The clinical and geographical characteristics, health-seeking behaviours of ST-segment elevation myocardial infarction patients with their total ischaemic time and short-term cardiac mortality outcomes: a local geographical perspective from a developing country

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ABSTRACT

Introduction: Ischaemic heart disease including ST-segment elevation myocardial infarction (STEMI) is the leading cause of death among Malaysians. Total ischaemic time (TIT) which consists of patient delay and systemic delay is a strong predictor of cardiovascular outcome in STEMI. Primary percutaneous coronary intervention (PPCI) is superior to medical thrombolysis in improving STEMI patients' survival outcomes. Our study aims to provide an insight into the clinical and geographical characteristics of STEMI patients, their health-seeking behaviour, TIT, interventions received and short-term cardiac mortality outcomes in the effort to improve the existing coronary care service.

Materials and Methods: This is a descriptive study looking into patients who were diagnosed with STEMI and presented to or were referred to Sarawak Heart Centre between 1st July 2022 and 31st December 2022.

Results: A total of 183 patients were recruited and 33.3% were <50 years old. The majority were in a different division during symptom onset from where the local PPCI centre is located and some underwent one or two transits before arrival at the revascularisation centre. More presented out-of-hour and they were more likely to present within the PPCI window. The median TIT for the study population was 3.3 hours. The short-term cardiac mortalities were 9.3% and only the Killip class was found to have a significant association. In this study, TIT was not significantly associated with short-term mortalities but those who died had a longer median TIT.

Conclusion: A local STEMI network should be set up using the 'Hub-and-Spoke' model in a staged-wise approach to reduce TIT given that PPCI is now the gold standard of treatment alongside continuous effort in patient education.

KEYWORDS:
ST-elevation myocardial infarction, total ischaemic time, geographical characteristics, health-seeking behaviours, developing country

INTRODUCTION

Ischaemic heart disease is the leading cause of death among the Malaysian population.[1] ST-segment elevation myocardial infarction (STEMI) among acute coronary syndrome stands the highest in-hospital and 30-day cardiac mortalities at 23.8% and 18.2% respectively in this nation.[2] Earlier revascularisation has been proven to confer better survival outcomes among STEMI patients.[3] The timeliness of revascularisation is measured by the mean of total ischaemic time (TIT) which is defined as the duration from symptom onset of chest pain till revascularisation and is contributed by patient delay and system delay.[4]

Patient delay is defined as the time of symptom onset to first medical contact.[5] It is mainly attributed to patients' awareness of the timeliness of their presentation and the location of patients at symptom onset which are part of the pre-hospital delay and directly affect the symptom-to-door time, and in turn, contribute to TIT. A study showed that pre-hospital delay has a greater impact than door-to-balloon time (DTB) on TIT.[6] System delay, on the other hand, is defined as the time from first medical contact to revascularisation and is contributed by non-patient-related factors including emergency medical service, transfer delay, and intra-hospital delay. TIT is a stronger predictor of cardiovascular outcome and is used to assess the performance of STEMI by the European Society of Cardiology.[4,5,7-9]

There are two modes of revascularisation, including primary percutaneous coronary intervention (PPCI) and fibrinolytic therapy. The timeliness of their administration is termed as DTB and door-to-needle (DTN) time respectively and directly contributes to the system delay of TIT. Fibrinolytic therapy is widely available in most hospitals and can be easily administered by any healthcare personnel. PPCI on the other hand, is technically demanding and can only be performed by a skilled interventional cardiologist in a catheterisation laboratory. Hence, in Malaysia, fibrinolytic therapy is still more widely performed than PPCI and is part of the recommendation by the National Clinical Practice Guideline (CPG) for the management of STEMI taking into account the

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socio-economic status and infrastructure availability of the local settings.[10] However, PPCI has been proven in multiple trials to be superior to medical thrombolysis in improving the survival outcomes of STEMI patients.[11-15]

Developing countries like Malaysia are not spared from the grasp of cardiovascular diseases such as STEMI. Every effort should be taken to improve the PPCI service sustainably for the long-term benefit of the local population given the evidence of its benefit and to strive to improve TIT at every level. While the effort to improve DTN and DTB time should be continued, the importance of pre-hospital healthcare services should not be overlooked. To improve pre-hospital healthcare and to expand the PPCI service, a geographical perspective of the local distribution of STEMI patients is important to evaluate the coverage of existing coronary care services for the revision of future care plans and service expansion. However, no existing data to date is available to show the local geographical distribution of STEMI patients at symptom onset before their admissions to a PCI-capable hospital in Southern Sarawak, Malaysia.

Sarawak Heart Centre, which is our study centre, is the only PCI-capable government hospital within the state of Sarawak and is located in the southern region, catering for approximately 1.2 million population.[16] The focus of the study is therefore, based on the patient's population within the southern region of Sarawak where delivery of PPCI service is possible given the location of the only PCI-capable centre in the state, which aims to provide an insight into the clinical and geographical characteristics of patients, their health-seeking behaviour, TIT, interventions received and short-term cardiac mortality outcomes which consist of in-hospital and 30-day cardiac mortalities among STEMI patients in the region, in tandem with the objective of Global Heart Attack Treatment Initiative (GHATI) to improve STEMI care. GHATI was launched by the American College of Cardiology in 2019 which works to improve heart attack outcomes of acute coronary syndrome (ACS) patients in low- and middle-income countries.[17] Information on the local geographical distribution of STEMI patients at symptom onset will also be provided in this study to establish a STEMI network within the local setting of southern Sarawak and in the hope of the expansion of service to reach out to the whole state in the future.

MATERIALS AND METHODS

Study Design and Setting

This is a descriptive study looking into patients who were diagnosed with STEMI and presented to or were referred to Sarawak Heart Centre between 1st July 2022 and December 2022, to study the characteristics, health-seeking behaviour of patients, TIT, interventions received and short-term cardiac mortality outcomes which consist of in-hospital and 30-day cardiac mortalities. Sarawak is a state of Malaysia located in the region of East Malaysia in northwest Borneo. Historically, the state of Sarawak was divided into five administrative divisions before the current 12 divisions (Betong, Bintulu, Kapit, Kuching, Limbang, Miri, Mukah, Samarahan, Sarikei, Serian, Sibu, Sri Aman) (Figure 1A). Sarawak Heart Centre is located in the Samarahan division in the southern region of Sarawak. When the emergency medical service team from the southern region of Sarawak receives an emergency call for a patient with suspected STEMI, the patient is sent to the nearest government medical centre within the division which is usually a secondary hospital for further evaluation and treatment including administration of fibrinolytic therapy if not for consideration of PPCI, before the decision of referral to a PCI-capable hospital which is our study centre. STEMI patients beyond the southern region of Sarawak will receive fibrinolytic therapy due to the non-availability of PPCI service and will only be referred to Sarawak Heart Centre for elective PCI later. During the acute admission, they are managed at the secondary hospital within their respective divisions.

Sarawak Heart Centre has cardiology and cardiothoracic departments to provide a comprehensive coronary care service. The Cardiology Department consisted of a total of 40 inpatient beds including eight beds in the coronary care unit and 32 beds in cardiac rehabilitation wards to provide high to low dependency inpatient care.[18] Patients who present with acute STEMI were admitted under the cardiology department and later referred for cardiothoracic services should open heart bypass surgery be required.

Participants

All patients from the southern region of Sarawak namely divisions of Kuching, Samarahan, Serian, Sri Aman and Betong who were diagnosed with STEMI and presented to or were referred to Sarawak Heart Centre between the period of 1st July 2022 and 31st December 2022 were recruited. Only patients from these divisions were included because, beyond these, it is not feasible to cover primary PCI service in terms of the travelling time with the current availability of PCI-capable centres in Sarawak.[10] Exclusion criteria include patients who were initially treated for STEMI but were later confirmed to have other diagnoses.

Data Collection and Outcome Measured

Demographic data including patients' age, sex, ethnicity, marital status, and cardiovascular risk factors were collected. In addition, the type of location during symptom onset, duration and distance from symptom onset to first medical contact, duration and distance from first medical contact to revascularisation centre, total distance travelled, DTN, DTB, TIT, Thrombolysis in Myocardial Infarction (TIMI) risk score, Killip score, mode of revascularisation, choice of fibrinolytic agent and revascularisation outcomes were recorded. Duration from symptom onset till arrival at first medical contact was then divided into groups of <3 hours, 3-12 hours, and >12 hours with cut-off values taken from the Malaysia Clinical Practice Guideline (CPG) for acute management of STEMI, 2019 to evaluate the adherence to the guideline for the mode of revascularisation or treatment received. These three groups of patients were also regrouped into ≤12 hours and >12 hours for subsequent analysis. The 12-hour cut-off is the determinant for PPCI.10 TIMI score was categorised into groups of low TIMI risk scores of 0-5, moderate TIMI risk scores of 6-7, and high TIMI risk scores >7. As for Killip classification, Killip I and II were considered as low Killip class whereas Killip III and IV were considered as high Killip class. The outcomes measured were patient delay, TIT, in-hospital and 30-day cardiac mortalities.

Statistical Analysis
Statistical analysis was performed with IBM SPSS version 27. Continuous variables with normal distribution were presented as mean (standard deviation) whereas skewed distributions were presented as median (interquartile range). Others include categorical data with quantitative variables which were presented in frequency (percentage). The Mann-Whitney U test was used for numerical variables and either Pearson's chi-square test or Fisher's exact test was used for categorical variables. Correlations between the total distance travelled from symptom onset till revascularisation and TIT was examined using the Pearson correlation coefficient test. Multivariable logistic regression analysis was used to determine the associations when there was more than one significant variable. Statistical significance was set at p-value <0.05.

Ethics
This study was approved by the Medical Review and Ethics Committee (MREC), Ministry of Health (MOH) in 2023 (Approval code: NMRR ID-23-00747-YFQ). MREC waived the informed consent for this study.

RESULTS

Clinical Characteristics
A total of 183 patients with STEMI were included in this study, amounting to an average of 31 STEMI patients per month in Sarawak Heart Centre. The median age of our study population was 55 years, and they were predominantly male. A vast majority of 175 (95.6%) had at least one cardiovascular risk factor, with smoking being the most common one. Most (75.3%) were at home when chest pain occurred. Hundred and thirty-three (73.5%) had low TIMI categories whereas 146 (80.7%) were Kilip I or II. Other clinical characteristics of patients are stated in Table I.

Geographical Characteristics
The majority of the patients were in the Kuching Division when chest pain occurred, which is a different division from where SHC is located (Figure 1B).

The median distance from symptom onset to the nearest hospital and Sarawak Heart Centre was 7.9 (range 4.1-16.4) km and 19.0 (range 13.8-34.1) km respectively with the maximum distance travelled being 396 km.

Patients' Health-seeking Behaviour and Pattern
Hundred and thirty-three (72.7%) presented to a hospital of whom 32 (17.5%) presented directly to SHC and 115 (63.2%) presented out-of-hour. Further information on the pattern of patient health-seeking behaviours in terms of FMC is available in Table II.

Ninety-four (70.7%) patients received revascularisation therapy at first medical contact . Patients who presented to first medical contact without revascularisation service or were unable to afford the payment of treatment such as those who went to private medical centres, needed to undergo one or two transits. Those who transited once before reaching the revascularisation centre consisted of 37 (27.8%) patients while those who transited twice before receiving revascularisation therapy consisted of two (1.5%) patients.

Those who presented to other non-PCI-capable hospitals were eventually sent to our cardiac centre for post-revascularisation care after receiving fibrinolytic therapy. One hundred and thirty-three (73.1%) patients transited once to another hospital before reaching SHC. Those who transited twice before arrival at SHC consisted of 15 (8.2%) patients.

Total Ischaemic Time and Interventions Received
The median TIT of our study population was 3.3 hours. Those presenting to the government or private clinics had a median TIT of 4.3 (3.1, 6.7) hours, which was significantly longer than those presenting to hospitals who had a median TIT of 2.9 (2.0, 4.9) hours (p=0.005, Z= -2.832). Also, those presenting to non-PCI capable, and PCI capable centres had median TIT of 3.5 (2.3, 5.1) and 2.3 (1.7, 4.6) respectively (p=0.029, Z= -2.187). Those who transited once before reaching a revascularisation centre had a longer median TIT of 4.3 (range 2.9-7.9) hours than those who presented directly to a revascularisation centre with a median TIT of 2.9 (range 2.0-4.6) hours (p=0.004). Those in rural areas at symptom onset had a significantly longer median TIT of 4.1 (range 2.7-6.8) hours than those in urban areas who had a median TIT of 2.9 (range 2.0-4.6) hours (p=0.012, Z= -2.499). Those who were at home and out of home at symptom onset had median TIT of 3.9 (range 2.1-5.7) hours and 2.8 (range 2.2-3.9) hours respectively (p=0.026, Z= -2.219).

Among our study population, 60.1% received fibrinolytic therapy and 12.0% received PPCI. Hundreds and two (77.3%) adhered to CPG for the mode of revascularisation. The median DTN and DTB times were 37 minutes and 55 minutes respectively.

Of those who received PPCI, those who presented directly to SHC had a shorter median TIT of 2.9 hours than those who presented to other non-PCI-capable hospitals in which the median TIT was 4.2 hours. Even for those who received fibrinolytic therapy, the TIT was shorter for those who presented directly to the study centre than those who presented to other centres (Figure 2).

Of the 52 (28.6%) patients who received medical therapy, 37 (71.2%) were due to late presentation myocardial infarction, 11 (21.2%) experienced spontaneous resolution of ST-segment elevation from 12-lead electrocardiogram and symptom relief before revascularisation, 1 (1.9%) refused thrombolysis therapy and 3 (5.8%) died before any revascularisation was given. Three (2.3%) patients underwent rescue PCI due to failed thrombolysis from fibrinolytic therapy.

There was no correlation between the total distance travelled from symptom onset to the revascularisation centre and TIT (R^2=0.020).

Patient Delay and the Associated Factors
Hundreds and fifty-seven (86.7%) patients presented for medical attention within 12 hours or less and were within the PPCI window. Of the late presenters who presented beyond 12 hours, two (8.3%) had a history of ischaemic heart disease

Table I: Characteristics of patients with myocardial infarction and survival outcomes

Characteristics	n(%)	(min, max)
Age in years - median (IQR)	55.0 (47.0, 66.0)	25.0, 82.0
Age <50-year-old	61 (33.3)	
Age ≥50-year-old	122 (66.7)	
Sex		
Male	160 (87.4)	
Female	92 (12.6)	
Ethnicity		
Malay	76 (41.5)	
Chinese	44 (24.0)	
Indian	1 (0.5)	
Indigenous	60 (32.8)	
Foreigner	2 (1.1)	
Marital status		
Married	151 (83.9)	
Single	12 (6.7)	
Divorced	11 (6.1)	
Widowed	6 (3.3)	
Risk factors		
No	8 (4.4)	
One	51 (27.9)	
Two or more	124 (67.7)	
Hypertension	87 (47.5)	
Diabetes mellitus	46 (25.1)	
Dyslipidaemia	67 (36.6)	
Family history of IHD	37 (20.6)	
Personal history of previous IHD	18 (9.8)	
Smoking	118 (65.2)	
Regular alcohol use	41 (22.9)	
Location during symptom onset		
Home	137 (75.3)	
Workplace	14 (7.7)	
Non-home, non-workplace	31 (17.0)	
Time of presentation at FMC		
Office hours	67 (37.0)	
Out of hours	115 (63.2)	
Type of healthcare facility upon presentation		
Government or private clinic	50 (27.3)	
Hospital	133 (72.7)	
PCI capable centre	33 (18.0)	
Non-PCI capable centre	150 (82.0)	
Duration from symptom onset to FMC in hours- median (IQR)	2.3 (1.2, 5.2)	0.2, 150.5
Duration of symptom onset to FMC		
<3 hours	114 (63.0)	
3 -12 hours	43 (23.8)	
>12 hours	24 (13.3)	
Duration from FMC to revascularisation centre in hours- median (IQR)	1.8 (1.3, 2.4)	0.7, 4.5
Mode of revascularisation		
PPCI	22 (12.0)	
Fibrinolytic therapy	110 (60.1)	
Medical therapy*	51 (27.9)	
Adherence to CPG recommendation for mode of revascularisation	123 (68.0)	
Choice of fibrinolytic agent		
Tenecteplase	18 (16.4)	
Streptokinase	92 (83.6)	
Door-to-needle time in minutes - median (IQR)	37.0 (22.0, 76.0)	
Door-to-needle time in minutes ≤ 30 minutes	41 (38.3)	
Door-to-balloon time in minutes - median (IQR)	55.5 (49.8, 77.3)	41.0, 184.0
Door-to-balloon time in minutes ≤ 90 minutes if presented to PCI capable centre or ≤ 120 minutes from FMC to wire-crossing if transferred from non-PCI capable centres	19 (86.4)	
Revascularisation outcome		
Successful	129 (97.7)	
Failed	3 (2.3)	
Rescue PCI	3 (2.8)	
Total ischaemic time in hours- median (IQR)	3.3 (2.1, 5.0)	0.5,55.1

Table I: Characteristics of patients with myocardial infarction and survival outcomes

Characteristics	n(%)	(min, max)
Total distance travelled between symptom onset and revascularisation centre in kilometres - median (IQR)	12.1 (7.6, 23.4)	0.8, 109.7
TIMI score- median (IQR)	3.0 (2.0, 6.0)	0.0,12.0
TIMI categories		
Low TIMI risk score	133 (73.5)	
Moderate to high TIMI risk score	48 (26.5)	
Killip score- median (IQR)	1.0 (1.0, 2.0)	1.0,4.0
Killip categories		
Killip I-II	146 (80.7)	
Killip III-IV	35 (19.3)	
In-hospital cardiac mortality outcome		
Alive	166 (90.7)	
Dead	17 (9.3)	
30-day cardiac mortality outcome		
Alive	166 (90.7)	
Dead	17 (9.3)	

CPG: Clinical practice guideline, FMC: First medical contact, IHD: Ischaemic heart disease, km: Kilometre, PPCI: Primary percutaneous coronary intervention, TIMI: Thrombolysis in myocardial infarction.
*Refer to standard acute coronary syndrome treatment (high-dose acetylsalicylic acid, high-dose P2Y12 inhibitor, fondaparinux/enoxaparin and high-dose statin)

Table II: Pattern of patient health-seeking behaviour according to FMC in different locations and the treatments received

		First medical contact				
		Hospital (n=133)			Clinic (n=50)	
		Government (n=115)		Private (n=18)	Health clinic (n=26)	General practitioner (n=24)
		PCI centre (n=32)	Non-PCI centre (n=83)			
Nearest medical centre*	Government	24	42	3	16	11
	private	7	38	15	10	12
	PCI centre	23	4	1	9	6
	Non-PCI centre	8	76	17	17	17
Location of symptom onset	Urban	25	51	18	13	18
	Rural	6	31	0	13	6
Time of presentation	Office hour	10	22	5	18	12
	Out of hour	22	60	13	8	12
Treatment received	PPCI	9	1	3	8	1
	Fibrinolytic therapy	15	66	9	11	9
	Medical therapy	8	16	6	7	14
Districts	Kuching	12	52	17	13	16
	Bau	-	5	-	-	1
	Lundu	-	6	-	-	-
	Samarahan	17	1	1	2	6
	Asajaya	1	-	-	4	-
	Simunjan	-	1	-	-	-
	Sebuyau	-	-	-	3	-
	Serian	-	12	-	1	1
	Siburan	1	-	-	1	-
	Tebedu	-	1	-	-	-

*Nearest medical centre is the nearest centre from the patient at symptom onset according to the distance calculated but is not necessarily the centre of presentation or FMC.

Table III: Factors associated with duration from symptom onset to arrival at FMC were analysed using Pearson's chi-square test

Factors	Duration from symptom onset to arrival at FMC		χ^2 (df)	p-value
	≤12 hours n (%)	>12 hours n (%)		
Age				
<50 years	52 (86.7)	8 (13.3)	0.000	0.984
≥50 years	105 (86.8)	16 (13.2)		
Gender				
Male	135 (85.4)	23 (14.6)	1.819	0.177
Female	22 (95.7)	1 (4.3)		
Ethnics				
Malay	63 (84.0)	12 (16.0)	1.444	0.837
Chinese	38 (86.4)	6 (13.6)		
Indian	1 (100.0)	0 (0.0)		
Indigenous	53 (89.8)	6 (10.2)		
Foreigner	2 (100.0)	0 (0.0)		
Marital status				
Married	128 (85.9)	21 (14.1)	0.293	0.589
Single/divorced/widowed	26 (89.7)	3 (10.3)		
Number of risk factors				
Less than 2	54 (93.3)	4 (6.9)	3.005	0.083
Two or more	103 (83.7)	20 (16.3)		
Smoker				
Yes	100 (86.2)	16 (13.8)	0.042	0.837
No	55 (87.3)	8 (12.7)		
Alcohol				
Yes	34 (82.9)	7 (17.1)	0.562	0.453
No	119 (87.5)	17 (12.5)		
Family history of IHD				
Yes	29 (80.6)	7 (19.4)	1.375	0.241
No	125 (88.0)	17 (12.0)		
Hypertension				
Yes	74 (86.0)	12 (14.0)	0.069	0.793
No	83 (87.4)	12 (12.6)		
Diabetes mellitus				
Yes	39 (86.7)	6 (13.3)	0.000	0.987
No	118 (86.8)	18 (13.2)		
Dyslipidaemia				
Yes	56 (83.6)	11 (16.4)	0.923	0.337
No	101 (88.6)	13 (11.4)		
Personal history of IHD				
Yes	16 (88.9)	2 (11.1)	0.080	0.777
No	141 (86.5)	22 (13.5)		
Location of symptom onset				
Home	114 (84.4)	21 (15.6)	2.308	0.129
Out of home	42 (93.3)	3 (6.7)		
Area of symptom onset				
Urban	108 (87.1)	16 (12.9)	0.089	0.766
Rural	47 (85.5)	8 (14.5)		
Time of presentation				
Office hours	51 (76.1)	16 (23.9)	10.433	0.001
Out of hours	106 (93.0)	8 (7.0)		

FMC: first medical contact. IHD: ischaemic heart disease

before the current presentation. Fourteen (58.3%) were within a radius of 20 km from the PCI-capable centre at symptom onset in which there is a disproportionate delay in presentation considering their distance from the treatment centre.

The association of all the factors listed in Table III with patient delay were studied. We found that only the time of presentation was significant in the association. When looking into this factor, the 115 (63.2%) of our study cohort who presented out of hour (Table I) were found to be more likely to present within the golden hour of the PPCI window of 12 hours or less (Odds Ratio, OR: 4.2; 95% Confidence Intervals, 95%CI: 1.7, 10.3) (Table III).

The association between distance and duration from symptom onset to arrival at first medical contact was not significant (p=0.901).

Mortality Outcomes and the Associated Factors

The in-hospital and 30-day (short-term) cardiac mortalities for our study population were 9.3%.

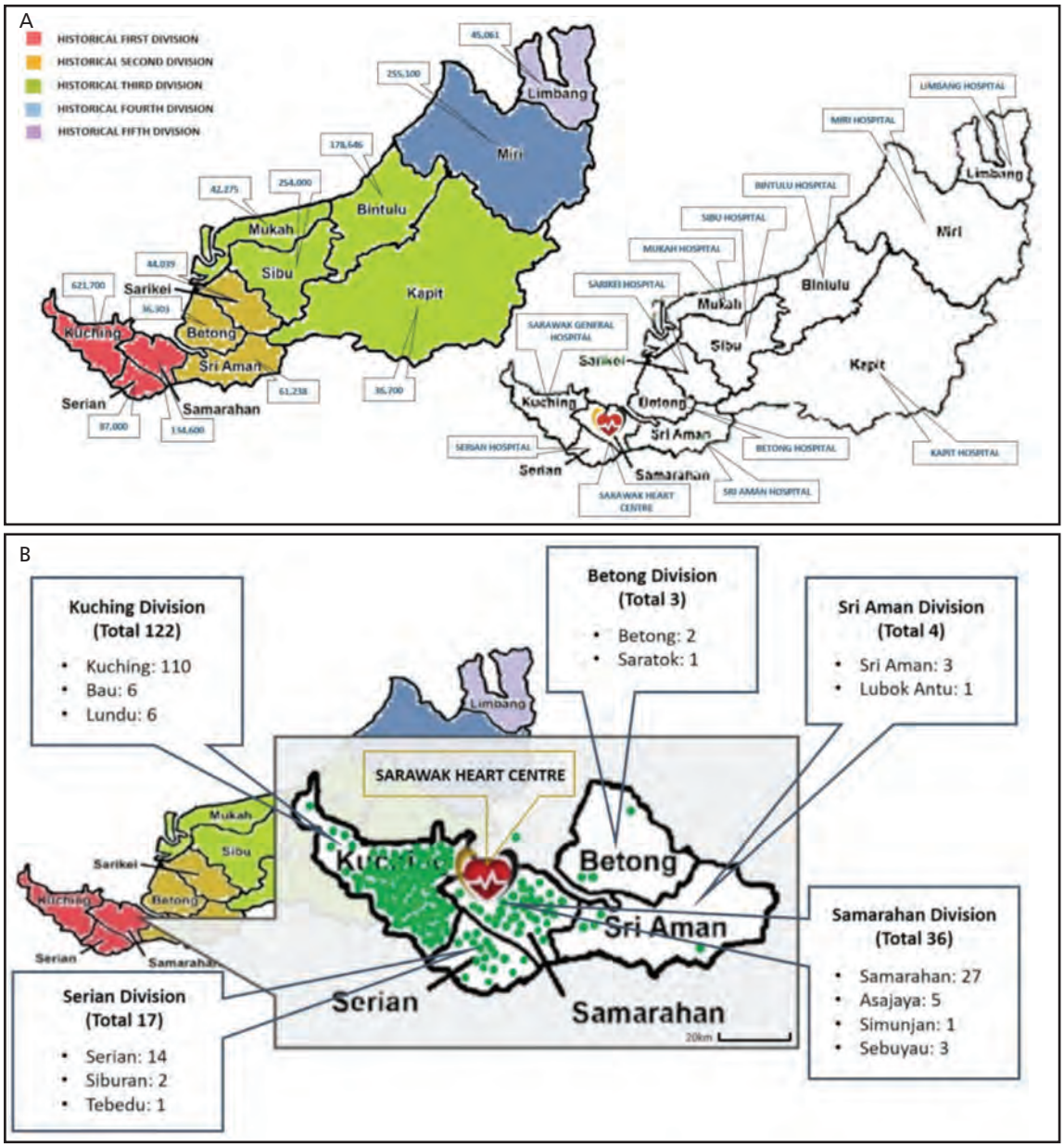


Fig. 1: A) Historical and current administrative divisions of the state of Sarawak, Malaysia and its respective population; B) Geotagging of study population at symptom onset

Univariate analysis using Pearson's Chi-square found that three out of 25 variables from our study were significantly associated with short-term mortalities, namely DTB (p=0.035), TIMI risk score (p<0.001) and Killip class (p<0.001). TIT, was, however, not significant in its association with the short-term mortalities for this study cohort. Nevertheless, those who died had a longer median TIT of 4.3 (range 2.4-8.4) hours than those who were alive with a median TIT of 3.1 (range 2.0-4.8) hours, albeit the association did not achieve statistical significance (p=0.175). The total distance travelled, and the number of transits was also not shown to be associated with mortality outcomes.

When confounding was adjusted using multivariable logistic regression, only the Killip class had a significant association with short-term mortality outcomes (OR 17.2, 95%CI 3.3, 88.5).

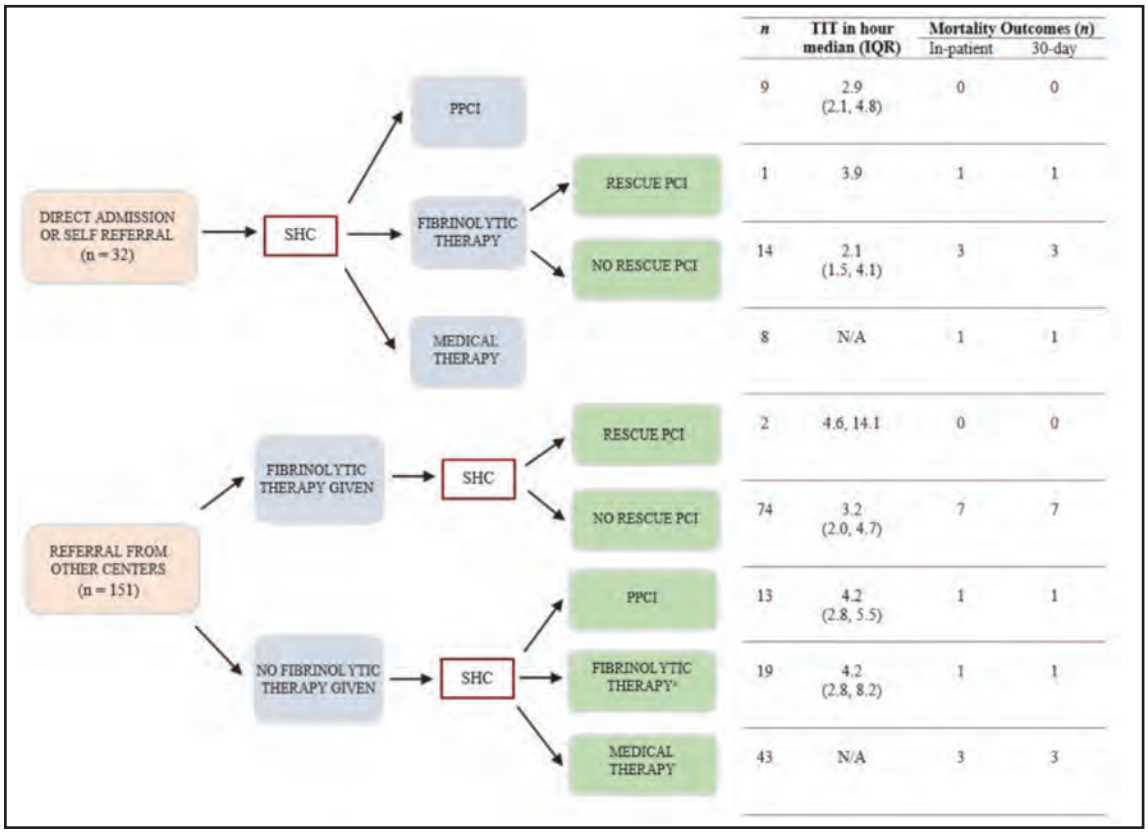
DISCUSSION

Overview

All STEMI patients deserve every effort to improve coronary care services especially when the population in our study consists of relatively young patients. The design of a seamless healthcare system that could shorten the TIT by targeting patient delay and systemic delay is the way forward.

Clinical Characteristics

The demographic trend of our study cohort gives an important insight into our target population for the effective



n	TIT in hour median (IQR)	Mortality Outcomes (*n*)	
		In-patient	30-day
9	2.9 (2.1, 4.8)	0	0
1	3.9	1	1
14	2.1 (1.5, 4.1)	3	3
8	N/A	1	1
2	4.6, 14.1	0	0
74	3.2 (2.0, 4.7)	7	7
13	4.2 (2.8, 5.5)	1	1
19	4.2 (2.8, 8.2)	1	1
43	N/A	3	3

Fig. 2: Flow diagram showing the different methods of presentation with treatment received and mortality outcomes
[a]No rescue PCI performed for patients who received fibrinolytic therapy among those who were referred from other centres.
Abbreviations: N/A = not applicable, PCI = percutaneous coronary intervention, PPCI = primary percutaneous coronary intervention, SHC = Sarawak Heart Centre

delivery of service and treatment. It is worthwhile noting that the percentage of patients among our study cohort who developed STEMI at <50 years old was 33.3% with the youngest being 25 years old. The STEMI population in our study was comparatively younger than the national statistics (55.6 years vs. 56.2 years respectively) as well as the regional Asia-Pacific population (61.6 years).[2,19] The younger trend phenomenon among STEMI patients was also observed in another study cohort.[20] The significant number of STEMI in the younger productive age group is worrying as it can impact the economic growth of the country as well as cause financial burden and stress to the patients and families. This finding is in tandem with a study done in a local population in Klang Valley which showed cardiovascular diseases being the most significant natural cause of sudden cardiac death with similar observation found among young adult population.[21] Classical cardiovascular risk factors are present among STEMI in young on top of a family history of ischaemic heart disease, smoking and male gender.[22-24] This highlights the need for more vigorous effort to improve our coronary care service.

Patient Delay

The median TIT of our study population (198 minutes) was shorter than that of the national level (252 minutes) as well as the TIT in a European country (387 minutes) and another country in Asia (245 minutes).[5,25,26] Nevertheless, there is still a need for further improvement. It can be seen from our study that patient delay is mainly contributed by patient health-seeking behaviour patterns which stemmed from their awareness of timeliness of presentation, the importance of early presentation, and presentation to the correct first medical contact when experiencing the symptoms of chest pain.

From our study, it can be seen that the TIT is not directly proportionate to the distance needed to travel from symptom onset. Patients who live close to the PCI-capable centre might have significant delays in their presentation, resulting in them missing the PPCI window. Although the exact factor that caused the disproportionate delay has not been investigated in this study, it reflected the inadequacy of patients' awareness of the importance of early presentation and the golden hour for PPCI. Patients' awareness translating into time of presentation was best seen in the group of patients who had a previous history of ischaemic heart disease in which they were more likely to present within the PPCI window than those who only experienced the symptom for the first time. Patients who had previous similar history might have been educated from previous admission and hence were better informed on early presentation. The poor level of healthcare awareness among the local general public especially among the rural population was also reflected in a cross-sectional survey for stroke symptoms and risk factors recognition.[27] Many nationwide surveys among Asian countries including Korea, Japan, Singapore and Malaysia

resonated with similar observations in terms of the current gap in coronary care at the pre-hospital level in regard to public awareness.[28-32] While a secondary prevention level of education is important, the general public needs to be aware of the need for early presentation and symptoms suggestive of ACS as primary prevention is still the key to better healthcare.

While 'time is essence' in patients' presentation, patients' education on the right place to present is also another vital component in reducing delay that directly contributes to TIT by reducing unnecessary transits. The general public needs to be aware of the nearest medical centres that provide revascularisation services and to have financial consideration in mind when deciding between a government and a private sector healthcare facility. Information on revascularisation centres should be made widely available to the public on easily accessible websites or patients' information leaflets as part of the primary prevention education during their attendance at regular primary healthcare clinics before the occurrence of cardiovascular events. Multimedia such as television or various social media platforms should be utilised to promote patients' awareness and to empower the general public on knowledge of symptom recognition and steps to be taken should themselves, family members or anyone close by develop symptoms suggestive of ACS.

The majority of our study cohort presented out-of-hour. Of those, they were more likely to present within the PPCI window. However, the availability of PPCI only within office hours caused the majority of them to receive fibrinolytic therapy instead.

Systemic Delay

The foundation of designing a good healthcare system lies in recognising factors that contribute to systemic delay be it at the pre-hospital level or the intra-hospital level. Established regional protocols that are agreeable among different healthcare facilities within the local region can reduce unnecessary systemic delay.

It can be seen from our study that the main density of STEMI patients at symptom onset was from another division, particularly at a nearby division of Kuching. One hundred and eight (59.0%) of our study cohort who were from other divisions out of Samarahan were not sent directly to SHC for PPCI although it was within the revascularisation window and the reach of PCI-capable hospital was within 2 hours. During the activation of the ambulances, patients were sent to a non-PCI-capable hospital within the division of the emergency medical service for arrangement of transfer to Sarawak Heart Centre. This has led to pre-hospital delays that contributed to prolonged TIT.

Although distance is an important consideration when planning for the coronary care service, our study showed that the distance does not preclude patients from presenting within the PPCI window. Hence, the establishment of a STEMI network could potentially further shorten systemic delay and the reduction of the TIT will improve patients' outcomes. Successful examples of STEMI networks can be seen in other Asian countries such as Korea, Singapore and Japan as well as the local regional MySTEMI Network in Malaysia.[33]

Mortality Outcomes

In our study population, the in-hospital mortality was comparable to the national and Singapore data (9.3 vs. 10.3%) but was higher as compared to other Asia-Pacific countries like Australia, Japan and Korea (5.6-5.7%), whereas 30-day mortality was lower compared to national and Singapore statistics (9.3% vs. 12.1%, and 10.4% respectively) but was higher as compared to Australia and Korea (5.9-6.3%)[10,19].

STEMI Network and Suggestions for Improvement

A study in Australia on the system of field triage of STEMI patients by electrocardiogram (ECG)-equipped ambulances and direct catheterisation laboratory transfer found that this system was associated with shorter treatment time and improved survival.[34] Similar field triage has been assimilated into the MySTEMI Network in Klang Valley. MySTEMI network is a local effort in the Klang Valley region of Malaysia to set up a network adapting the hub-and-spoke model to provide better access to immediate care for STEMI patients.[35] They are important reference works to set up a STEMI network in the local region of Southern Sarawak.

Special coronary care ambulances equipped with ECG machines and trained paramedics which are allowed to bypass the non-PCI-capable hospitals are needed for direct transfer with the collaboration of the emergency department and PCI-capable hospital. The ambulance paramedics should be trained to perform a 12-lead ECG on suspected MI patients and for ECG interpretation. ECG showing STEMI can then be transmitted to the emergency department for confirmation and activation of the catheterisation laboratory. Patients can then be transferred directly to the catheterisation laboratory for PPCI if the estimated transfer time is within 2 hours. The ambulances should also be equipped with fibrinolytic therapy for earlier revascularisation for patients who are located further away from the catheterisation laboratory in which the estimated transfer time is more than 2 hours. Electronic communication platforms can be set up to ease the communication between the ambulance paramedics, emergency department personnel and cardiology team.[36]

Similar suggestions were resounded by another study in which the study also promoted integrated care pathways that allow the application of guidelines according to local culture and hospital system which has been shown to reduce the DTB time. Several countries including Korea, Hong Kong and Pakistan have replicated the effort and found the beneficiary effect of the care pathways.[37]

Catheterisation laboratory that operates 24 hours will be able to cater for the needs of more STEMI patients. PPCI service that expands beyond office hours will be beneficiary to the majority of our study cohort who presented out-of-hour. With PPCI now being the gold standard of treatment for STEMI patients, every effort to pursue the delivery of the best possible care should be encouraged.[38-40]

Post-revascularisation care is another part of coronary care service that needs attention. Being the only heart centre in the state within the government setting, Sarawak Heart Centre has only limited beds to cater for all cardiac patients from the whole state of Sarawak. To avoid overwhelming a single centre, a suggestion would be to divert post-revascularised patients from other divisions to other hospitals equipped with intensive care units. Regular updates of patients' progress to the cardiology team through the platform of telemedicine within the local STEMI network can be useful. Using the 'Hub-and-Spoke' model, Sarawak Heart Centre can function as the 'Hub centre' while other hospitals within the network could be the 'spoke hospitals.[16]

The ultimate aim of the STEMI network is to have more cathetherisation laboratories throughout the whole state. With finite resources being the main limitation, a staged approach will be a wise step forward to allow for a gradual and sustainable expansion of coronary care services.

LIMITATIONS AND SUGGESTIONS FOR FUTURE STUDIES

The main limitation of our study is in its single-centre design. With Sawarak Heart Centre being the only patient catchment area, other patients who presented to and then died in other non-PCI-capable centres or private hospitals were not included. This might lead to an under-representation of the mortality rate among the regional STEMI patients. In addition, the small sample size might affect the accuracy of the result. Another limitation is the lack of long-term cardiac mortality and morbidity outcomes within the study cohort. There was also no data regarding patients who relied on the ambulance service for presentation to the PCI-capable centre. This information will be useful to support the need for special coronary care ambulances within the chain of the STEMI network.

Future studies can be done to look into factors that contributed to systemic delay including transit time, transfer delay and the use of ambulance service. Collaborative work from different centres to further evaluate other components of systemic delay can aid in the improvement of coronary care service by focusing on the specific components. A longer follow-up to look into long-term mortality, morbidity and functional outcomes of the study cohort is called for to provide insight into the long-term outcomes. Further patients' characteristics such as cholesterol profile, body mass index, and waist circumference as a comprehensive risk factor can also be investigated as compared to individual cardiovascular risk factors for their association with survival or morbidity outcomes.

CONCLUSION

This study postulates the long-term goal for coronary care services of reducing total ischaemic time (TIT) among ST-segment elevation myocardial infarction (STEMI) patients by overcoming factors that contributed to patient delay and systemic delay including increasing patient awareness through public education and setting up a local STEMI network. Although TIT was not found to have a statistically significant association with short-term mortality outcomes among our study cohort, its significance in long-term survival outcomes of STEMI patients had been well-proven in many studies that its importance should not be ignored with the consideration that primary percutaneous coronary intervention (PPCI) is now the gold standard of treatment for STEMI. The 'Hub-and-Spoke' model can be adopted in setting up a local STEMI network in a staged-wise approach to shorten the pre-hospital and intra-hospital delay in the effort of reducing TIT.

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CONFLICTS OF INTEREST

All authors of this study have no conflicts of interest to declare.

REFERENCES

1. World Health Organization. Health data overview for Malaysia. 2020. Available from: https://data.who.int/countries/458. Accessed on 25 January 2024.
2. WA Wan Ahmad. (Ed). Annual Report of the NCVD-ACS Registry, 2018–2019. Kuala Lumpur, Malaysia: National Cardiovascular Disease Database, 2022.
3. Antman EM, Anbe DT, Armstrong PW, Bates ER, Green LA, Hand M, et al. ACC/AHA guidelines for the management of patients with ST-elevation myocardial infarction; a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Revise the 1999 Guidelines for the Management of patients with acute myocardial infarction). J Am Coll Cardiol 2004; 44: E1-211.
4. Byrne RA, Rossello X, Coughlan JJ, Barbato E, Berry C, Chieffo A, et al. ESC Scientific Document Group, 2023 ESC Guidelines for the management of acute coronary syndromes: developed by the task force on the management of acute coronary syndromes of the European Society of Cardiology (ESC), Eurp Heart J 2023; 44(38): 3720-826.
5. O'Connor CT, Ibrahim A, Buckley A, Maguire C, Kumar R, Kumar J, et al. Total ischaemic time in STEMI: factors influencing systemic delay. Br J Cardiol. 2022; 29(2): 17.
6. Bessonov IS, Kuznetsov VA, Gorbatenko EA, Dyakova AO, Sapozhnikov SS. Influence of total ischemic time on clinical outcomes in patients with ST-segment elevation myocardial infarction. Kardiologiia 2021 6; 61(2): 40-46.
7. Sardar MR, Dawn Abbott J. Myocardial salvage and mortality in STEMI: a race against ischemic time. Catheter Cardiovasc Interv 2016; 87(7): 1201-2.
8. Kurmi P, Tripathi VD, Tripathi SK. Impact of total ischemic time on clinical outcomes in patients with st-elevation myocardial infarction: lost time is never found again. Cureus 2022; 14(3): e23143.
9. Khowaja S, Ahmed S, Kumar R, Shah JA, Khan KA, Khan NU, et al. Time to think beyond door to balloon time: significance of total ischemic time in STEMI. Egypt Heart J 2021; 73: 95.
10. National Heart Association of Malaysia. 2019. Clinical practice guideline for management of acute ST segment elevation myocardial infarction (STEMI). Available from: https://www.moh.gov.my/moh/resources/penerbitan/CPG/CPG%20STEMI%202019.pdf. Accessed on 25 January 2024.
11. Chia YW, Chia MYC. Reducing the total ischaemic time in ST-segment elevation myocardial infarction: Every step matters. Ann Acad Med Singap 2021; 50(9): 662-5.

12. Stenestrand U, Lindbäck J, Wallentin L; RIKS-HIA Registry. Long-term outcome of primary percutaneous coronary intervention vs prehospital and in-hospital thrombolysis for patients with ST-elevation myocardial infarction. JAMA 2006; 296(14): 1749-56.
13. Chacko L, P Howard J, Rajkumar C, Nowbar AN, Kane C, Mahdi D, et al. Effects of percutaneous coronary intervention on death and myocardial infarction stratified by stable and unstable coronary artery disease: a meta-analysis of randomized controlled trials. Circ Cardiovasc Qual Outcomes 2020; 13(2): e006363.
14. Aversano T, Aversano LT, Passamani E, Knatterud GL, Terrin ML, Williams DO, et al. Thrombolytic therapy vs primary percutaneous coronary intervention for myocardial infarction in patients presenting to hospitals without on-site cardiac surgery: a randomized controlled trial. JAMA 2002; 287(15): 1943-51.
15. Grines CL, Browne KF, Marco J, Rothbaum D, Stone GW, O'Keefe J, et al. A comparison of immediate angioplasty with thrombolytic therapy for acute myocardial infarction. N Engl J Med 1993; 328: 673-9.
16. Olivari Z. Hospital networks for the treatment of acute myocardial infarction. Ital Heart J 2005; 6(6): 459-64.
17. Levenson B, Herrera C, Wilson BH. New ACC global heart attack treatment initiative: improving STEMI care worldwide. J Am Coll Cardiol 2020 7; 75(13): 1605-08.
18. Sarawak Heart. Website of the Department of Cardiology Sarawak Heart Center. Available from: https://www.sarawakheart.org/wards
19. Tern PJW, Ho AKH, Sultana R, Ahn Y, Almahmeed W, Brieger D, et al. Comparative overview of ST-elevation myocardial infarction epidemiology, demographics, management, and outcomes in five Asia-Pacific countries: a meta-analysis. Eur Heart J Qual Care Clin Outcomes 2021; 7(1): 6-17.
20. Singh B, Singh A, Goyal A, Chhabra S, Tandon R, Aslam N, et al. The prevalence, clinical spectrum and the long term outcome of ST-segment Elevation Myocardial infarction in young – a prospective observational study. Cardiovasc Revasc Med 2019; 20(5): 387-91.
21. Rahimi R, Singh MKC, Noor NM, Omar E, Noor SM, Mahmood MS, et al. Manifestation of coronary atherosclerosis in Klang Valley, Malaysia: an autopsy study. J Atheroscler Thromb 2018; 25(5): 405-9.
22. Hoit BD, Gilpin EA, Henning H, Maisel AA, Dittrich H, Carlisle J, et al. Myocardial infarction in young patients: an analysis by age subsets. Circulation 1986; 74(4): 712-21.
23. Lorca R, Pascual I, Aparicio A, Junco-Vicente A, Alvarez-Velasco R, Barja N, et al. Premature STEMI in men and women: current clinical features and improvements in management and prognosis. J Clin Med 2021; 10(6): 1314.
24. Chan MY, Woo KS, Wong HB, Chia BL, Sutandar A, Tan HC. Antecedent risk factors and their control in young patients with a first myocardial infarction. Singapore Med J 2006; 47(1): 27-30.
25. WA Wan Ahmad. (Editor). Annual Report of the PCI Registry, 2019–2020. Kuala Lumpur, Malaysia: National Cardiovascular Disease Database, 2023.
26. Alexander T, Kumbhani DJ, Subban V, Sundar H, Nallamothu BK, Mullasari AS. Acute ST-elevation myocardial infarction in the young compared with older patients in the Tamil Nadu STEMI program. Heart Lung Circulation 2021; 30(12): 1876-82.
27. Nik Ramli NN, Genasan D, Rossman NS. Assessing the awareness on symptoms and risk factors of stroke amongst rural community in central region of Malaysia: a cross-sectional survey. Malays J Med Sci 2024; 31(1): 150-60.
28. Kim HS, Lee H, Kim K, Park HK, Park KS, Kang GW et al. The general public's awareness of early symptoms of and emergency responses to acute myocardial infarction and related factors in South Korea: a national public telephone survey. J Epidemiol 2016; 26: 233-41.
29. Park KS. Factors affecting awareness of myocardial infarction symptoms among the general public in Korea. Epidemiol Health 2020; 42: e2020032.
30. Abdo Ahmed AA, Mohammed Al-Shami A, Jamshed S, Fata Nahas AR, Mohamed Ibrahim MI. Public awareness of and action towards heart attack symptoms: an exploratory study. Int J Environ Res Public Health 2020; 17: 8982.
31. Quah JL, Yap S, Cheah SO, Ng YY, Goh ES, Doctor N, et al. Knowledge of signs and symptoms of heart attack and stroke among Singapore residents. BioMed Res Int 2014; 2014: 572425.
32. Yonemoto N, Kada A, Yokoyama H, Nonogi H. Public awareness of the need to call emergency medical services following the onset of acute myocardial infarction and associated factors in Japan. J Int Med Res 2018; 46: 1747-55.
33. Takano T, Ida T, Tanaka K, Obayashi K, Kimura E. Prehospital care (CCU network) of acute myocardial infarction and treatment of cardiogenic shock by intra-aortic balloon pumping JpnCirc J 1981; 45: 623-35.
34. Farshid A, Allada C, Chandrasekhar J, Marley P, McGill D, O'Connor S, et al. Shorter ischaemic time and improved survival with pre-hospital STEMI diagnosis and direct transfer for primary PCI. Heart Lung Circ 2015; 24(3): 234-40.
35. National Heart Association of Malaysia. 2016. MySTEMI Network Newsletter. Available from: https://www.malaysianheart.org/files/570cb80d52e57.pdf. Accessed on 25 January 2024.
36. Candiello A, Alexander T, Delport R, Toth GG, Ong P, Snyders A, et al. How to set up regional STEMI networks: a Stent - Save a life!' initiative. Euro Intervention 2022; (16): 1313-7.
37. Tern PJW, Vaswani A, Yeo KK. Identifying and solving gaps in pre- and in-hospital acute myocardial infarction care in Asia-Pacific countries. Korean Circ J 2023; 53(9): 594-605..
38. Jahic E. Experience and outcomes of primary percutaneous coronary intervention for patients with st-segment elevation myocardial infarction of tertiary care center in Bosnia and Herzegovina. Med Arch 2017; 71(3): 183-7.
39. Steg G, James S, Atar D, Badano L, Bldmstrom-Lundqvist C, Di Mario C, et al. Management of acute myocardial infarction in patients presenting with persistent ST-segment elevation: the task force on the management of ST-segment elevation acute myocardial infarction of the European society of cardiology. Eur Heart J 2012; 33: 2569-619.
40. Andersen HR, Nielsen TT, Rasmussen K, Thuesen L, Kelbaek H, Thayssen P, et al. A comparison of coronary angioplasty with fibrinolytic therapy in acute myocardial infarction. N Engl J Med 2003; 349: 733-42.