onset to hospital arrival times	Minutes
Tunisia	120
South Africa	204
Egypt	249
Morocco *	420
Algeria *	420
Kenya	750
Ivory Coast	1,200
Ethiopia	1,560

*Maghreb Region

Healthcare Funding Challenges

African countries present with a diverse range of challenges related to funding. According to Tantchou, et al, health insurance practically doesn't exist in Cameroon. This puts strain on the extended family unit leaving them indebted. [55] These challenges are also echoed in Ivory Coast where the cost of the

"cheap" streptokinase reaches 263 USD, while the guaranteed interprofessional minimum wage is 79 USD per month, and in Nigeria where the drug is not a prioritised thrombolytic option in standard guidelines and hardly affordable. [33,41]

A lack of health insurance is raised in a few countries as barriers to effective STEMI care. [38,39,41,44] This led to non-testing of cardiac biomarkers, using bare metal stents (BMS) instead of drug-eluding stents (DES), unavailability of P2Y12 inhibitors, deviance from guidelines, non-utilisation of effective adjunct anti-platelet therapy, and hinders the introduction of prehospital thrombolysis. [35,38,39,41,56 56]

The private sector in South Africa owns the majority of all the PCI facilities and can therefore only be utilised by 18.1% of the population, unless upfront payment of up to $3500 is made. [57] This is further elaborated by Stassen, et al, Tickley, et al, and Meel, et al, who reported delays and denial of thrombolysis due to private hospitals requesting upfront payment.[13,18,21] Snyders, et al, describes needless delays due to a health insurer mandating transfer from one PCI facility to another. [45]

A cost-effectiveness analysis in Ethiopia found that an integrated package consisting of aspirin, ACE-inhibitor, beta-blocker, and streptokinase yielded significant cost benefit compared to a highly skilled intervention consisting of PCI, aspirin, and clopidogrel. Their results indicated the need to reprioritise basic pharmacologic regimens for AMI treatment in their resource-constrained settings rather than investing in high-cost interventions like PCI. [37]

In the Maghreb region, 62% of patients had government health insurance. [30] In Egypt, up to 93% of patients are covered for STEMI treatment expenses. [22,26]

Prehospital Challenges

EMS transportation of STEMI patients in Africa is negligible. Usage rates are reported as 9.4% in Ethiopia, 11.7% in Nigeria, 11.9-27.7% in Tunisia, 22% in Egypt, and a wide range of 16 – 51% in different sectors in South Africa. [12,13,20–22,28,41,44,54] This is believed to be due to the limited availability of EMS or an overburdened service. [13,18,19,21–23,32,39,44] In Nigeria the EMS service was described as practically non-existent. [41] Other challenges facing EMS in Africa is the lack of ECGs and the regulations around administering prehospital fibrinolytics. [14,18,45,56] In comparison, Tunisia and Senegal reported practising prehospital fibrinolytics in their respective prehospital settings. [33,58]

Healthcare Facility Challenges and referral

Healthcare facilities in Africa are plagued by disorganised ED units, infrastructure-, and resource limitations. [13,14,20,38,39,53] This is evident in the significant in-hospital delays for STEMI reperfusion and shortage of medications. The ACCESS Registry in the Maghreb region reported 42% of eligible STEMI patients did not receive any form of reperfusion therapy within 24hours, 30% of patients received fibrinolysis, of which the majority (92%) receiving streptokinase. This was deemed due to cost- and resource limitations. A mere 27% of eligible STEMI patients received PPCI. [30]

None of the STEMI patients admitted to two tertiary hospitals in Ethiopia received thrombolytic medication and only 7.2% of patients received PCI. This shortfall in STEMI management was due to lack of medication and limited cath-lab facilities amongst others. [44] These limitations have further contributed to longer in-hospital stays and non-adherence to guidelines whereby very few patients received morphine (12.9%) and nitrates (35.5%) in the ED. [35]

Ivory Coast reported fibrinolysis being performed in 11.3% - 13% of patients within 12 hours of onset of symptoms, and 19.8% - 21.3% of patients receiving primary PCI. Moreover, the most used stents were BMS. [38,39] Feedback from the Afri-Cardio conference indicates a severe shortage of PCI facilities, with only five cath-labs available in the 10 participating countries. Reference is made to successes in Abidjan and Dakar where new facilities have been established, and thrombolysis rates increased from 11.3% to 31% in less than a decade. [33]

A public PCI facility in Kenya reported a mere 5% of eligible STEMI patients receiving thrombolysis, and a further 12% received PCI. [53] Data from a private facility in Kenya demonstrate that 53.1% - 55% of patients received thrombolysis and 13% - 18% received primary PCI. Door-to-needle (D2N) times were 47 – 49 mins, and Door-to-balloon (D2B) times were reported as 84 and 137 minutes, respectively. In both studies, almost two-thirds of patients didn't receive any reperfusion at all. The unavailability of PCI facilities and cost implications were described as contributing factors. [31,32] Further, the absence of a 24hr on site team has been shown as causing further delays. Conversely, Varwani et al, argues due to the low volume of primary PCIs conducted in the region, it is not yet cost-effective to have an on-site team. [31] Likewise, Libya and Nigeria both reported delayed reperfusion rates in their systems. [40,41]

In South Africa there is currently 1 PCI facility for every 887,096 people, of which the majority are private facilities, concentrated in major cities and along the coast, and improperly spread with some high population-density areas deficient in facilities. [57,59,60] An example of this mis-spread is seen where

the North-West province has 1 PCI facility, and it's bordering province, Gauteng, is home to 46% of the entire country's PCI facilities. [61] Earlier ACCESS-registry data from South-Africa indicated that 18% of patients received thrombolysis on admission, with streptokinase in 54.5% and tenecteplase 30.3%. Further, PCI was performed within 24 hours of hospitalisation in 61.3% of cases. [14] An initial pilot study in South Africa assessed time intervals in STEMI referral pathways and concluded that there were significant delays where fibrinolysis was administered within 30 minutes in 50% of direct access (DA), and 20% of inter-facility transfer (IFT) patients. Primary PCI within 60 minutes of FMC was only achieved in 13% of DA patients, and none of the IFT patients. [45] Further, several observational studies in South Africa report on reperfusion times. Meel, et al, reported that only 37% of eligible patients received fibrinolytic therapy, of which only 3% received it within 1 hour. Median D2N times were reported as 60 minutes for those receiving the agent in the ED, and 85 minutes for those receiving it in the coronary care unit (CCU). Factors for these delays were poor systems of care, inadequate triage, unorganised patient flow, and under-resourced hospitals. [13] Other median D2N times were reported to range from 54 minutes by Maharaj, et al; 105 minutes by Tickely, et al; and a mean of 183 minutes by Zakariya, et al. Reasons for these delays were contributed to shortcomings in patient flow, junior doctors consulting senior doctors, lack of coordinated systems of care, busy health facilities, and the unavailability of thrombolytics. [12,20,21] Fortunately, Chetty, et al, reported D2N times of 43 minutes, citing the availability of trained physicians and expert consultation decreasing perfusion times. [62]

Two authors reported on a Hub-and-spoke model in Cape Town, South Africa. Patients present to their respective primary or secondary healthcare facility, where those with STEMI receive thrombolytics, and further referral to tertiary institutions for failed thrombolysis. Within this STEMI SOC angiography is also conducted at PCI-facilities. [19,50] However, these systems are still troubled by prolonged triage times, limited resources, a high patient burden, and insufficient ECG diagnostic proficiency. This is evident due to only 39.6% of STEMI patients receiving thrombolysis as shown by Uys, et al, and median times from diagnosis to fibrinolysis being 67 minutes, as reported by Beyers, et al. [19,49]

Earlier data from a single centre in Tunisia reported median diagnosis to reperfusion times of 46 minutes for direct presenters and 110 minutes for transferred patients. Causes of delays were noted as inter-department decisions (off-site cardiologist vs general practitioner in the ED) and transferred patients. [58] More recent results from the FAST-MI Tunisia registry, which captured data from 72.2% of Tunisian public hospitals, indicate a substantial increase in reperfusion rates. Fibrinolysis was administered in 31.8% of patients, of which 27.7% occurred in the prehospital setting, and primary PCI was performed in 30% of patients. Median times from symptom onset to fibrinolysis was 180 min and

for primary PCI was 360 minutes respectively. Regional hospitals were more inclined to administer fibrinolytics, whereas PCI-facilities performed primary PCIs more often. This was in part due to greater adherence to recommendations and better organisation of STEMI-treatment stakeholders. Some limitations identified were low levels of prehospital fibrinolysis, limited direct cath-lab admission, and poorly structured healthcare networks in regional hospitals. [54]

Egyptian authors were the first to describe in-depth their STEMI Stent for Life initiative which was launched in 2011. A registry was conducted after a series of meetings to resolve barriers previously identified. Following the meetings, a press conference, patient awareness campaigns, and physician education meetings were held. Further, the cardiology board met with the minister of health, and subsequently received support to the initiative through covering the expenses associated with PCI procedures; initiating a STEMI protocol; investing in EMS, training, along with acquiring new ECGs; rapid ECG transmission, and supporting public awareness campaigns. [26] They reported an improvement of primary PCI rates along with median D2B times. BMS were still used in 80.7% of cases compared to 19.3% receiving DES. [26]

Also in Egypt, Sobhy, et al, conducted a long-term prospective, cross-sectional, multicentre registry study evaluating their STEMI SOC from 2014-2017. An increase in immediate transfers to PCI facilities, increased number of PCIs, a decrease in fibrinolysis, and a significant decrease in D2B times from 60- to 50 minutes were reported. [48] The authors credited their education campaigns of both patients and healthcare practitioners for these improvements. Shaheen, et al, reported on their hub-and-spoke model in Northern Cairo, with one main PCI-capable hospital as the hub, along with three nearby referring spoke hospitals. WhatsApp® was used as an easily accessible digital communications platform to share ECG and relevant patient data. This allowed for swift diagnosis and urgent transfer by EMS straight to the cath-lab of the hub-hospital for primary PCI. A pharmaco-invasive (PI) approach was ensued in cases of expected delays. A written STEMI protocol along with flowcharts were applied by the hub, spoke, and EMS. Training sessions were held to demonstrate the value of early reperfusion in STEMI patients. Results were observed and reported on pre-and post-implementation of their STEMI SOC. Median time from symptom onset to FMC was unchanged between the two groups, however D2B times were reduced from 54.3 minutes to 44.1 minutes. D2N times remained unchanged. The use of fibrinolysis decreased significantly from 36.4% to 7.5%, while primary PCI increased from 59.8% to 77.1%. Both median CCU and total hospital stay days decreased after the STEMI SOC implementation. Further, in-hospital mortality improved from 6.4% to 2.8%. The authors concluded their STEMI SOC was feasible and improved patient outcomes. [24] A qualitative survey by Shaheen, et al, identified

limited resources, lack of trained interventional cardiologists, insufficient numbers of CCU beds, and lack of regional STEMI networks and hospital policies as the main barriers in the management of STEMI patients.[22]

Policies, legislation, and Quality Assurance

Several studies reported on a lack of adherence to guideline recommended therapy. Discharge medication post-STEMI has been shown to be effective to reduce complications such as re-infarction and death, these include dual-antiplatelet medications (aspirin and clopidogrel), beta-blockers, ACE-inhibitors, and statins. [28,35,53] Ethiopian and Kenyan data reveals 61.1% and 56% compliance rates, while Nigerian and Tunisian data indicated a need to increase adherence to international guidelines [28,35,41,44,53] South African authors revealed marginally better adherence with 83.6% of patients receiving appropriate secondary prevention prescriptions. [49]

In addition, various authors identified the need to implement policies between receiving and referring hospitals. Tickley, et al, commented that there was no STEMI network in place in their tertiary institution in Johannesburg, South Africa. [21] Shaheen, et al, recommends STEMI management protocols to be in place to encourage ED bypass and direct cath-lab admission, repatriation policies post STEMI management, and implementation of medical codes for post thrombolysis. [22] The authors further report only 21% of PCI centres and 8% of non-PCI centres had written STEMI management plans in place. [22] By implementing these recommendations, along with the PI approach, both Shaheen, et al, and Mohamed, et al, were able to decrease reperfusion times, increase primary PCI, decrease the use of fibrinolytics, and improve mortality in their respective STEMI SOC in Egypt. [24,48] DIDO times were reported as 40 minutes in Egypt, one hour in Tunisia, and up to 8 hours in South Africa, these delays should also be addressed with appropriate policies. [13,23,24,58] Further, as seen in South Africa and Kenya, long delays and disorganised ECG interpretation flows were noted. [12,21,53]

Furthermore, the introduction of STEMI registers was reported in Tunisia, South Africa, and Nigeria. [14,41,54] These registers stimulated improvement in ACS care and outcomes in Nigeria, and increased PCI access in South Africa. [14,41] In addition, STEMI Registers aided in data collection to assess time trends, current status and areas for improvement, and characteristics of ACS patients in Kenya and Egypt. [32,48,53] Shaheen, et al, reported on their quality control indicators for STEMI diagnosis and management being variably implemented in PCI and less so in non-PCI facilities. [22]

Technology Gaps

Several authors commented on the lack of ECGs and technology in their pre- and in-hospital systems in Egypt, Kenya, and South Africa. [13,21,22,31,32] Stassen, et al, and Shaheen, et al, both mentioned the use of Whatsapp® informally and formally amongst STEMI management role-players to send ECGs amongst each other to improve STEMI care. [18,24] Snyders, et al, showed that paramedics were taking photos of ECGs and sending it to cardiologists for expert consultation. [45]

In addition, Coetzee, et al, and Stassen, et al, presented the use of geospatial analysis (GIS), isochrones, and mapping to determine STEMI treatment and transportation pathways in South Africa. [60,61]

Healthcare worker challenges

Many African countries raised the concern due to a shortage of medical staff. Cameroon, as an example, only has one doctor per 12,500 people; Egypt, Kenya, South Africa, and Ethiopia all disclosed a shortage of trained interventional cardiologists, nurses, and technicians. [22,32,44,55]

Kenyan authors referred to poorly exposed healthcare workers failing to diagnose STEMI on ECGs. [32] This was echoed in South Africa as well, where ECG misdiagnosis delayed fibrinolytic therapy. [13] ECG misdiagnosis was reported as 10%, 16%, and up to 29.2%. [19–21] A recurring theme in South Africa, was a perceived hesitancy towards the administration of thrombolytics. This was reported by multiple authors including Snyders, et al, Tickley, et al, Stassen, et al, and Lynch, et al. [17,18,21,56] Further, Meel, et al, Bouraoui, et al, and Chetty, et al, reported on the importance of having expert opinion readily available to assist in the diagnosis of STEMI on ECG. [13,58,62]

Egyptian and Tunisian authors report in their respective STEMI SOC on the training of healthcare workers within their networks. Mohamed, et al described continuous medical education campaigns, emphasizing on the importance of immediate transfers, enrolling a total of more than 3,700 cardiologists. This training was subsequently expanded to prehospital providers and referral physicians. [48] Shaheen, et al, conducted training sessions to doctors, nurses, and technicians, which included performing quality ECGs, the value of early diagnosis and rapid referral, and the introduction of a flowchart on sending ECGs through Whatsapp®. [24] A training program was conducted in Tunisia for ED physicians to demystify the perceived risk of fibrinolysis, and another has been shown to improve ACS management and has subsequently been expanded to other regions. [28,58]

Summary

Given that the literature on STEMI SOC in Africa is scarce with only Egypt, Tunisia, and South Africa reporting some information on their systems, a myriad of barriers were identified. These included that STEMI patients in Africa are generally younger than their Western counterparts, present late to healthcare facilities, have low education levels, insufficient healthcare insurance, and are non-adherent to discharge medication. Emergency Medical Services are lacking, there's a shortage of PCI-facilities, EDs are disorganised, STEMI reperfusion times are delayed, data collection and quality assurance initiatives are inadequate, and STEMI-referral networks and -registries are left wanting. In addition, there's a deficiency of ECG and telemetry, a shortage of healthcare workers, a lack of adherence to guideline recommended therapy, and a perceived hesitancy of medical personnel to administer fibrinolytics, suggestive of a need for more clinical education.

Discussion

This scoping review set out to describe and summarise the body of literature pertaining to STEMI SOC, as well as barriers and solutions to STEMI SOC implementation, in the African context. Overall STEMI SOC literature is scarce in Africa. More research is needed to elucidate barriers and facilitators in every country, to be able to implement specific STEMI SOCs for the respective regions. Out of the 49 included articles, only Egypt, South-Africa, and Tunisia made reference to some sort of STEMI system of care within their countries. [19,24–26,48–50,54] Of these three, Egypt has shown their STEMI SOC implementation to be feasible, improved patient outcomes, and increased access to primary PCI. [24,48]

The seven universal themes identified were largely echoed in reviews by Mehta, et al, and Nascimento, et al, exploring barriers to STEMI SOC implementation in LMICs and India. [63,64]

Time to treatment is critical to preserve myocardium. Any delay will impact on myocardium salvage. [28,35] Delays in symptom onset to FMC was also witnessed in other LMICs like India and Brazil. [10,65] Several recommendations have been made to focus on public education of signs and symptoms of STEMI, the value of early diagnosis, early reperfusion, and the importance of using EMS. Chandrashekar, et al, additionally recommends public service announcements and educational campaigns educating the public through social media, the entertainment industry, community theatres, and platform's such as "Whatsapp" and "WeChat." [5] Mehta, et al, concludes that for the educational message to be effective, it needs to be targeted at the right group, be written in simple words, comprehensible to all levels of education, and be clear and concise. They suggested building the message into stories of movies and TV shows as it might have a bigger impact. [63] Countries should

explore these recommendations within their respective localities to target the intended group in an aim to decrease the delayed presentations as seen in this review.

Reasons for the younger age of STEMI patients reported in this review are diverse and regional, with causes attributed due to higher prevalence and at times undertreatment of risk factors (smoking, hypertension, obesity, diabetes, hypercholesterolaemia), insufficient prevention programs, urbanisation and lifestyle changes, shorter lifespan, HIV-prevalence, non-adherence to chronic medication, recreational drug use, and higher salt intake. [19,20,24,26,28,30,32,34,38–41,48,50,51,53,54,62] Countries should focus on their specific burdens and implement proven strategies to minimise their effects.

Substantial progress was made in Egypt with the Minister of Health investing in infrastructure, cost of PCI, funding for training, and other associated expenses in STEMI care. [25,26] Chandrashekar and colleagues, argue that governments, NGOs, and other stakeholders should find ways to cover healthcare costs for STEMI patients. Funding should be directed to cover all patients, regardless of their ability to pay. Policymakers should negotiate costs and minimal pricing for drugs and devices though bulk purchasing initiatives. [5] Mehta, et al, reiterates the need for government support to cover expenditure as the costs to the patient has been revealed as one of the major contributors towards patient-related delay. The authors suggest a small contribution should come from the patients themselves, as it promotes awareness and co-participation in their own well-being. [63] Notably, especially for LMICs with their limited resources, both Mohan, et al, and Guy, et al, have shown, in their settings that investments in STEMI SOC yielded economic benefits to society. [66,67] Investments in social insurance or universal health insurance, should be prioritised to ensure equal access to care to all, as can be seen in other LMICs like India's Tamil Nadu Social Insurance Scheme and the Brazilian United Health Service where free medical care has been introduced for STEMI care. [10,68]

The low rate of EMS usage in Africa was also reflected by Mould-Millman, et al, who reported that an estimated 8.7% of the African population is covered by a prehospital service. [69] EMS serves as the entry point to STEMI care and is instrumental in improving outcomes as it has the ability to detect STEMI early on, direct patients to the most appropriate facility or initiate prehospital fibrinolysis. Investing in EMS-infrastructure, ECG interpretation training, ECG telemetry, and interagency communication between EMS and PCI facilities are recommended. [1,5,63,70] Several systems in HICs and LMICs report on their successes with prehospital 12-Lead ECGs, telemedicine support, and direct cath-lab activations. [11,71–75] A challenge, especially in Africa with its limited resources, would be prehospital false cath-lab

activations. This can be reduced through training, ECG transmission, clear algorithms, and artificial neural networks. [76–78]

Hub-and-spoke models with a PI approach are lucrative strategies in Africa in a bid to overcome limited resources. Alexander, et al, showed in a multicentre prospective study that the introduction of a hub-and-spoke model in India increased rates in both the PI strategy as well as PPCI. [79] Streptokinase is mostly still used in LMICs as it is an attractive agent due to its lower cost. However, it is associated with higher mortality rates and lower perfusion success rates when compared to the fibrin specific alternatives. Tenecteplase is easy to administer as a weight adjusted bolus and safer compared to tissue Plasminogen Activator in preventing non-cerebral bleeds and blood transfusions. [1,80] Governments should intervene to negotiate costs and minimal pricing for these drugs. [5]

A dedicated team consisting of government liaisons, statisticians, cardiologist groups, EMS representatives, information technology, health related NGO's, policymakers, and hospital management should be assembled to implement STEMI referral and by-pass policies, STEMI registers, identify local challenges, implement geographic mapping, STEMI management algorithm implementation, and discharge- / post discharge management. The STEMI-India model showed that a dedicated team ensured collaboration amongst hospitals, EMS, and insurance agencies. [5,81] This has further shown to reduce FMC to device times by cutting out interhospital delays and expediting interhospital transfers. [82–87] The STEMI registry should ideally be securely cloud based, give real-time feedback, quality controlled, and the need for time allocation to staff for data collection and stakeholders for data analysis. Countries should aim to build these live registries, as seen in STEMI-India, AHA's Mission Lifeline, Brazil's RESSIST registry, and others as they allow for regular feedback and monitoring of outcomes. [5,11,79] Some STEMI registers were reported on in this review, with variable implementation successes, data capturing, and monitoring of outcomes amongst the different countries.

Recommendations are that a 12-Lead ECG should be performed within 10 minutes of FMC. [1,5] Government should coordinate with technology companies for innovation in supplying low cost 12 Lead ECG's. This helps in overcoming manpower and infrastructure constraints. Alexander, et al, refers to their model, a low-cost 12 Lead ECG device that was developed, capable of ECG transmission, vital sign monitoring, and data storage to assist in analysis and quality improvement purposes. This device can be used in the patient's home, in an ambulance, or any hospital facility. [68,81]

Clinicians should be well versed with STEMI definition and clinical diagnosis and the importance of early triage and reperfusion. [1] This can be achieved through continuous medical education programs which should be low-cost or no-cost to the healthcare worker. Alexander, et al, advocates for periodic training to be done, with an emphasis on spoke hospitals, especially those that will be newly introduced to being thrombolytic centres. [81] Nascimento, et al, additionally advocates for task shifting of healthcare workers in addition to non-medical workers. Examples of task shifting include greater EMS responsibility, telemedicine and regulatory staff, quality assurance, data collection, data maintenance, and continuity of care. [64] As witnessed in Tunisia and Egypt, these training sessions achieved the wanted outcomes and improved access to STEMI reperfusion. [24,28,48,58]

Limitations

It is possible that some relevant studies on STEMI SOC in Africa could have been missed during the searches of the different databases. It could be that the search string was not adequately deployed. It is also possible that some literature could have been published in a different language, as has been seen where eight studies were submitted due to them being in French. Nevertheless, the search string was employed in the appropriate databases, piloted, and tested with the assistance from a librarian skilled in search strategies meeting the recommendations for an optimal search strategy. Further, as a large part of this review was based on prospective- and retrospective observational studies, the inherent risks of bias, confounding, and limited external validity of many included studies, and cannot be used to demonstrate decision-making. Other limitations were the lack of data in the African context, along with the diverse nature of the systems amongst African countries.

Conclusion

In conclusion, the literature on STEMI systems of Care in Africa is scarce with only Egypt, Tunisia, and South Africa reporting some information on their systems. The coordination and introduction of a STEMI Systems of Care in African settings potentially holds great advantages as has been witnessed in other LMICs and HICs. A myriad of barriers has been reported in this review, as well as potential facilitators in the implementation of these networks. Each setting will be unique and will require interagency liaison, government support, infrastructure investment, legislation, and quality assurance programs, amongst others to ensure its success. Role-players should endeavour approaching other LMICs and HICs, including organisations like STEMI STENT-for-life initiatives and STEMI-India to learn from their lessons and processes. Ultimately, STEMI SOC has shown to be cost effective, reduces treatment delays, allows more people to access PCI, and will reduce morbidity and mortality.

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PART C

Addenda

STEMI Systems of Care in Africa: A Scoping Review

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This proposal is submitted in partial fulfilment of the requirements for the MPHIL Emergency Medicine Degree in the Faculty of Health Sciences at the University of Cape Town

Supervisors: Willem Stassen
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October 2023

Declaration

I, Albertus Johannes Pool, hereby declare that the work on which this thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university. I authorise the University to reproduce for the purpose of research either the whole or any portion of the contents in any manner whatsoever. I further declare the following:

8. I know that plagiarism is a serious form of academic dishonesty.
9. I have read the document about avoiding plagiarism, am familiar with its contents and have avoided all forms of plagiarism mentioned there.
10. Where I have used the words of others, I have indicated this by the use of quotation marks.
11. I have referenced all quotations and properly acknowledged other ideas borrowed from others.
12. I have not and shall not allow others to plagiarise my work.
13. I declare that this is my own work.
14. I am attaching the summary of the Turnitin match overview.

Signed by candidate

Signature: **……**

Date: **…October…2023…**

Overview

Ischaemic heart diseases (IHD) are the leading cause of death and disability globally. [1] It accounts for more than 1 out of every 10 premature deaths caused by non-communicable diseases (NCDs). [2]

High-income countries (HICs) have seen a decrease in cardiovascular disease (CVD) mortality, whereas low-and-middle-income countries (LMICs) are experiencing a rise in CVD deaths. [3,4] It is estimated that 80% of CVD deaths now occur in LMICs, consequently impacting the younger working age population with significant direct and indirect economic consequences. [5] This phenomenon is due to better care and prevention in HICs; and urbanisation, lifestyle changes, population growth, aging, and changing health epidemiology in LMICs. [4]

Furthermore, it is predicted that the incidence of CVD will double in Sub-Saharan Africa and is projected by the World Health Organisation (WHO) to overtake communicable, maternal, perinatal, and nutritional diseases as the leading cause of death within the next two decades. [3,6]

ST-elevation myocardial infarction (STEMI) is an urgent condition of IHD. STEMI should be treated early to prevent further myocardial damage and to reduce morbidity and mortality. Primary Percutaneous Coronary Intervention (PPCI) is the treatment modality of choice if it can be performed within 120min of First Medical Contact (FMC). [1] However, if PPCI cannot be performed within 120min of FMC, fibrinolysis is an alternative option. [1] Fibrinolysis might be a viable option in LMICs with their limited resources and shortage of PCI-facilities. [5]

To enhance the efficacy of STEMI management, the European Society of Cardiology (ESC) as well as American Heart Association (AHA) endorses STEMI Systems of Care (STEMI SOC) as a Class 1, Level B recommendation. [1,7] STEMI SOC organises the healthcare system's approach to STEMI to decrease time delays and improve outcomes. [1,5,7] In several systems, including LMICs, the introduction of regional STEMI SOCs has had positive results in reducing treatment delays as can be seen in India, Brazil, and rural America. [8–10]

Along with Africa's dire shortage of PCI facilities, significant delays to reperfusion, and poor access to PCI based on geography and socio-economic status is also observed. [6,11–13] System delays in STEMI management is multifactorial and the implementation of well organised

STEMI SOCs integrate prehospital and in-hospital STEMI management to decrease these delays. [10]

The proposed study will therefore seek to interrogate the body of literature to determine the current state of STEMI SOCs in Africa. Additionally, barriers and solutions to STEMI SOC implementation in Africa will be appraised.

Results from this project will inform further research that seeks to provide answers on the current state of STEMI SOC in Africa.

Aim

The aim of the study is to describe and summarise the body of literature pertaining to STEMI SOC, as well as barriers and solutions to STEMI SOC implementation, in the African context.

Methods

The Scoping Review has been designed following the PRISMA-ScR Guidelines. [14]

Search Strategy

The search strategy will be made up of three elements:

4. STEMI Systems of Care
5. STEMI
6. Africa

These three elements have been combined to compile a comprehensive search strategy in order to answer the main research question. Medline via Pubmed, EbscoHost, and Google Scholar databases will be interrogated. For Google Scholar, only the first 10 pages will be reviewed when sorted by relevance. The search strategy is contained in Appendix A. The search strategy will be refined with a librarian to improve its appropriateness and accuracy.

Inclusion / exclusion criteria

All study types that collected primary data or that ran an analysis on an existing data set, conference abstracts, reports, and unpublished 'grey' literature will be included. Literature published in any language will be included, though the search strings will be in English. However, if no English abstract is available, it will be excluded. Only studies published between 1 August 2003 and 31 August 2023 will be included in the study. Studies where a full text is not available or obtainable will also be excluded.

Duplicate studies will be manually eliminated by one reviewer. Two reviewers will independently assess the studies for eligibility based by first reviewing the title, then abstract and hereafter full text. The reference lists of the included full-text articles will next be interrogated in the same manner (duplicate and independent, review of titles, abstracts, and full-text). Any discrepancies will be handled by an independent reviewer. Screening and data management will be conducted in Rayyan. [15]

Data extraction and analysis

Data will be extracted from the included literature and an extraction table will be produced using Excel (Microsoft Corporation, Redmond, Washington, U.S). The extraction table will summarise the type of paper / information source (e.g. original research, report, commentary), country of origin, purpose, sample, design, and information related to STEMI SOC, barriers, and solutions to implementing STEMI SOC in the African context.

After data extraction, data will subjected to descriptive analysis to develop a summary description of the main themes contained in the literature. This will be supported by the extraction table and accompanied by a descriptive summary. If possible, a formal risk of bias assessment will be undertaken and a meta-analysis of mortality rates will be undertaken.

Ethical Considerations

The study will not pose any direct risks or benefits to any persons as there will be no direct contact with participants. Furthermore, the literature to be included in the review will be accessible in the public domain. Ethical approval is therefore not a requirement for this study.

Dissemination Plan

We will seek publication in a journal that is relevant to emergency- or cardiovascular health care within the African context. In order to ensure accessibility for researchers from Africa, we will seek open access publication or will ensure that the results are self-archived.

TIMELINE

	2023					
Task	**August**	**September**	**October**	**November**	**December**	**January**
Finalise Proposal						
Initial Search and eligibility assessment						
Data extraction						
Analysis						
Preparing and submission for publication						

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Appendix A: Search Strategies

EBSCOhost Research Databases; Search Screen - Advanced Search; Database - Africa-Wide Information; CINAHL

("system* of care" OR "coronary care network*" OR "regional network*" OR "coronary care system*" OR "care network*" OR "community network*" OR "health network*" OR regionalisation OR regionialization OR management OR treatment) AND (STEMI OR "ST-elevation myocardial infarction" OR "heart attack*" OR "occlusion myocardial infarction" OR OMI OR "coronary occlusion" OR "ST-Segment Elevation Myocardial Infarction" OR "ST-elevated myocardial infarction" OR "st-segment elevated myocardial infarction") AND (Africa OR African OR Algeria OR Angola OR Benin OR Botswana OR "Burkina Faso" OR Burundi OR "Cabo Verde" OR Cameroon OR Cameroun OR "Canary Islands" OR "Cape Verde" OR "Central African Republic" OR Chad OR Comoros OR Congo OR "Cote d'Ivoire" OR "Democratic Republic of Congo" OR Djibouti OR Egypt OR Eritrea OR eSwatini OR Ethiopia OR Gabon OR Gambia OR Ghana OR Guinea OR Guinea- Bissau OR "Ivory Coast" OR Jamahiriya OR Kenya OR Lesotho OR Liberia OR Libya OR Madagascar OR Malawi OR Mali OR Mauritania OR Mauritius OR Mayotte OR Morocco OR Mozambique OR Namibia OR Niger OR Nigeria OR Principe OR Reunion OR Rwanda OR "Saint Helena" OR "Sao Tome" OR Senegal OR Seychelles OR "Sierra Leone" OR Somalia OR "St Helena" OR Sudan OR Swaziland OR Tanzania OR Togo OR Tunisia OR Uganda OR "Western Sahara" OR Zaire OR Zambia OR Zimbabwe)

PubMed:

(((((("ST Elevation Myocardial Infarction"[Mesh]) OR (STEMI OR ST-elevation myocardial infarction OR heart attack OR occlusion myocardial infarction OR OMI OR coronary occlusion OR ST-Segment Elevation Myocardial Infarction OR ST-elevated myocardial infarction OR st-segment elevated myocardial infarction)) OR ("Myocardial Infarction"[Mesh])) OR ("Coronary Occlusion"[Mesh])) AND (("Community Networks"[Mesh]) OR ("systems of care" OR "system of care" OR coronary care network OR regional network OR coronary care networks OR regional networks OR coronary care system OR coronary care systems OR care network OR care networks OR community network OR community networks OR health network OR health networks))) AND ((emergency OR trauma OR EMS OR prehospital OR pre-hospital OR ambulance) OR ("Emergency Medicine"[Mesh] OR "Emergency Medical Services"[Mesh] OR "Ambulances"[Mesh] OR "Emergency Treatment"[Mesh]))) NOT (COVID)) AND ((Africa OR African OR Algeria OR Angola OR Benin OR Botswana OR "Burkina

Faso" OR Burundi OR "Cabo Verde" OR Cameroon OR Cameroun OR "Canary Islands" OR "Cape Verde" OR "Central African Republic" OR Chad OR Comoros OR Congo OR "Cote d'Ivoire" OR "Democratic Republic of Congo" OR Djibouti OR Egypt OR Eritrea OR eSwatini OR Ethiopia OR Gabon OR Gambia OR Ghana OR Guinea OR Guinea- Bissau OR "Ivory Coast" OR Jamahiriya OR Kenya OR Lesotho OR Liberia OR Libya OR Madagascar OR Malawi OR Mali OR Mauritania OR Mauritius OR Mayotte OR Morocco OR Mozambique OR Namibia OR Niger OR Nigeria OR Principe OR Reunion OR Rwanda OR "Saint Helena" OR "Sao Tome" OR Senegal OR Seychelles OR "Sierra Leone" OR Somalia OR "St Helena" OR Sudan OR Swaziland OR Tanzania OR Togo OR Tunisia OR Uganda OR "Western Sahara" OR Zaire OR Zambia OR Zimbabwe) OR ("Africa"[Mesh]))

Google Scholar:

STEMI AND “SYSTEMS OF CARE” AND AFRICA

First 10 pages screened for Inclusion.

Appendix B

Extraction Template

Study title	Author(s)	Origin	Setting	Aims/purpose	Methodology	Themes
Management of acute coronary syndromes in Maghreb countries: The ACCESS (ACute Coronary Events — a multinational Survey of current management Strategies) registry	Abdelhamid Moustaghfir, Mohand Haddak, Rachid Mechmeche	Algeria, Morocco and Tunisia	Facility based	We sought to describe the epidemiology, management, and clinical outcomes of patients hospitalized with acute coronary syndromes (ACS) in three countries in western North Africa	Prospective, multinational, observational registry	• Patient Related Challenges • Healthcare Funding challenges • Healthcare Facility Challenges
Profile of cardiac disease in Cameroon and impact on health care services.	Tantchou Tchoumi, Jacques Cabral, Butera, Gianfranco.	Cameroon	Facility based	The aim of the study was to investigate the preparedness of health care services for patients presenting with CVD in general and specifically, in St. Elizabeth catholic general hospital Shisong, cardiac centre.	prospective observational study	• Healthcare Funding challenges • Healthcare worker Challenges
Population awareness of cardiovascular disease and its risk factors in Buea, Cameroon	Aminde, Leopold Ndemnge, Takah, Noah, Ngwasiri, Calypse, Noubiap, Jean Jacques, Tindong, Maxime, Dzudie, Anastase, Veerman, J. Lennert.	Cameroon	Facility based	We aimed to assess the population awareness (and associated factors) of CVD types and risk factors in Buea, Cameroon.	This was community-based cross-sectional study	• Patient Related Challenges
Barriers to the Implementation of Primary PCI in the Management of STEMI in Egypt.	Shaheen, Sameh, Helal, Ayman, Anan, Islam.	Egypt	Both	The aim of the present study is to explore the current practice in STEMI management in Egypt, to assess the resources and capabilities of governmental hospitals, and to identify the most common gaps, barriers, and potential areas for improvement to widely provide PPCI in Egypt	face-to-face qualitative in-depth interviews	• Patient Related Challenges • Healthcare Funding challenges • EMS / prehospital Challenges • QI/QA / Legislation / policies • Healthcare Facility Challenges • Technology Gaps • Healthcare worker Challenges

Development of Primary Percutaneous Coronary Intervention as a National Reperfusion Strategy for Patients with ST-Elevation Myocardial Infarction and Assessment of Its Use in Egypt	Sobhy, Mohamed; Elshal, Ahmed; Ghanem, Noha; Hasan-Ali, Hosam; Farag, Nabil; Okasha, Nireen; Farag, El Sayed; Sadaka, Mohamed; Abo El Enein, Hisham; Salama, Sameh; Khamis, Hazem; Shokry, Khaled; Ragy, Hany; Elshorbagy, Amany; Mehanna, Radwa	Egypt	Facility based	This study aims to identify the mean time to primary PCI (door to balloon time) for STEMI patients and thus assess the percentage of primary PCI for STEMI patients and its success rate in Egypt. It also aims to evaluate different patterns of treatment for STEMI patients by the assessment of treatment modality rates for thrombolytic therapy or PCI (balloon dilation and/ or stenting)	Observational - A long-term prospective, cross-sectional, multicenter registry study	• Patient Related Challenges • EMS / prehospital Challenges • QI/QA / Legislation / policies • Healthcare Facility Challenges • Healthcare worker Challenges
Factors Affecting Symptom Onset to First-Medical-Contact in Egyptian STEMI Patients	BalbaaAmira, ; ElGuindy, Ahmed; Natarajan, Madhu; Schwalm, Jon-David	Egypt	N/A	to elucidate the factors affecting symptom onset to FMC from the patients and health system perspective at The Aswan Heart Center (AHC)	mixed-methods observational study	• Patient Related Challenges • EMS / prehospital Challenges • QI/QA / Legislation / policies
Implementation of a Regional STEMI Network in North Cairo (Egypt): Impact on The Management and Outcome of STEMI Patients	Shaheen, Sameh M; Saleh, Atef K; Okasha, Nireen K; Abdalhamid, Mohammed A; Fakhry, Hany M; Guindy, Ramez R;	Egypt	Both	The aim of this study was to examine the feasibility and impact of establishing a regional STEMI network on the management and outcomes of STEMI patients in north Cairo	Prospective multicenter cross-sectional observational study	• Patient Related Challenges • EMS / prehospital Challenges • QI/QA / Legislation / policies • Healthcare Facility Challenges • Technology Gaps • Healthcare worker Challenges
Stent for Life Initiative placed at the forefront in Egypt 2011	Sobhy, Mohamed, Sadaka, Mohamed, Okasha, Nireen, Farag, El Sayed, Saleh, Ayman, Ismail, Hussein, Seteiha, Mohamed El, Ragy, Hany, Hameed, Mohamed Abdel, Mehanna, Radwa.	Egypt	Both	The Stent for Life registry was launched to access the current situation of the Egyptian population presenting with STEMI, and to determine what were the barriers to providing patients with cardiac problems appropriate care	This registry was conducted at 14 centres covered all the Egyptian regions - Porspective	• Patient Related Challenges • Healthcare Funding challenges • Healthcare Facility Challenges

Before the door: Comparing factors affecting symptom onset to first medical contact for STEMI patients between a high and low-middle income country.	Balbaa, Amira, ElGuindy, Ahmed, Pericak, Dan, Natarajan, Madhu K, Schwalm, J D.	Egypt	Facility based	to elucidate the factors affecting symptom onset to FMC from the patients and health system perspective, comparing a newly developed regional cardiac center in a LMIC and a wellestablished cardiac center in a HIC.	This mixed-methods observational study. A review of the AHC STEMI registry and the HGH STEMI registry was conducted. A modified version of the Response to Systems Questionnaire (RSQ) that captures the six domains and basic demographic data was developed and reviewed by a panel of experts from both AHC and McMaster University/Population health Research Institute / Hamilton Health Sciences	• Patient Related Challenges • EMS / prehospital Challenges • Healthcare Facility Challenges
Management quality indicators and in-hospital mortality among acute coronary syndrome patients admitted to tertiary hospitals in Ethiopia: prospective observational study.	Fanta, Korinan ; Daba, Fekede Bekele ; Tegene, Elsah ; Melaku, Tsegaye ; Fekadu, Ginenus ; Chelkeba, Legese	Ethiopia	Facility based	this study aimed to assess the clinical profile, management quality indicators and clinical outcomes of patients with ACS admitted to two tertiary hospitals in Ethiopia.	prospective observational study.	• Patient Related Challenges • Healthcare Funding challenges • EMS / prehospital Challenges • QI/QA / Legislation / policies • Healthcare Facility Challenges • Healthcare worker Challenges
Prevention and treatment of cardiovascular disease in Ethiopia: a cost-effectiveness analysis	Mieraf Taddesse Tolla, Ole Frithjof Norheim , Solomon Tessema Memirie , Senbeta Guteta Abdisa, Awel Ababulgu , Degu Jerene , Melanie Bertram , Kirsten Strand , Stéphane Verguet6 and Kjell Arne Johansson	Ethiopia	Neither	to assess cost-effectiveness of prevention and treatment of ischemic heart disease (IHD) and stroke in an Ethiopian setting	a generalized cost-effectiveness analysis	• Healthcare Funding challenges
Treatment Outcomes of Patients with Acute Coronary Syndrome Admitted to Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia	Kassahun Bogale, Desalew Mekonnen, Teshome Nedi and Minyahil Alebachew Woldu	Ethiopia	Facility based	to assess the treatment outcome and associated factors for ACS in Tikur Anbessa Specialized Hospital (TASH	A retrospective cross-sectional study	• Patient Related Challenges • Healthcare Funding challenges • QI/QA / Legislation / policies • Healthcare Facility Challenges

Factors Associated with the Extent of Coronary Artery Disease and the Attained Outcome of Percutaneous Coronary Intervention at Gesund Cardiac and Medical Center (GCMC), Addis Ababa, Ethiopia	Shashu, Bekele Alemayehu; Baru, Ararso	Ethiopia	Facility based	assessing factors associated with the extent of coronary artery disease and the attained outcomes in patients undergoing percutaneous coronary intervention in Ethiopia's Gesund Cardiac Medical and Center	single center retrospective observational study	• Patient Related Challenges
Primary PCI in the management of STEMI in sub-Saharan Africa: insights from Abidjan Heart Institute catheterisation laboratory	Arnaud Ekou, Hermann Yao, Isabelle Kouamé, Rolande Yao Boni, Esther Ehouman, Roland N'Guetta	Ivory Coast	Facility based	The aim of this study was to report the results of primary PCI and outcomes in the catheterisation laboratory of the Abidjan Heart Institute	a cross-sectional, observational study	• Patient Related Challenges • Healthcare Funding challenges • EMS / prehospital Challenges • Healthcare Facility Challenges
Medium and long-term follow-up after ST-segment elevation myocardial infarction in a sub-Saharan Africa population: a prospective cohort study.	Yao, Hermann; Ekou, Arnaud; Hadéou, Aurore; N'Djessan, Jean-Jacques; Kouamé, Isabelle; N'Guetta, Roland;	Ivory Coast	Facility based	We aimed to assess medium and long-term prognosis in patients with STEMI admitted to Abidjan Heart Institute	A prospective, single centre study	• Patient Related Challenges • Healthcare Funding challenges • Healthcare Facility Challenges
Optimizing the management of acute coronary syndromes in sub-Saharan Africa: A statement from the AFRICARDIO 2015 Consensus Team	Kakou-Guikahue, Maurice, N'Guetta, Roland, Anzouan-Kacou, Jean Baptiste, Kramoh, Euloge, N'Dori, Raymond, Ba, Serigne Abdou, Diao, Maboury, Sarr, Moustapha, Kane, Abdoul, Kane, Adama, Damorou, Findide, Balde, Dadhi, Diarra, Mamadou Bocary, Djiddou, Mohamed, Kimbally-Kaki, Gisèle, Zabsonre, Patrice, Toure, Ibrahim Ali, Houénassi, Martin, Gamra, Habib, Chajai, Bachir, Gerardin, Benoit, Pillière, Rémy, Aubry, Pierre, Iliou, Marie Christine, Isnard, Richard, Leprince, Pascal, Cottin, Yves, Bertrand, Edmond, Juillière, Yves, Monsuez, Jean Jacques.	Ivory Coast	Both	To propose a consensus statement to optimize management of ACS in sub-Saharan Africa on the basis of realistic considerations.	Conference consensus statement	• Patient Related Challenges • Healthcare Funding challenges • EMS / prehospital Challenges • Healthcare Facility Challenges

A prospective review of acute coronary syndromes in an urban hospital in sub-Saharan Africa	JAY SHAVADIA, GERALD YONGA, HARUN OTIENO	Kenya	Facility based	We set out to define the demographics, presentation and outcomes of patients admitted with an acute coronary syndrome (ACS) at the Aga Khan University Hospital, Nairobi (AKUHN	A prospective survey	• Patient Related Challenges • Helthcare Funding challenges • EMS / prehospital Challenges • QI/QA / Legislation / policies • Healthcare Facility Challenges • Technology Gaps • Healthcare worker Challenges
Outcomes in patients with acute coronary syndrome in a referral hospital in sub-Saharan Africa	Varwani, Mohamed Hasham, Jeilan, Mohamed, Ngunga, Mzee, Barasa, Anders	Kenya	Facility based	To determine the in-hospital and long-term (30-day and one-year) mortality rates of ACS patients treated at the Aga Khan University Hospital, Nairobi (AKUHN). Secondary objectives were to determine the rate of in-hospital non-fatal events, specifically heart failure, recurrent myocardial infarction (MI), need for repeat revascularisation, stroke and major bleeding, and to determine the rate of rehospitalisation in the first year owing to major adverse events (recurrent MI, stroke and major bleeding).	a cross-sectional, retrospective review	• Patient Related Challenges • QI/QA / Legislation / policies • Healthcare Facility Challenges • Technology Gaps
Presentation, management and outcomes of acute coronary syndrome: a registry study from Kenyatta National Hospital in Nairobi, Kenya	Ehete Bahiru, Tecla Temu, Bernard Gitura, Carey Farquhar, Mark D Huffman, Frederick Bukachi	Kenya	Facility based	We sought to create an ACS registry at Kenyatta National Hospital to evaluate the presentation, management and outcomes of ACS patients	a retrospective chart review	• Patient Related Challenges • QI/QA / Legislation / policies • Healthcare Facility Challenges • Technology Gaps
Understanding of and perceptions towards cardiovascular diseases and their risk factors: a qualitative study among residents of urban informal settings in Nairobi	Murunga, WekesahFrederick, Kyobutungi, Catherine, Grobbee, Diederick E, Klipstein-Grobusch, Kerstin.	Kenya	out-of-hospital	In this study conducted among the residents of Nairobi slums, where more than half of the urban dwellers of the city live, we investigated the understanding of and perceptions towards CVD and their risk factors and how the understanding and perception affected actions taken by individuals to prevent CVD and in seeking care and adhering to treatment	phenomenological qualitative study, focus group discussions	• Patient Related Challenges
Acute Coronary Syndrome patterns in the Young: risk factor profile and in-hospital outcome in a tertiary referral hospital in Kenya	Varwani, Mohamed, Ngunga, Mzee, Msunza, Miriam, Mohamed, Jeilan	Kenya	Facility based	The study aimed to describe the characteristics of young individuals hospitalized with ACS and report on in-hospital outcomes.	This single-center retrospective study	• Patient Related Challenges
Evaluation of risk factors in acute myocardial infarction patients admitted to the coronary care unit, Tripoli Medical Centre, Libya	Abduelkarem, A. R., El-Shareif, H. J., Sharif, S. I.	Libya	Facility based	The aim of this study was to provide an overview of the risk factors for acute myocardial infarction in patients attending Tripoli Medical Centre, Libya.	Review of Case Records	• Patient Related Challenges • Healthcare Facility Challenges

Registry for Acute Coronary Events in Nigeria (RACE-Nigeria): Clinical Characterization, Management, and Outcome	Isezuo, Simeon, Sani, Mahmoud Umar, Talle, Abdullahi, Johnson, Adeyemi, Adeoye, Abiodun Moshood, Ulgen, Mehmet S., Mbakwem, Amam, Ogah, Okechukwu, Edafe, Emmanuel, Kolo, Philip, Nagabea, Murtala, Adebayo, Rasaaq, Nwafor, Eze, Daniel, Folasade, Zagga, Muiyawa, Umar, Hayatu, Oboirien, Isa, Sulaiman, Balarabe A., Abdullahi, Umar, Mijinyawa, Muhammad Sani, Buba, Farouk, Aje, Akinyemi, Okolie, Henry, Shehu, Muhammad Nazir, Adamu, Umar, Olusegun-Joseph, Akinsanya, Familoni, Ranti, Chibuzor, Nwuriku, Olunuga, Taiwo Olabisi, Ejim, Emmanuel, Olaide, Awodu Rasheed, Ojji, Dike, Sanni, Bushra, Ajuluchukwu, Jane N., Balogun, Michael O., Omotoso, Ayodele B., Ajit, Mullasari, Falase, Ayodele	Nigeria	Facility based	The Registry for Acute Coronary Events in Nigeria (RACE-Nigeria) is aimed at determining the incidence, peculiarities in the characteristics, management, and all-cause mortality of ACS	A prospective, observational, and multicentered	• Patient Related Challenges • Healthcare Funding challenges • EMS / prehospital Challenges • QI/QA / Legislation / policies • Healthcare Facility Challenges
Management of acute coronary syndrome in South Africa: insights from the ACCESS (Acute Coronary Events – a Multinational Survey of Current Management Strategies) registry	COLIN SCHAMROTH, ACCESS South Africa investigators	South-Africa	Facility based	to gain insights into the descriptive epidemiology, current practice patterns, and one-year outcomes of patients hospitalised with acute coronary syndrome (ACS), whether this be unstable angina (UA)/non-STsegment elevation acute coronary syndrome (NSTE-ACS) or ST-segment elevation myocardial infarction (STEMI), in developing countries	prospective, observational registry	• Patient Related Challenges • Healthcare Funding challenges • EMS / prehospital Challenges • QI/QA / Legislation / policies • Healthcare Facility Challenges
Evaluating the time interval from diagnosis to fibrinolysis at centres in the drainage area of Tygerberg Hospital, Cape Town, South Africa	BeyersB, D; Doubell, A F; Griffiths, B; Jalavu, T	South-Africa	Facility based	To determine the median time interval between diagnosis and fibrinolysis in patients presenting to centres within the drainage area of Tygerberg Hospital, Cape Town, SA,	retrospective medical record review	• Patient Related Challenges • QI/QA / Legislation / policies • Healthcare Facility Challenges • Healthcare worker Challenges

Non-ST elevation myocardial infarction (NSTEMI) in three hospital settings in South Africa: does geography influence management and outcome? A retrospective cohort study	Moses, Jane; Doubell, Anton F; Herbst, Philip G; Klusmann, Karl J C; Weich, Hellmuth S V H	South-Africa	Facility based	This study aimed to determine whether the management of an NSTEMI differs depending on the hospital to which the patient presents (patients presenting to secondary hospitals being less likely to receive early invasive management), and if so, whether this is a consequence of geographical remoteness or level of care, and how this influences outcome.	retrospective cohort study	• Healthcare worker Challenges
The 12-month period prevalence and cardiac manifestations of HIV in patients with acute coronary syndrome at a tertiary hospital in Cape Town, South Africa: a retrospective cross-sectional study.	Pennefather, Camilla; Esterhuizen, Tonya; Doubell, Anton; Decloedt, Eric H;	South-Africa	Facility based	The objective of this study was to determine the 12-month period prevalence of HIV in patients with ACS and to compare the risk-factor profile, ACS presentation and management between HIV-positive and HIV-negative adults	We conducted a retrospective review	• Patient Related Challenges
Time to fibrinolytics for acute myocardial infarction: Reasons for delays at Steve Biko Academic Hospital, Pretoria, South Africa	Meel, R, Gonçalves, R.	South-Africa	Facility based	To establish the proportion of STEMI patients receiving fibrinolytic agents at Steve Biko Academic Hospital (SBAH), Pretoria, SA, identify any delays to receiving fibrinolytic agents, and uncover reasons for those delays	prospective, observational study	• Patient Related Challenges • Healthcare Funding challenges • EMS / prehospital Challenges • QI/QA / Legislation / policies • Healthcare Facility Challenges • Technology Gaps • Healthcare worker Challenges
The proportion of South Africans living within 60 and 120 minutes of a percutaneous coronary intervention facility	Willem Stassen, Lee Wallis, Craig Vincent-Lambert, Maaret Castren, Lisa Kurland	South-Africa	Facility based	The aim of this study was to determine the proportion of South Africans living within 60 and 120 minutes of a PCI facility.	PCI facility and population data were subjected to proximity analysis to determine the average drive times from municipal ward centroids to PCI facilities for each province in South Africa - mapping	• Healthcare Funding challenges • Healthcare Facility Challenges
The incidence and outcomes of high-risk acute coronary syndromes in the Western Cape Province of South Africa: a prospective cohort study	Cilliers, J D ; Joubert, L ; Beyers, B ; Ngarande, E ; Herbst, P ; Doubell, A ; Pecoraro, A	South-Africa	Facility based	To describe the incidence of ST-elevation myocardial infarction (STEMI) and high-risk non-ST-elevation ACS (HR-NSTEACS) in the TBH referral network, describe the in-hospital and 30-day mortality of these patients, and identify important high-risk population characteristics	prospective cohort study	• Patient Related Challenges • QI/QA / Legislation / policies • Healthcare Facility Challenges

The application of optimisation modelling and geospatial analysis to propose a coronary care network model for patients with ST-elevation myocardial infarction.	Stassen, Willem, Olsson, Leif, Kurland, Lisa.	South-Africa	Both	the aim of this study was to propose the optimal reperfusion strategy in a coronary care network model for patients who present with STEMI	This study applied geospatial analysis with network optimisation modelling, to determine which strategy (thrombolysis or PCI) is most appropriate for patients presenting within each of the municipal wards of the North West province. - mapping	• Healthcare Facility Challenges • Technology Gaps
Profile and management of acute coronary syndromes at primary- and secondary-level healthcare facilities in Cape Town	Uys, F., Beeton, A. T., van der Walt, S., Lamprecht, M., Verryn, M., Vallie, Y., Stokes, D., Millar, R. S., Viljoen, C. A.	South-Africa	Facility based	to describe the profile, clinical presentation and management of patients with ACS treated at primaryand secondary-level healthcare facilities in Cape Town, South Africa.	We conducted a retrospective folder review	• Patient Related Challenges • EMS / prehospital Challenges • Healthcare Facility Challenges • Healthcare worker Challenges
Door-to-needle time for administration of fibrinolytics in acute myocardial infarction in Cape Town	Maharaj, Roshen C., Geduld, Heike, Wallis, Lee A.	South-Africa	Facility based	To determine the current door-to-needle time for the administration of fibrinolytics for acute myocardial infarction (AMI) in emergency centres (ECs) at three hospitals in Cape Town	A retrospective review of case notes	• Patient Related Challenges • EMS / prehospital Challenges • QI/QA / Legislation / policies • Healthcare Facility Challenges
Chart review of acute myocardial infarction at a district hospital in KwaZulu-Natal, South Africa	Chetty, Roland, Ross, Andrew.	South-Africa	Facility based	The aim of the study was to determine the profile and management of patients admitted with ischaemic chest pain.	The design was retrospective and descriptive	• Patient Related Challenges • Healthcare Facility Challenges • Healthcare worker Challenges
Barriers to the implementation of prehospital thrombolysis in the treatment of ST-segment elevation myocardial infarction in South Africa: An exploratory inquiry.	Lynch, Andrew, Sobuwa, Simpiwe, Castle, Nicholas	South-Africa	out-of-hospital	The current study aimed to explore, through a qualitative inquiry, barriers to PHT for the treatment of myocardial infarction within a South African context.	A qualitative single-case study design was used where a series of semi-structured interviews were conducted involving purposefully selected participants	• Healthcare Funding challenges • EMS / prehospital Challenges • QI/QA / Legislation / policies • Healthcare worker Challenges

Barriers and facilitators to implementing coronary care networks in South Africa: a qualitative study	Stassen, Willem, Kurland, Lisa, Wallis, Lee, Castren, Maaret, Vincent-Lambert, Craig	South-Africa	Both	To determine the current perceived state of CCNs, to determine the barriers to optimising CCNs and to suggest facilitators to optimising CCNs within the South African context.	A qualitative descriptive approach was employed, by performing two structured in-depth and two focus group interviews	• Patient Related Challenges • Healthcare Funding challenges • EMS / prehospital Challenges • QI/QA / Legislation / policies • Healthcare Facility Challenges • Technology Gaps • Healthcare worker Challenges
Acute myocardial infarction at a district hospital in KwaZulu-Natal – Management and outcomes	Badat Zakariya, Rangiah Selvandran.	South-Africa	Facility based	This study analysed the management of patients presenting with STEMI and NSTEMI as well as the outcomes in a district-level resource-limited environment with no PCI or on-site cardiology service.	descriptive cross-sectional study	• Patient Related Challenges • EMS / prehospital Challenges • QI/QA / Legislation / policies • Healthcare Facility Challenges • Healthcare worker Challenges
Time to thrombolysis and factors contributing to delays in patients presenting with ST-elevation myocardial infarction at Chris Hani Baragwanath Academic Hospital, Johannesburg, South Africa	Tickley, I, van Blydenstein, S A, Meel, R.	South-Africa	Both	The primary objective of this study was to elucidate the time to thrombolysis and reasons for delays in administration or nonadministration of thrombolytic agents to patients with STEMI presenting to CHBAH. Secondary objectives were to determine the demographics of patients presenting with STEMI, and their echocardiogram and coronary angiogram findings	This single-centre prospective observational study	• Patient Related Challenges • Healthcare Funding challenges • EMS / prehospital Challenges • QI/QA / Legislation / policies • Healthcare Facility Challenges • Technology Gaps • Healthcare worker Challenges
Referral pathways for reperfusion of STEMI-developing strategies for appropriate intervention: the SA heart STEMI early intervention project	Adriaan Snyders and Rhena Delport	South-Africa	Both	to establish the current time intervals present in the referral pathways to percutaneous coronary intervention (PCI) facilities in the Tshwane Metropole and to further identify the barriers to appropriate management of STEMI.	A cross-sectional observational study	• Patient Related Challenges • Healthcare Funding challenges • EMS / prehospital Challenges • Healthcare Facility Challenges • Technology Gaps
STEMI early reperfusion programme: cardiology	Snyders, Adriaan.	South-Africa	Facility based	Article discussing the South African Society of Cardiovascular Intervention (SASCI) ST Segment Elevation Myocardial Infarction (STEMI) Early Reperfusion Programme's call to action to implementation in Gauteng and the rest of South Arica	Editorial	• Patient Related Challenges • Healthcare Funding challenges • QI/QA / Legislation / policies • Healthcare Facility Challenges • Healthcare worker Challenges

Revealing the value of geospatial information with isochrone maps for improving the management of heart attacks in South Africa	Coetzee, Serena, Snyman, Lourens, Delport, Rhena.	South-Africa	Facility based	In this essay we describe a map, recently prepared for the South African Heart Association STEMI SA Early Intervention Initiative, that envisages to improve systems of care to afford timely and appropriate management of ST-elevation Myocardial Infarction (STEMI) heart attacks	The map shows geographic access to public cathlabs based on a maximum drive-time threshold of two hours, which is sub-divided into thirty-minute intervals. Maptitude was utilised for the isochrone modelling and map visualization. the data package for South Africa, shipped with the Maptitude software, was used together with OpenStreetMap placenames - mapping	• Healthcare Facility Challenges • Technology Gaps
Coronary care networks in the resource-limited setting: systems of care in South Africa	Stassen, Willem.	South-Africa	Facility based	Determine the amount and location of PCI-facilities in South Africa and to relate coverage to population; and access in relation to socio-economic status for each South African province	cross-sectional	• Healthcare Facility Challenges
Gender inequality in acute coronary syndrome patients at Omdurman Teaching Hospital, Sudan	Mirghani, Hyder O; Elnour, Mohammed A; Taha, Akasha M; Elbadawi, Abdulateef S;	Sudan	Facility based	To assess gender differences in presentation, management, and outcomes of acute coronary syndrome in Sudan.	cross-sectional descriptive longitudinal study	• Patient Related Challenges
Knowledge, attitudes, and preventative practices regarding ischemic heart disease among emergency department patients in northern Tanzania.	Hertz, J T; Sakita, F M; Manavalan, P; Mmbaga, B T; Thielman, N M; Staton, C A	Tanzania	Facility based	To increase understanding of knowledge, attitudes, and preventative practices regarding ischemic heart disease (IHD) in sub-Saharan Africa in order to develop patient-centered interventions to improve care and outcomes	prospective observational study	• Patient Related Challenges

Management of patients with acute STelevation myocardial infarction: Results of the FAST-MI Tunisia Registry	Faouzi AddadID , Abdallah Mahdhaoui , Jeridi Gouider , Essia Boughzela, Samir Kamoun4, Mohamed Rachid Boujnah5, Habib Haouala6 , Habib Gamra, Faouzi Maatouk , Ali Ben Khalfallah , Salem Kachboura , Hedi Baccar, Nejeh Ben Halima, Ali Guesmi, Khaled Sayahi, Wissem Sdiri, Ali Neji, Ahmed Bouakez, Sami Milouchi, Kais Battikh, Yves Jullieres, Nicolas Danchin, Jean Jacques Monsuez, Genevieve Mulak, Albert Hagege, Vincent Bataille, Rafik Chettaoui, Mohamed Sami Mourali,	Tunisia	Both	we sought to analyse the demographic and the clinical characteristics as well as the modalities of myocardial reperfusion employed in STEMI patients enrolled into the FAST-MI Tunisia registry comparing the management strategies between university (generally with cath lab) and regional hospitals (without cath lab), and investigating the independent predictors of in-hospital mortality.	prospectively	• Patient Related Challenges • EMS / prehospital Challenges • QI/QA / Legislation / policies • Healthcare Facility Challenges
Management of acute coronary syndrome in emergency departments: a cross sectional multicenter study (Tunisia)	Sriha Belguith, Asma; Beltaief, Kaouthar; Msolli, Mohamed Amine; Bouida, Wahid; Abroug, Hela; Ben Fredj, Manel; Zemni, Imen; Grissa, Mohamed Habib; Boubaker, Hamdi; Hsairi, Mohamed; Nouira, Samir;	Tunisia	Facility based	We aimed to describe diagnosed acute coronary syndrome (ACS) and its care management and outcomes in emergency departments (EDs) and to determine related cardiovascular risk factors (CVRFs).	a multicenter cross-sectional study. Data were prospectively collected	• Patient Related Challenges • EMS / prehospital Challenges • QI/QA / Legislation / policies • Healthcare worker Challenges
Predictors of acute coronary syndrome in pre hospital patients with chest pain	Saida Zelfani, Selim Boudiche, Héla Manai, M Sami Mourali, Mounir Daghfous	Tunisia	out-of-hospital	The objective of our study was to identify predictive factors of STEMI in patients with acute chest pain, in the Emergency Care System of the North Est (SAMU 01) of Tunisia.	a prospective observational study, through telephonic interviews.	• Patient Related Challenges • Healthcare Facility Challenges • Healthcare worker Challenges
Delay of Fibrinolysis in ST-Elevation Myocardial Infarction: Results of an Investigation Conducted in a Single Center in Sousse Tunisia	Bouraoui, Hatem, Trimeche, Besma, Hajri, Samia Ernez, Mahdhaoui, Abdallah, Romdhane, Meriem Ben, Jeridi, Gouider.	Tunisia	Facility based	The aim of our study was to assess the delay of fibrinolysis in ST elevation myocardial infarction (STEMI) in our region and to identify characteristics associated with prolonged delay	prospective cohort study	• EMS / prehospital Challenges • QI/QA / Legislation / policies • Healthcare Facility Challenges • Healthcare worker Challenges

STEMI care in the elderly: Does under-treatment reflect appropriate clinical judgment or therapeutic nihilism?	Gupta, Tanush.	Tunisia	Facility based	we sought to determine in-hospital outcomes for elderly patients presenting with STEMI in a Tunisian center and to study factors related to in-hospital death in this population	Single Centre retrospective observational study	• Patient Related Challenges • Healthcare Facility Challenges

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

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29 January 2024

HREC/REF: 063/2024

A/Prof W Stassen
Division of Emergency Medicine
Email: willem.stassen@uct.ac.za
Email: plxalb001@myuct.ac.za

Dear A/Prof Stassen

PROJECT TITLE: STEMI SYSTEMS OF CARE IN AFRICA : A SCOOPING REVIEW – (MPHIL EMERGENCY MEDICINE CANDIDATE: ALBERTUS JOHANNES POOL)

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee.

The HREC note that the proposed study is a scoping review.

As the scoping review involves published literature available through publicly accessible electronic databases, research ethics review and approval is not required.

This is in accordance with Section 1.1.8 of the Department of Health's Ethics in Health Research: Principles, Processes and Structures (South African Department of Health, 2015), which states: *"Research that relies exclusively on publicly available information or accessible through legislation or regulation usually need not undergo formal ethics review. This does not mean that ethical considerations are irrelevant to the research."*

The HREC acknowledges that the Mphil Emergency Medicine Candidate: Albertus Johannes Pool is also involved in this project.

Yours sincerely

Signed by candidate

PROFESSOR MARC BLOCKMAN
CHAIRPERSON, FACULTY OF HEALTH SCIENCES HUMAN RESEARCH ETHICS COMMITTEE

Permission Letters

Figure 1

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Portions		Figure. Hypothetical Construct of the RelationshipAmong the Duration of Symptoms of Acute MI BeforeReperfusion Therapy, Mortality Reduction, and Extentof Myocardial Salvage

Figure 2

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Figure 3 & 4

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