Original Article

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Exploring the Causes and Factors Contributing to Pre-hospital Delays in Acute Myocardial Infarction Patients: A Hospital-based Cross-sectional Study from a Resource-limited Setting

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ABSTRACT

Introduction: Early treatment of Acute Myocardial Infarction (AMI) is crucial for reducing mortality. However, not all patients arrive early enough to receive optimal therapy, especially in developing countries. Several factors contribute to increased pre-hospital delays.

Aim: To explore the frequency and causes of delayed presentations among patients with AMI in Sudan.

Materials and Methods: This hospital-based cross-sectional study included 224 patients admitted to Al-Shaab Teaching Hospital and the Sudan Heart Centre, Khartoum State, Sudan between September 2022 and November 2022. A validated questionnaire was used to collect data, and patients were categorised into two groups: those who arrived after 12 hours (delayed) and those who arrived within 12 hours (non delayed). Statistical analysis was performed using the Chi-square test to assess associations between pre-hospital delay and patient characteristics, with a p-value of <0.05 considered statistically significant.

Results: More than half of the patients, 119 (53.1%), experienced a delay in arriving at the hospital. The most common cause of delay was seeking care at a non reperfusion centre, affecting 76 (64%) of delayed patients. The study found significant associations between delayed presentation and factors such as education level (p=0.03), smoking status (p=0.004), and residency location (p=0.04). However, no significant associations were observed with age, gender, mode of transportation, chronic co-morbidities, previous myocardial infarction, or family history of AMI.

Conclusion: The study concluded that more than half of the patients experienced delays, primarily due to visiting non reperfusion centres. Delays were also linked to lower education levels, non smoking status, and living outside the capital, Khartoum. Public education campaigns about the importance of early hospital presentation for AMI could help reduce delays and improve outcomes.

Keywords: Co-morbidities, Emergency medical services, Mortality, Non reperfusion centres

INTRODUCTION

Coronary artery disease is the leading cause of death worldwide, accounting for 15.9% of all deaths [1]. Its prevalence in Africa has increased dramatically in recent decades and is now considered the eighth leading cause of death in people over the age of 60 years [2]. The AMI is a common complication of life-threatening coronary artery disease, with significant morbidity and mortality. Fortunately, MI treatment has improved dramatically over the past three decades and continues to evolve [3].

Because one-third of deaths due to AMI occur shortly after the onset of symptoms, before reaching the hospital, rapid diagnosis and intervention are critical. Early reperfusion therapy significantly reduces mortality and morbidity in patients with ST-Elevation Myocardial Infarction (STEMI) and helps prevent fatal arrhythmias [4]. The updated Global Cardiovascular Society guidelines recommend reperfusion therapy for all patients with ischemic symptoms lasting less than 12 hours [5, 6]. This 12-hour window is especially important in low- and middle-income countries [7].

Although starting reperfusion therapy within 60 minutes of symptom onset has been shown to reduce mortality and morbidity by 50%, studies show only a small percentage of patients arriving at the hospital during this "golden hour." For instance, data indicate that only 22 to 44%, and in some cases up to 50%, of patients arrive at the hospital within two hours of symptom onset [4,8]. This period, referred to as the "pre-hospital delay," is the time between the onset of symptoms and arrival at the hospital. Sudan lacks adequate data on this issue, posing a serious problem that could lead to increased mortality and morbidity, especially in the resource-limited healthcare sector [9]. Thus, present study aimed to estimate the frequency of delays in patient arrivals following AMI symptoms. Additionally, authors aimed to identify the key factors contributing to these delays. Furthermore, the study assessed the association between pre-hospital delay and various patient characteristics.

MATERIALS AND METHODS

A hospital-based cross-sectional study was conducted to examine the factors contributing to pre-hospital delay in patients with Acute Myocardial Infarction (AMI) in Khartoum State, Sudan, from September 2022 to November 2022, at two major cardiology centres: Al-Shaab Teaching Hospital and the Sudan Heart Centre. These centers were selected because they are the largest cardiac care facilities in Sudan and the only hospitals in Khartoum State with emergency departments equipped to treat AMI patients.

The present study adhered to the ethical guidelines of the 1975 Declaration of Helsinki and was approved by the Ethical Committee of the Faculty of Pharmacy at the University of Khartoum, Sudan (FPEC-49-2022). Data collection was conducted after obtaining permission from the administrations of the selected cardiology centers' training and research Departments. Written informed consent was obtained from all patients, and the purpose of the

study was explained to them. Each participant was informed of their right to voluntarily withdraw from the study at any time without any consequences.

Inclusion criteria:

- Adult patients (≥18 years of age) who presented with symptoms consistent with AMI.
- Conscious and clinically stable patients upon arrival at the emergency departments.

Exclusion criteria:

- Patients who were critically ill or unstable.
- Patients unable to respond or participate in an interview.
- Patients with incomplete data or those unable to provide informed consent.

A consecutive sampling method was used to enroll eligible patients presenting with AMI during the study period.

Study Procedure

Data were collected using a validated structured questionnaire adopted from a previous study [10]. A panel of cardiologists reviewed the questionnaire for relevance and appropriateness to the Sudanese context. The questionnaire was divided into three main sections:

1. Demographic information: This section included age, gender, educational level, occupation, and place of residence.
2. Temporal differences: This section captured the difference between the onset of symptoms and hospital arrival, which is the main variable of interest. A cut-off of 12 hours was used to define "late" (≥12 hours) versus "not late" (<12 hours).
3. Medical history: This section included questions about past medical history, including Hypertension (HTN), diabetes, smoking, family history of heart disease, and previous myocardial infarction.

Data were collected through structured interviews with patients or their accompanying persons. When patients were unsure of the exact time of symptom onset, information was obtained from the accompanying person. Interviews were conducted by medical practitioners divided into two groups (one for each hospital). Data collectors were trained to ensure consistency and accuracy in the responses collected and recorded. Patients who arrived late (i.e., after 12 hours) were additionally interviewed to identify possible causes of delay, including factors related to patient decision-making, access to health care, and transportation issues.

Primary exposure variable: The main exposure of interest was the time from symptom onset to hospital arrival. Patients were classified as either delayed (≥12 hours) or non delayed (<12 hours) based on the time interval.

Outcome variables: The main outcome variables included sociodemographic factors (age, gender, education, occupation, etc.), medical history (e.g., co-morbidities, prior heart disease), and factors associated with delay in seeking treatment (e.g., lack of awareness, access to medical facilities, and transportation issues).

STATISTICAL ANALYSIS

Statistical analyses were conducted using IBM Statistical Package for Social Sciences (SPSS), version 22.0 software (SPSS Inc., Chicago, Illinois, USA). Descriptive statistics were employed to summarise sociodemographic data and the time intervals between symptom onset and hospital arrival. Categorical variables were presented as frequencies and percentages. The Chi-square test was utilised to assess associations between pre-hospital delay and various patient characteristics, including sociodemographic factors and medical history. Binary logistic regression analysis was performed to identify independent factors associated with delay, controlling for confounding variables. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The study population comprised 129 (57.6%) male and 95 (42.4%) female patients. The majority were aged 60-79 years, totaling 103 (46%). In terms of education, 68 (30.4%) subjects had completed primary school, while 54 (24.1%) were illiterate or had no formal education. Regarding employment, 163 (72.8%) were unemployed, and 197 (87.9%) were married. Smoking status showed that 70.1% were non smokers. Health insurance was held by 143 (63.8%) of the patients, and 116 (51.8%) lived outside Khartoum [Table/Fig-1]. Significant associations were noted between pre-hospital delay and certain patient characteristics. Illiterate patients, followed by those with a university education, were significantly more likely to experience delays compared to patients with primary or secondary education (p-value=0.03). Non smokers were also significantly more delayed than smokers or ex-smokers (p-value=0.004). Furthermore, patients residing outside Khartoum were more likely to experience delays compared to those living within Khartoum (p-value=0.04). No significant associations were found between pre-hospital delay and other variables [Table/Fig-1].

Variables	Category	n (%)			p-value
		Total	Less than 12 hours	12 hours or more	
Age (years)	<40	7 (3.1)	2 (29.0)	5 (71.0)	0.5
	40-59	100 (44.6)	51 (51.0)	49 (49.0)	
	60-79	103 (46.0)	45 (44.0)	58 (56.0)	
	>80	14 (6.3)	7 (50.0)	7 (50.0)	
Gender	Male	129 (57.6)	66 (51.0)	63 (49.0)	0.1
	Female	95 (42.4)	39 (41.0)	56 (59.0)	
Education	Illiterate	54 (24.1)	17 (31.5)	37 (68.5)	0.03
	Primary	68 (30.4)	36 (53.0)	32 (47.0)	
	Secondary	66 (29.5)	37 (56.0)	29 (44.0)	
	University	36 (16.1)	15 (42.0)	21 (59.0)	
Employment	Employed	61 (27.2)	25 (41.0)	36 (59.0)	0.2
	Unemployed	163 (72.8)	80 (49.0)	53 (51.0)	
Marital status	Single	27 (12.1)	13 (48.0)	14 (52.0)	0.8
	Married	197 (87.9)	92 (47.0)	105 (53.0)	
Smoking	No	157 (70.1)	63 (40.0)	94 (60.0)	0.004
	Ex-smoker	31 (13.8)	17 (55.0)	14 (45.0)	
	Yes	36 (16.1)	25 (69.0)	11 (31.0)	
Insurance	No	81 (36.2)	43 (53.0)	38 (47.0)	0.1
	Yes	143 (63.8)	62 (43.0)	81 (57.0)	
Residence	Khartoum	108 (48.2)	58 (54.0)	50 (46.0)	0.04
	Outside Khartoum	116 (51.8)	47 (40.5)	69 (59.5)	

[Table/Fig-1]: Patient characteristics and their association with pre-hospital delay (N=224).

To identify independent predictors of delay, binary logistic regression was conducted after adjustment for potential confounding variables. The overall model was statistically significant and revealed that employment status was an independent predictor of delay (B=-0.699, p=0.040). Specifically, unemployment was linked to reduced odds of delay compared to being employed (OR=0.497).

Although not statistically significant at the conventional alpha level, gender (B=-0.506, p=0.091) and residence location (B=0.526, p=0.083) revealed trends suggesting an influence on delay outcomes. None of the other variables, including age, education, marital status, smoking, and insurance status, demonstrated any appreciable association with delay after adjusting for confounding variables (p>0.05 for all) [Table/Fig-2].

Variables	B	SE	Wald	p-value	Exp (B)
Age (years)	0.252	0.197	1.63	0.202	1.287
Gender	-0.506	0.299	2.86	0.091	0.603
Education level	-0.138	0.151	0.84	0.361	0.871
Employment status	-0.699	0.340	4.22	0.040	0.497
Marital status	-0.193	0.433	0.20	0.657	0.825
Smoking habit	-0.339	0.258	1.72	0.190	0.713
Insurance status	-0.203	0.300	0.46	0.499	0.816
Location of residency	0.526	0.303	3.01	0.083	1.692
Constant	2.419	1.286	3.54	0.060	11.234

[Table/Fig-2]: Binary logistic regression analysis identifying independent predictors of delay.

Hypertension (HTN) was the most common co-morbidity, present in 99 (42%) patients. Diabetes Mellitus (DM) followed, affecting 93 patients (41.5%), while hyperlipidemia was reported in 58 (26%) patients. The most common past medical history was a previous history of chest pain or epigastric pain, reported by 108 (48%) patients. This was followed by a family history of myocardial infarction in first-degree relatives, noted in 73 (32.6%) patients, and a prior myocardial infarction in 39 (17.4%) patients [Table/Fig-3].

Variables	Category	Frequency (%)			p-value*
		Total	Less than 12 hours	12 hours or more	
Co-morbid disease	Hypertension (HTN)	108 (48.2)	48 (44.4)	60 (55.6)	0.2
	Diabetes mellitus	39 (17.4)	18 (46.2)	21 (53.8)	
	Hyperlipidemia	73 (32.6)	33 (45.2)	40 (54.8)	
	Congestive heart failure	38 (17)	17 (44.7)	21 (55.3)	
Past medical history	Previous chest/ epigastric pain	129 (57.6)	66 (51)	63 (49)	0.4
	Previous Myocardial Infraction (MI)	95 (42.4)	39 (41)	56 (59)	
	Family history of MI (in 1st degree relatives)	54 (24.1)	17 (31.5)	37 (68.5)	
	Previous coronary angiography	68 (30.4)	36 (53)	32 (47)	

[Table/Fig-3]: Patients' chronic co-morbidities and past medical history, and their association with pre-hospital delay (N=224).
*Chi-square test, p-value of <0.05 statistically significant.

Severe chest pain was the most common first symptom, reported by 161 (71.9%) patients, while epigastric pain was the least common first symptom, reported by 22 (9.8%) patients. Regarding the time of symptom onset, most patients experienced symptoms at night, with 90 (40.2%) patients reporting this. None of these variables (symptom type, time of symptom onset, location of symptoms, or mode of transportation) were significantly associated with pre-hospital delay [Table/Fig-4].

Among the 119 patients who experienced delayed presentation, the most common cause was visiting a non reperfusion center, reported by 76 (64%) patients. Expecting spontaneous improvement was reported by 60 (50.4%), and 59 (50%) patients sought care from a general practitioner before going to the hospital [Table/Fig-5].

DISCUSSION

The present study aimed to investigate the delay in time to hospital admission for patients with Acute Myocardial Infarction (AMI) and to gain key insights into the factors contributing to late intervention and their impact on early clinical outcomes. The findings revealed that more than half of the patients (53%) had a late presentation, surpassing a similar study conducted in a developing country, which

Variables	Category	Frequency (%)			p-value*
		Total	Less than 12 hours	12 hours or more	
First symptom	Epigastric pain	22 (9.8)	7 (31.8)	15 (68.2)	0.3
	Severe chest pain	161 (71.9)	80 (49.7)	81 (50.3)	
	Other	41 (18.3)	18 (43.9)	23 (56.1)	
Time of onset	Morning	73 (32.6)	37 (50.7)	36 (49.3)	0.5
	Afternoon	61 (27.2)	30 (49.2)	31 (50.8)	
	Night	90 (40.2)	38 (42.2)	52 (57.8)	
Place	Home	173 (77.2)	77 (44.5)	96 (55.5)	0.2
	Other	51 (22.8)	28 (54.9)	23 (45.1)	
Transportation	Ambulance	24 (10.7)	11 (45.8)	13 (54.2)	0.06
	Public transportation	44 (19.6)	13 (29.5)	31 (70.5)	
	Taxi	144 (64.3)	76 (52.7)	68 (47.2)	
	Other	12 (5.4)	5 (41.7)	7 (58.3)	

[Table/Fig-4]: Acute Myocardial Infarction (AMI) onset, first symptom, and place of attack and their association with pre-hospital delay (N=224).
* Chi-square test p-value of <0.05 statistically significant.

Reason	n (%) among total patients (N=224)	n (%) among delayed patients (n=119)
Going to a non reperfusion center	76 (33.9)	76 (63.9)
Tolerating pain	67 (29.9)	67 (56.3)
Lack of knowledge about symptoms	61 (27.2)	61 (51.3)
Expecting spontaneous improvement	60 (26.8)	60 (50.4)
Going to the general practitioner	59 (26.3)	59 (49.6)
Inappropriate time of symptoms	47 (21)	47 (39.5)
Long distance	46 (20.5)	46 (38.7)
Self-treatment	43 (19.2)	43 (36.1)
Ignoring pain	27 (12.1)	27 (22.7)

[Table/Fig-5]: Frequency of different causes of pre-hospital delay.

reported 48.9% late presentations within a comparable 12-hour interval for participants [7]. This pre-hospital delay is an important issue, as many studies have shown that mortality is more closely associated with ischemic time than with door-to-balloon time [11]. Emphasising prolonged ischaemic time, especially the pre-hospital delay, is crucial for improving patient outcomes.

Patient demographics and socioeconomic characteristics exhibited multiple associations with hospitalisation delay. Significant associations were found for educational level, smoking status, and residence. In particular, illiterate patients experienced greater delays, a finding consistent with studies conducted in Iran, Egypt, and Saudi Arabia [12-14]. Illiterate patients tended to present later than those with primary and secondary education, which may be due to a lack of awareness of AMI symptoms and appropriate actions in such cases. This highlights the importance of educational intervention programs for the public.

Furthermore, non smokers also experienced more significant delays compared to smokers and ex-smokers, which aligns with a previous study from Japan [15]. This may be because smoking exacerbates pain and decreases myocardial blood flow, prompting smokers to seek treatment earlier [15].

Patients living outside Khartoum experienced more significant delays in hospital arrival compared to those living in Khartoum. This finding reflects the fact that most states and rural areas in Sudan lack sufficient Percutaneous Coronary Intervention (PCI)-capable

centres. There are fewer than ten PCI centers across Sudan, with more than half located in Khartoum, forcing many patients to travel there for care. This association has been noted in similar studies from other countries [7,10,16]. This highlights the disparities in healthcare access between urban and rural populations, necessitating targeted interventions to improve healthcare accessibility, particularly in remote areas.

Interestingly, other sociodemographic factors such as age, gender, and marital status did not show significant associations with delayed presentation in present study, which aligns with findings from another research [12]. While some previous studies have reported associations between sociodemographic variables and delay [11,15,17], these were not observed in the current study.

Regarding chronic co-morbidities, no significant associations were found between Hypertension (HTN), Diabetes Mellitus (DM), hyperlipidemia, or heart failure and delayed time to hospital admission, which is consistent with a prior study [10]. This may be explained by the fact that many individuals experiencing AMI may not immediately recognise the severity of their symptoms, regardless of chronic diseases. However, other studies have reported associations between these conditions and delayed hospital visits, especially in patients with HTN and heart failure in STEMI cases [11], as well as diabetes [15,17]. In contrast, studies have shown that hyperlipidemia does not correlate as strongly with pre-hospital delay [18].

Analysis of Presenting Symptoms and Past Medical History

Upon analysing presenting symptoms and past medical history, no significant associations were found between late hospital arrival and chest or epigastric pain, previous myocardial infarction, and family history of myocardial infarction. This contrasts with other studies that demonstrate an association between family history and delayed hospital arrival [12, 19]. Interestingly, although myocardial infarction or recurrent myocardial infarction was previously thought to contribute to delays in some studies [20], no such association was found in the present study, consistent with previous observations [12].

The most frequent reason for pre-hospital delay was the initial consultations at non reperfusion centers, as supported by earlier findings [21,22]. This highlights a significant systemic issue that deserves additional scrutiny. Future research is needed to examine referral patterns, healthcare provider decisions, and logistical obstacles, in order to inform targeted interventions, including provider education and telemedicine assistance, to improve timely access to reperfusion therapy.

Recognising myocardial infarction symptoms, understanding the significance of early hospital presentation, and the necessity of seeking care at a center with reperfusion capabilities should be the main educational themes. Seeking help from a non reperfusion centre can cause unnecessary delays in life-saving interventions.

Limitation(s)

The sample size was not predetermined due to limited time; thus, all eligible patients who presented at the study centers during the set period were included. During data collection, Sudan encountered major political unrest and protests, making it risky and sometimes impossible to access certain areas, including heart clinics. This led to several temporary pauses in data collection to ensure the safety of the team. There was also a challenge of recall bias, although efforts were made to speak with patients within 48 hours of symptom onset to mitigate this. Additionally, patients who passed away before reaching the hospital or were too unstable to participate were not included, which may affect the generalisability of the results. Future studies should employ a prospective design and include patients from regions without specialised treatment centers to better understand cause-and-effect relationships and to represent a more diverse population.

CONCLUSION(S)

More than half of the patients in present study experienced delayed hospital arrival. The study concluded that the primary reason for delays was visiting non reperfusion centers. Further, delays were associated with lower education levels, non smoking status, and residing outside the capital, Khartoum. Fortunately, these factors can be modified through public awareness campaigns regarding AMI and the importance of seeking timely treatment at appropriate facilities. Significant associations with pre-hospital delay were found related to educational level, smoking status, and place of residence, but no significant association was noted with chronic co-morbidities or medical history. These findings underscore the need for targeted interventions to reduce delays and improve patient outcomes.

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Authors' contributions: RMM, AAS, and KOA were involved in study concept and design, data analysis and interpretation, and had full access to all data in the study. They took responsibility for the integrity of the data and the accuracy of the data analysis. RMM, BAY, and KOA acquired the data. All authors contributed to the drafting and editing of the article and approved the submitted manuscript.

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