ORIGINAL ARTICLE

Prevalence and Patient Factors Related to Pre-Hospital Delay in Young Patients with ST-Elevation Myocardial Infarction (STEMI)

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ABSTRACT

Introduction: ST-Elevation Myocardial Infarction (STEMI) often leads to out-of-hospital cardiac arrests, particularly among younger individuals with comorbidities such as diabetes, hypertension and smoking. This study aimed to determine the prevalence and patient factors associated with pre-hospital delays in young STEMI patients. **Materials and methods:** A retrospective study was conducted involving patients aged between 19 and 55, admitted between 1st January 2020 and 31st December 2022 to the Coronary Care Unit (CCU), Hospital Raja Permaisuri Bainun in Ipoh, Perak. Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) version 29. **Results:** A total of 340 patients' medical records were reviewed. The majority of patients were male (93.2%), aged 46-55 (57.1%) and Malay (58.8%). Smoking (69.7%), hypertension (43.8%), and diabetes (34.1%) were the most prevalent comorbidities. The in-hospital mortality rate was 3.2%. The prevalence of pre-hospital delay was 44.7% with a median delay of 7.01 hour (IQR: 10.34 hour). Patients with diabetes [OR: 1.72 (95% CI: 1.02, 2.90)], responding with "did nothing, hope it will go away" [OR: 3.63 (95% CI: 1.36, 9.69)], "lay down and tried to relax" [OR: 2.94 (95% CI: 1.43, 6.07)] and first medical contact (FMC) with a general practitioner (GP) [OR: 11.32 (95% CI: 2.20, 58.27)] were significantly associated with prolonged hospital delays ($p < 0.05$). **Conclusion:** These is critical need for targeted public health campaigns to educate young and at-risk individuals on STEMI warning signs to modify patient response behavior, ensure timely treatment, and ultimately reduce premature mortality among this population.
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Keywords: Prevalence, Pre-hospital delay, Young, ST-elevation myocardial infarction (STEMI), Patient factor

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INTRODUCTION

The World Health Organization (WHO) study reported that over 100 million people worldwide experience acute myocardial infarction (AMI) each year, resulting in approximately 9 million deaths. Globally, heart disease is responsible for 19.8 million deaths from CVDs in 2022 (1). Coronary artery disease (CAD) occurs when atherosclerosis narrows the coronary arteries, reducing blood supply to the heart. If a plaque ruptures, it can suddenly block blood flow, leading to acute coronary syndrome (ACS), a serious condition requiring urgent medical attention (2).

In Malaysia, during the pandemic, ACS admissions decreased from 20,604 to 15,162. Meanwhile, mortality rates increased across all demographics at discharge (7.7% vs. 6.7%), at 30 days (10.2% vs. 9.3%), and one year (18.9% vs. 17.8%) (3). In contrast, only 9.4% of ST-elevation myocardial infarction (STEMI) patients qualify for percutaneous coronary intervention (PCI), while 75% are eligible for thrombolytic therapy (4). Timely reperfusion using thrombolytic agents or primary PCI is essential to limit myocardial damage and preserve heart function (2). Unfortunately, some patients did not receive reperfusion therapy within the recommended timeframe due to pre-hospital delay (5).

In Malaysia, delays in seeking medical attention, misdiagnosis, and late reperfusion therapy significantly increase mortality rates among STEMI patients (6). During the COVID-19 pandemic, the incidence of thrombolysis declined, while mortality rates increased despite the emergency and trauma department (ETD) maintaining efficiency in timely thrombolysis administration (7). Prehospital delay is influenced by various factors including sociodemographic, clinical, cognitive, and emotional characteristics (8). Many patients need help recognizing symptoms and guidance to seek medical attention properly (8)
The National Cardiovascular Disease Database-Acute Coronary Syndrome (NCVD-ACS) Registry reported that the mortality rate for STEMI patients remains high in Malaysia in 2020-2021. The COVID-19 period was associated with higher mortality rates at all time points

compared to the pre-COVID period (18.9% vs.17.8% at one year). Crucially, this negative trend uniformly impacted all demographic and clinical groups, including age, ethnicity, gender, and ACS categories (3). A key contributor to high mortality is the delay in seeking treatment (6). Studies show that patients arriving at the hospital more than six hours after symptom onset have a higher risk of in-hospital mortality (9)

Although young age is typically considered protective against cardiovascular diseases, this advantage is increasingly being overshadowed by the rising prevalence of major cardiovascular risk factors among the younger population (10). Factors such as diabetes, hypertension, obesity, sedentary lifestyles, poor dietary habits, smoking, and non-compliance with medical advice are now more frequently observed in younger individuals. As a result, young patients are no longer immune to severe cardiac events, and their outcomes may be compromised due to a false perception of invulnerability, delays in seeking treatment, and underestimation of symptoms.

One critical factor influencing outcomes in young cardiac patients is the duration of the pre-hospital period, which refers to the time between symptom onset and hospital arrival. This period can be divided into two main components: patient delay and system delay. Patient delay refers to the duration between the onset of symptoms and the decision to seek medical attention which often prolonged due to factors such as symptom misinterpretation, denial, fear, or uncertainty (2,11). On the other hand, system delay encompasses delays within the healthcare and emergency response systems, including prolonged ambulance response times, inefficient referral pathways, and delays in reaching hospitals equipped with reperfusion facilities (2,12).
A study in Pahang found that public awareness of heart attack or myocardial infarction risk factors was very low, with most people only able to recognize one modifiable risk factor (13). In Taiwan, delayed arrival at ETD was more common among women and older patients (14). While coronary artery disease has been widely studied globally, understanding the situation in Malaysia is crucial, as data on pre-hospital delay factors remain limited (2)

For instance, patients with diabetes and congestive heart failure are more likely to delay seeking treatment. They tend to face significantly longer delays, possibly due to atypical symptoms resulting from diabetic neuropathy, which reduces pain perception (15). Women with prolonged delays are also less likely to experience chest pain, instead presenting with atypical symptoms such as pain in the back, shoulder, or stomach pain .

These atypical presentations are frequently ill-defined and pose a significant challenge for both patients and healthcare providers (16). Patients may fail to recognize the seriousness of their symptoms, leading to delays in seeking medical attention. Similarly, clinicians may misinterpret these non-specific symptoms, especially in younger individuals or those without a known history of cardiovascular disease, resulting in missed or delayed diagnosis. This lack of clarity in symptom presentation contributes to treatment delays and may worsen outcomes in ACS patients who do not exhibit typical chest pain.

Self-treatment and coping strategies also contribute to delays. Patients who attempt to manage symptoms with self-medication are three times more likely to arrive late at the hospital (17). Younger patients face unique challenges, including atypical or delayed symptom presentation, non-adherence to treatment, and symptoms that differ from those of older adults not as well studied compared to older populations (18). Therefore, this study aims to determine the prevalence and patient factors contributing to pre-hospital delay in young STEMI patients.

MATERIALS AND METHODS

Study design and Population

This cross-sectional study included patients aged 19 to 55 who were admitted to the Coronary Care Unit (CCU) at Hospital Raja Permaisuri Bainun, Ipoh, Perak, between 1st January 2020 and 31st December 2022

Data Collection, Inclusion and Exclusion Criteria

We analyzed records of patients aged ≤55 years who were admitted with a provisional diagnosis of STEMI. Patients with a prior history of STEMI, foreigners, or those whose diagnosis was ultimately changed to non-STEMI were excluded. To ensure data quality, patients was excluded if their records contained more than 10% missing data, or specifically lacked critical time markers for analysis such as symptom onset, hospital arrival, and first electrocardiogram (ECG)). Data collection involved systematically reviewing clinical notes from the ETD and CCU, including admission clerking notes, discharge summaries, referral notes, and progress notes.

Several variables were selected based on their relevance to pre-hospital delay and the feasibility of data collection from medical records. The five key variables are symptom onset time, first medical contact (FMC), symptom location, diabetes status, and pain scores. Diabetes was included due to its association with delayed care-seeking behavior, which may increase pre-hospital delay (19). Pain score was considered, as higher pain levels could affect the urgency of seeking medical help (20)

To estimate the required sample size for logistic regression analysis, the study applied the events per variable (EPV) concept and the formula $n = 100 + xi$, where x is an integer and i represents the number of independent

variables (21). With five independent variables, a sample size of 350 was calculated, including a 10% allowance for dropouts, resulting in a final estimated sample size of 389. A total of 340 eligible patients were included in the study, which was sufficient for multivariable analysis.

Patients admitted to the CCU at HRPB with a provisional diagnosis of STEMI and those aged below 55 years were included. Exclusion criteria included a history of STEMI, foreign nationality, or a diagnosis later revised to a condition other than STEMI. Patients who died before hospital arrival or shortly after admission in the ETD were excluded from this study since patients were recruited after they admitted to CCU. Samples with more than 10% missing data or missing key time records for symptom onset, hospital arrival, or first electrocardiogram (ECG) were also excluded. Data were collected by reviewing patients' clinical notes in the ETD and CCU, including admission clerking notes, discharge summaries, referral notes, and doctors' progress notes.

Operational Definition

Young STEMI patients are those aged 55 years or younger (18). Patients who arrive within three hours of symptom onset are classified as early arrivals, while those arriving after three hours are considered late arrivals (2). This duration is determined by reviewing medical records to find the exact time of symptom onset and hospital arrival. The times of arrival at the ETD is recorded when the first ECG is performed, which is the most accurate and reliable method in most hospitals (22).

Statistical Analysis

The data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 29. For demographic characteristics, comorbidities, clinical presentation, response towards symptoms, descriptive statistics and delay time, the results were presented as frequency and percentage (%) for categorical variables. For age, pain score, ejection fraction (EF) and random blood sugar (RBS), the median and interquartile range, (IQR) was used as the data were not normally distributed. Simple logistic regression was used for the univariable analysis. Variables with a p-value < 0.25 in the univariable analysis were selected for the final model. A multiple logistic regression test using the forward, backward and manual method was performed to determine the best model. Variables with p-value < 0.05 were considered statistically significant.

Ethical Clearance

This study was approved by the Medical Research and Ethics Committee (MREC) of the Ministry of Health Malaysia. The National Medical Research Registry (NMRR) ID-23-00490-OI2 (IIR) was obtained. A formal request to assess patient health records was submitted to the Hospital Director, the Head of the Department of Cardiology and the Head of the Department of Clinical Research Centre (CRC) at HRPB.

RESULTS

Socio-demographic, Comorbidities and Clinical Characteristics

Table I presents the socio-demographic, comorbidities and clinical characteristics of young patients with STEMI. Most patients are aged between 46 and 55 years (57.1%), with a median age of 47 years (IQR: 10). The majority of patients are male (93.2%), with females comprising 6.8%. For ethnicity, the largest group is Malay (58.8%), followed by Indian (26.5%), Chinese (12.6%), and other ethnicities (2.1%). The observed comorbidities in this population include smoking (69.7%), hypertension (43.8%), diabetes (34.1%), dyslipidemia (19.4%), a family history of heart attack (15.9%), and a history of heart disease (0.6%).

Table I: Demographic, comorbidities and clinical characteristics of young STEMI patients (N=340)

Variables	n (%)	Median (IQR)
Age (years)	340	47(10)
Age category		
<35	29 (8.5)	
36-45	117 (34.4)	
45-55	194 (57.1)	
Gender		
Male	317 (93.2)	
Female	23 (6.8)	
Ethnicity		
Malay	200 (58.8)	
Chinese	43 (12.6)	
Indian	90 (26.5)	
Others	7 (2.1)	
Diabetes		
Yes	116 (34.1)	
No	224 (65.9)	
Heart disease		
Yes	2 (0.6)	
No	338 (99.4)	
Dyslipidemia		
Yes	66 (19.4)	
No	274 (80.6)	
Family history of heart attack		
Yes	54 (15.9)	
No	286 (84.1)	
Hypertension		
Yes	149 (43.8)	
No	191 (56.2)	
Smoking		
Yes	236 (69.4)	
No	104 (30.6)	
Pain score	310 (91.2)	7 (4)
0	15 (4.8)	

CONTINUE

Table I: Demographic, comorbidities and clinical characteristics of young STEMI patients (N=340) (CONT.)

Variables	n (%)	Median (IQR)
Pain score	310 (91.2)	7 (4)
1-3	185 (59.7)	
4-6	90 (29.0)	
7-10	20 (6.5)	
Missing	30 (8.8)	
Typical presentation		
Chest pain	308 (90.6)	
Heaviness	184 (54.1)	
Radiated to left arm	146 (42.9)	
Diaphoresis	219 (64.4)	
Shortness of breath	124 (36.5)	
Atypical presentation		
Epigastric pain	12 (3.5)	
Vomiting	55 (16.2)	
Killip Classification		
Killip I	237 (69.7)	
Killip II	44 (12.9)	
Killip III	17 (5.0)	
Killip IV	42 (12.4)	
Ejection fraction		44.55 (9.65)
Random blood sugar		10.34 (5.11)
ECG		
Inferior	194 (57.1)	
Anteroseptal	44 (12.9)	
Anterior	84 (24.7)	
Lateral	97 (28.5)	
Posterior	28 (8.2)	

For clinical characteristics, the majority of participants experienced chest pain with pain score between 1-3 (54.4%) and displayed classic symptoms, including chest pain (90.6%), diaphoresis (64.4%), pain radiating to the left arm (42.9%) and shortness of breath (36.5%). A smaller percentage of patients presented with atypical symptoms, such as vomiting (16.2%) and epigastric pain. Most patients (69.7%) were categorized as Killip I and approximately 57.1% of the patients had an inferior wall STEMI. The median ejection fraction (EF) was 44.55 (IQR:9.65) while the median capillary blood sugar (CBS) was 10.34 (IQR: 5.11).

Response to Symptoms in Young Patients with STEMI

Table II presents the responses of young patients with STEMI to their symptoms. The data show that 95.3% attributed their symptoms to the heart. Most patients responded by "took themselves to the ETD" (53.9%), followed by "called/visited a GP" (15.6%), "lay down and tried to relax" (15.0%), and "did nothing, hope it will go away" (9.1%). Majority (76.5%) of patients reported experiencing symptoms at home. After symptom onset, 40.6% went directly to HRPB, 38.5% presented to the ETD in a district hospital or private hospital, while 16.5% went to GP and 4.4% went to health clinic. Around 56.8% were admitted during the night, on weekends, or public holidays. Only a few patients (1.8%) took medication before seeking medical care.

Table II : Responses to symptoms, treatments, complications and outcome of young patients with STEMI (N=340)

Variables	n (%)
Initial attribute to symptoms	
Heart	324 (95.3)
Indigestion	12 (3.5)
Fatigue	3 (0.9)
Muscle pain	1 (0.3)
Initial response toward symptoms	
Did nothing, hope it will go away	31 (9.1)
Lay down and tried to relax	51 (15.0)
Self-medicated	15 (4.4)
Told someone	5 (1.5)
Called/visited GP	53 (15.6)
Called an ambulance	4 (1.2)
Took himself to ETD	181 (53.2)
Location heart symptoms started	
Home	260(76.5)
Workplace	42 (12.4)
Public place	38 (11.2)
FMC	
HRPB	138 (40.6)
District Hospital/Private hospital	131 (38.5)
Health clinic	71 (4.4)
GP	
Symptom onset	
Regular working hours (8am-5pm)	112 (32.9)
After working hours (night/weekend/public holiday)	228 (67.1)
History of any medication before went to hospital	15 (4.4)
Treatment	
Thrombolysis only	33 (9.7)
Catheterization only	56 (16.5)
Thrombolysis & Catheterization	225 (66.2)
Thrombolysis & refused catheterization	15 (4.4)
Did not received thrombolysis & Catheterization	11 (3.2)
Resuscitation	28 (8.2)
Complications	
Cardiogenic shock	38 (11.2)
APO	5 (1.5)
Arrhythmia	56 (16.5)
Heart block	1 (0.3)
Left ventricular dysfunction	8 (2.4)
Gum bleeding	10 (2.9)
Major bleeding	16 (4.7)
No complication	219 (64.4)
Outcome	
Discharge	310 (91.2)
AOR	8 (2.4)
Death	11 (3.2)
Refer for CABG	11 (3.2)

Treatments and Complications in Young Patients with STEMI

Table II also shows the treatments and complications encountered by young STEMI patients. In the management

of STEMI, thrombolytic therapy was administered to the majority of patients, with Streptokinase used in 75.3% and Tenecteplase in 5.0% of cases, while 19.7% did not receive thrombolysis treatment within the recommended time frame, as they missed the treatment window. For catheter-based interventions, 63.2% of patients underwent percutaneous coronary intervention (PCI), 19.4% underwent diagnostic coronary angiography without subsequent intervention, 11.5% did not undergo any catheterization, and 5.9% refused the procedure.

The most common complications included cardiogenic shock (16.5%), major bleeding (11.2%), left ventricular dysfunction (4.7%), acute pulmonary oedema (APO) (2.4%) and heart failure (0.9%). After treatment, 91.2% of patients were discharged, 3.2% were referred for in-patient coronary artery bypass graft (CABG) and 2.4% discharged against medical advice (AOR). The in-hospital mortality rate was 3.2%.

Prevalence of Pre-hospital Delay in Young Patients with STEMI

Among young patients with STEMI, 44.7% experienced pre-hospital delay, while 55.3% arrived within 3 hours of symptom onset. The distribution of pre-hospital delay times was right-skewed, indicating that most patients had shorter delays, but a few experienced very prolonged delays. The median pre-hospital delay was 7.01 hours (IQR: 10.34 hours), with a range from 3.07 to 173.62 hours. For symptom onset, 55.3% of patients presented within 3 hours, 31.2% between 3–12 hours, and 13.5% after more than 12 hours from symptom onset. Overall, from 86.5% of patients arrived within the 12-hour therapeutic window for reperfusion therapy, almost 19.7% of those eligible did not receive thrombolysis within the recommended timeframe.

Factor Related to Pre-hospital Delay in Young Patients with STEMI

The bar chart (Figure 1) compares the prevalence of various risk factors between early and late presenters. Smoking was more common in late presenters (71.7%) compared to early presenters (67.6%). Hypertension was almost equally distributed between early (44.7%) and late presenters (42.8%). Hyperlipidemia was slightly more prevalent in late presenters (21.1%) than early presenters (18.1%). Heart disease was rare, with only 0.7% in early presenters. Diabetes was more common in late presenters (40.1%) compared to early presenters (29.3%). These findings suggest that late presenters tend to have a higher prevalence of smoking, hyperlipidemia and diabetes.

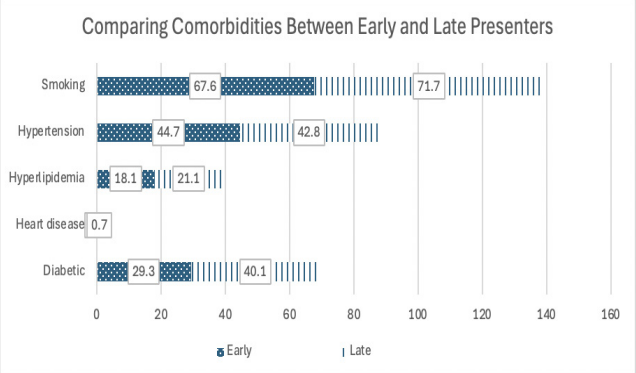

Figure 1: Comparing Comorbidities Between Early and Late Presenters.

In the multivariable analysis, four factors were independently associated with pre-hospital delay among young patients with STEMI .The forest plot presents adjusted odds ratios (ORs) with 95% confidence intervals (CIs) for factors influencing pre-hospital delay (Figure 2). Patients with diabetes mellitus had a higher likelihood of delayed presentation (AOR 1.72, 95% CI: 1.02–2.90, p=0.043). Compared to those who sought immediate help, patients who initially "did nothing, hoping it would go away" (AOR 3.63, 95% CI: 1.36–9.69, p=0.010) or "lay down and tried to relax" (AOR 2.94, 95% CI: 1.43–6.07, p=0.004) were significantly more likely to experience delay. Importantly, patients who FMC at GP had markedly increased odds of delay (AOR 11.32, 95% CI: 2.20–58.27, p=0.004), reflecting potential barriers in timely recognition and referral from primary care.

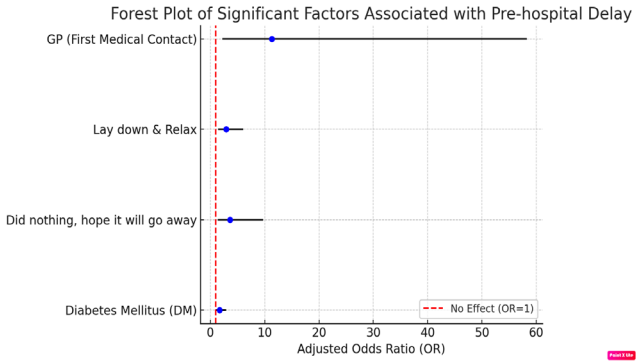

Figure 2: Forest plot of the Adjusted Odds Ratios with 95% Confidence Intervals.

DISCUSSION

The demographic characteristics of the patients revealed several notable trends. The majority of patients were

aged between 45 and 55 years, making up 57.1% of the total sample. Factors such as genetics, lifestyle, and higher rates of conditions like diabetes and hypertension may contribute to this trend. STEMI is more common in younger patients than non-ST elevation myocardial infarction (NSTEMI) (23), likely due to differences in risk factors like early smoking, genetic predisposition, or more aggressive coronary artery disease progression in younger individuals.

Most STEMI patients were male, confirming the established trend of higher incidence in younger males. The study also explored ethnicity's influence on STEMI risk, noting that the percentage of Indian ethnicity in the study (26.5%) was similar to a Singaporean study of young patients under 50 (20.6%) (24). This may reflect shared genetic, lifestyle or socio-economic factors that increase STEMI risk in young Indian populations.

The higher proportion of smokers among late presenters may indicate poor health-seeking behavior or delayed medical intervention, which could contribute to worsening conditions over time. Similarly, the increased prevalence of hyperlipidemia and diabetes in late presenters highlights the role of metabolic disorders in disease progression. These factors are known contributors to cardiovascular diseases, which may explain why individuals with these conditions seek medical care at later stages when symptoms become severe.

The differences in risk factor prevalence between early and late presenters highlight the need for targeted prevention strategies. Modifiable factors such as smoking and metabolic disorders play a significant role in disease progression, making early detection and lifestyle interventions crucial in reducing complications. The low prevalence of heart disease in early presenters may suggest the benefits of timely medical intervention in preventing severe outcomes.

Smoking was the most prevalent comorbidity among young STEMI patients, which aligns with findings from a Singapore study (24). Other research has also shown a higher prevalence of smoking as a comorbidity in younger STEMI patients compared to older populations (25,26). Smoking accelerates coronary artery disease and significantly contributes to STEMI in younger individuals. Besides, quitting smoking within a year of STEMI significantly reduces mortality at 1-year follow-up (27)

Additionally, a significant percentage of young STEMI patients had comorbidities like diabetes and HTN, with 38.8% affected by at least one condition. The prevalence of diabetes was higher in the Malaysian population compared to the Singapore study (34.1% vs. 28.2%). The study highlighted the impact of lifestyle factors, such as dietary habits and processed food consumption, on the increased prevalence of these conditions. Diabetes is particularly relevant in discussions of pre-hospital delays, as neuropathy often causes atypical symptoms and reduced pain sensation, leading patients to misinterpret the severity of their condition.

Dyslipidemia, a key risk factor for cardiovascular diseases, had a lower prevalence in the study compared to findings in Turkey and other populations, suggesting possible geographic, cultural, or lifestyle differences (24). The presence of multiple comorbidities in patients with diabetes can complicate their health perception, contributing to delays in seeking urgent medical attention during STEMI.

The study revealed that most young patients reported pain scores between one and three, emphasizing the importance of documenting pain scores to assess disease severity and initiate appropriate treatment. In contrast, one study showed increased delay time correlated with decreased symptom severity, such as chest pain, shortness of breath, and perspiration (22). However, the study also highlighted the inaccuracy of certain pain scoring documentation for STEMI patients.

Most young STEMI patients were able to accurately identify their cardiac symptoms and sought prompt specialist consultation. However, the study stressed the need for improved awareness, especially among younger individuals, to avoid misinterpreting or underestimating symptoms, which can result in delayed treatment. Patients' initial responses varied, with some seeking appropriate treatment at the hospital's ETD with minimal delay, while others opted to rest or relax instead of seeking treatment. Accessing hospitals, concerns about waiting times, and confusion over STEMI symptoms contributed to difficulties in reaching the hospital. Factors like geographic location, healthcare facility hours, and perceived symptom severity influenced patients' initial healthcare choices.

Several factors contribute to pre-hospital delays in STEMI patients such as hesitation to seek medical help due to concerns about burdening others. However, informed family members or friends can encourage timely medical attention. Visiting a GP is another major contributor to pre-hospital delay, as patients face long wait times, lack of immediate ECG access, and potential misdiagnosis due to limited diagnostic tools (4,28). Additionally, self-treatment, such as taking painkillers to wait out symptoms, further prolongs delays and patients who self-medicate are 9.02 times more likely to delay FMC (17)

Most patients (66.2%) received both thrombolysis and catheterization, in line with standard treatment protocols for STEMI. However, 16.5% underwent catheterization without thrombolysis, likely due to contraindications for thrombolytic therapy, such as recent surgery or hemorrhagic stroke. Interestingly, 4.4% of patients

refused catheterization after thrombolysis, underscoring the importance of patient autonomy and thorough communication about the benefits and risks of invasive procedures.

The study also emphasized the importance of well-trained healthcare professionals for managing complications, including resuscitation. These findings highlight the need for interventions to improve patient acceptance of necessary treatments and ensure timely responses to critical situations for better outcomes. In-hospital mortality was 2.8%, which is slightly lower than in similar studies. Among younger patients, our rate (3.2%) was lower than that reported in Turkey (3.6%) (24). This could be attributed to the lower prevalence of comorbidities and greater physiological resilience among younger patients.

Out of 340 patients, 55.3% arrived within 3 hours, 31.2% between 3–12 hours, and 13.5% after more than 12 hours, with 44.7% classified as late presenters. In comparison, a study conducted in Kelantan and Terengganu involving 222 STEMI patients (mean age 58 years) reported a median symptom-to-door time of 130.5 minutes, with 64% arriving within 3 hours and 36% arriving later. The use of a 3-hour cut-off was consistent with Malaysian clinical guidelines for evaluating pre-hospital delay and reperfusion eligibility (4).

In the present study, the median pre-hospital delay was 7.01 hours, which is considerably longer than the times reported in Russia (1.5 hours) and Japan (1.48 hours), where shorter delays are associated with improved clinical outcomes (17). However, prolonged delays exceeding three hours have also been documented in the Maldives (3.83 hours) (29) and Bangladesh (9.0 hours) (9). These international variations highlight the influence of socio-demographic factors, health-seeking behaviors and accessibility of healthcare systems in shaping pre-hospital delay patterns. This study's results highlight that patient-related delays in hospital presentation remain a major barrier to timely reperfusion therapy. Although most patients presented within the 12-hour therapeutic window, about 13.5% arrived late and were ineligible for reperfusion, indicating inadequate symptom recognition or delayed decision-making to seek medical care.

The study identified key factors contributing to pre-hospital delays in young STEMI patients. Those with comorbidities, especially diabetes, had longer delays, which aligns with prior research (30). Despite differences in the literature, the study found no significant association between pain scores and pre-hospital delay, warranting further investigation (9).

Although most patients experienced typical symptoms, many reported less severe symptoms, stressing the need for increased awareness to prevent delays. Some patients recognized heart-specific symptoms like chest pain, while others who experienced more gradual discomfort such as dyspnoea, back pain, or muscle aches often underestimated these signs of a potential myocardial infarction, hoping the pain would simply go away on its own (31). Young patients with common risk factors like smoking, hypertension and dyslipidemia had unique responses to symptoms, such as "did nothing" or "lying down to relax" which impacted their decision to seek immediate medical help.

Our findings highlight both patient-related and system-related factors contributing to pre-hospital delay in STEMI. The presence of diabetes was associated with increased delay, possibly due to atypical symptom presentation and reduced pain perception among patient with diabetes. Patient behavioral responses, such as waiting for symptoms to resolve or attempting to relax, were also strong predictors of delay, emphasizing the need for public education on recognizing acute cardiac symptoms and acting promptly. The strongest predictor of delay was first medical contact with a GP, suggesting that delays in referral or limited availability of emergency pathways in primary care may significantly hinder timely access to reperfusion therapy. Addressing these modifiable factors could substantially reduce treatment delays and improve outcomes in young STEMI patients.

This study identified first FMC with a GP as the factor contributing to pre-hospital delay. Direct ETD or emergency medical services (EMS) access remains crucial to avoid treatment delays. Patients who first consulted a GP often experienced longer delays before receiving reperfusion therapy. These delays commonly occur because chest pain symptoms are underestimated or misdiagnosed as gastric problems. Limited access to diagnostic tools such as ECG or cardiac biomarkers and long waiting times for consultation result in delay treatment.

Improving assessment in primary care is very important and GPs should maintain a high index of suspicion for possible STEMI to ensure prompt referral to the ETD or activation of EMS. Strengthening collaboration between GPs and hospitals through early ECG assessment and direct ambulance transfer protocols will help to enhance timely access to direct care.

Early recognition and timely EMS activation can improve outcomes by ensuring faster medical intervention (32). However, studies show mixed results regarding EMS impact on pre-hospital delays. While ambulances in the US reduce travel time compared to private vehicles, late presentation included the absence of EMS utilization (33). A Malaysian study found late arrivals regardless of ambulance use, GPs, or health clinics (4). Nonetheless, paramedics' role in providing immediate treatment, such as administering aspirin and Plavix during transport, remains crucial in improving survival and outcomes

(11).

To strengthen the management of STEMI in younger patients, continuous training should be extended to all healthcare providers actively involved in pre-hospital care, emergency departments, and health clinics, including nurses and assistant medical officer (AMOs). Such programs should emphasize the recognition of atypical symptom presentations and the need to maintain a high level of clinical suspicion, particularly in younger patients, women, and those with comorbidities such as diabetes. Ongoing professional development will help frontline providers identify critical warning signs, even in less typical cases. In addition, implementing triage protocols tailored for use in emergency and clinic settings will support early detection and accurate triaging of young STEMI patients, ultimately reducing delays and improving outcomes.

Addressing heart disease in young STEMI patients requires a comprehensive approach, including timely diagnosis, specialized care, psychological support, lifestyle interventions, and long-term management. Public health campaigns and community-based interventions are key to reducing pre-hospital delays and improving outcomes. Empowering individuals with knowledge about symptoms and family history helps them act quickly. Healthcare providers also play a critical role in reducing pre-hospital delays. Early risk factor recognition and lifestyle modifications can prevent STEMI's premature onset. Utilizing mobile apps and social media platforms can promote healthy behaviors among youth, and partnering with youth organizations encourages participation in health activities.
In conclusion, addressing STEMI in young patients requires a holistic approach that emphasizes early diagnosis, specialized care, psychological support, lifestyle changes, and long-term management. Public health campaigns, education, and resources are essential in reducing pre-hospital delays. Empowering individuals with knowledge and promoting healthy behaviors are crucial for improving outcomes. Healthcare providers play a key role in recognizing risk factors early, implementing lifestyle changes, and preventing STEMI.

Study Strength and Limitation

This study has several strengths, particularly in its selection of the sample population from Perak, a western region of Malaysia. Perak is the second-largest state on the Malaysian Peninsula and the fourth largest in the country. The specific details of the ECG, including date and time, were directly collected from the first printed ECG records.

However, our study also had certain important limitations. Firstly, the results of this study do not reflect the entire population of Malaysia as it was a retrospective single tertiary center study in Perak. Therefore, it does not represent the entire population sample of the country. Secondly, the sample size was smaller than the targeted sample size since due to difficulties in tracing medical records. Some records had been relocated or used for other research or clinical audits during the data collection process. Thirdly, this study did not include patients who did not reach the hospital or died shortly after admission in ETD. Fourthly, although we thoroughly reviewed all the clinical records of patients, our data is limited by the retrospective nature of the chart review for data collection.

This study focused solely on patient-related factors due to the retrospective nature of data collection and limited availability of certain key variables in the medical records. Important contributors to pre-hospital delay such as socioeconomic status, health literacy, geographical location, mode of transportation, and level of patient education were not included as they were not documented in the records. Therefore, the findings may not fully represent all potential contributors to pre-hospital delay.

Although using patient-specific symptoms and reactions from medical records helps reduce recall bias, this retrospective data collection method has some limitations. These include incomplete or missing records, lack of standardized documentation by attending doctors, and potential researcher bias when interpreting patients' reactions. These limitations highlight the need for future prospective studies that incorporate a broader range of variables to provide a more comprehensive understanding of pre-hospital delays in STEMI patients.

Besides, we did not study the one-month and long-term clinical outcomes of these patients. A future study to assess the long-term outcomes of the young population would provide further insights into the complications of STEMI care in the Malaysian population. Since the study is specific to Malaysia, its generalizability to other healthcare settings may be limited. However, a brief comparison with healthcare systems in neighbouring countries such as Singapore, Thailand, and Indonesia could provide valuable context and highlight both shared challenges and unique differences in pre-hospital care and ACS management.

CONCLUSION

This study successfully profiled young patients with STEMI in Perak, confirming a high prevalence of smoking, hypertension, diabetes, and dyslipidemia. Crucially, researchers found that nearly half of these young patients experienced significant pre-hospital delays in seeking medical attention. The patient factors driving this delay were specifically, the patients' denial of symptoms by responding by "doing nothing" or "trying to relax" and initial contact with a GP instead of ETD with reperfusion facilities. These findings highlight a critical need for targeted public health campaigns to

educate young and at-risk individuals on STEMI warning signs. Such interventions are necessary to modify patient response behavior, ensure timely treatment, and ultimately reduce premature mortality among this population.

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