



## Characteristics, in-hospital management, and complications of acute myocardial infarction in northern and Central Vietnam

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### ABSTRACT

**Introduction:** Contemporary data on the epidemiology of acute myocardial infarction (AMI) in Vietnam are extremely limited.

**Methods:** We established population-based registries of residents from 2 provinces in a northern urban (Hai Phong), and a central rural (Thanh Hoa), province of Vietnam hospitalized with a validated first AMI in 2018. We described patient characteristics, in-hospital management and clinical complications, and estimated incidence rates of AMI in these two registries.

**Results:** A total of 785 patients (mean age = 71.2 years, 64.7% men) were admitted to the two hospitals with a validated first AMI. Approximately 64% of the AMI cases were ST-segment-elevation AMI. Patients from Thanh Hoa compared with Hai Phong were more likely to delay seeking acute hospital care. The incidence rates (per 100,000 population) of initial AMI in Thanh Hoa and Hai Phong were 16 and 30, respectively. Most patients were treated with aspirin (Thanh Hoa: 96%; Hai Phong: 90%) and statins (both provinces: 91%) during their hospitalization. A greater proportion of patients in Hai Phong (69%) underwent percutaneous revascularization than those in Thanh Hoa (58%). The most common in-hospital complications were heart failure (both provinces: 12%), cardiogenic shock (Thanh Hoa: 10%; Hai phong: 7%); and cardiac arrest (both provinces: 9%). The in-hospital case-fatality rates for patients from Thanh Hoa and Hai Phong were 6.8% and 3.8%, respectively.

**Conclusions:** The incidence and hospital case-fatality rates of AMI were low in two Vietnamese provinces. Extent of pre-hospital delay and in-hospital use of evidence-based therapies were suboptimal, being more prominent in the rural province.

### 1. Introduction

The morbidity and mortality from non-communicable diseases has been consistently increasing over the last several decades in Vietnam, reflecting an epidemiologic transition to chronic disease as has been seen elsewhere globally [1,2]. These trends have likely stemmed from a more westernized lifestyle, more effective prevention and treatment of infectious diseases, and increases in life expectancy [1–3]. Based on the most recent national report in 2010, cardiovascular disease, including acute myocardial infarction, was the leading cause of death among

Vietnamese adults, accounting for approximately one-third of all deaths annually [4]. At the Vietnam National Heart Institute, the largest tertiary care referral hospital for the management of patients with cardiovascular disease in Hanoi, the number of patients hospitalized for cardiovascular disease nearly doubled between 2007 and 2015 [5].

Based on the 2014 Joint Annual Health Review by the Vietnam Ministry of Health, no population-based epidemiologic study has been conducted in Vietnam that has described the incidence rates, treatment practices, and the in-hospital complications associated with acute myocardial infarction (AMI) [4]. Given the lack of contemporary data

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about AMI in different geographic settings in Vietnam, and the emerging importance of this clinical condition, we describe the epidemiology, hospital management, and in-hospital prognosis among residents of two large urban and rural provinces in northern and central Vietnam hospitalized with an independently validated AMI.

## 2. Methods

The present study and our data collection activities were based on the framework of our prior investigations, namely the Worcester Heart Attack Study and the Hanoi Heart Attack Study. These large clinical/epidemiological investigations described the epidemiology of AMI among patients admitted to hospitals in the Worcester, Massachusetts, USA, metropolitan area [6–8] and Hanoi, Vietnam, respectively [9–11].

### 2.1. Ethics statement

This study was approved by the Institutional Review Board at the Hanoi University of Public Health in Vietnam with a waiver of patient consent. Patient records and abstracted information were anonymized and de-identified prior to analysis.

### 2.2. Study setting

The present study was conducted among residents of two provinces in northern and central Vietnam, namely Hai Phong province (population = 1.8 million, 2010 census; urban proportion: 44%) and Thanh Hoa province (population = 3.4 million, 2010 census; rural population: 90%). These sites were purposely selected for representing urban and rural Vietnamese populations. The two central hospitals (Hai Phong hospital: 900 beds; Thanh Hoa hospital: 800 beds) serving residents of these large provinces have specialized cardiology departments with coronary angioplasty capacity and serve as the major referral centers for an area of approximately 70 miles. These cardiology departments are satellite centers of the Vietnam National Heart Institute and utilize the standardized diagnostic and treatment protocols of this Institute. The vast majority of residents (>90%) living in these provinces have public health insurance. We established two registries of patients who were hospitalized with an independently validated first AMI at these correspondent hospitals during calendar year 2018.

### 2.3. Ascertainment of the study population

Patients were diagnosed as having an AMI if they had at least two of the following three criteria present: (1) a typical history of angina which was not relieved by rest and/or the use of nitrates; (2) elevations in serum troponins; and (3) serial ECG changes consistent with an evolving AMI as recommended by the contemporary universal definition of AMI [12,13]. We categorized AMI as either ST-segment elevation myocardial infarction (STEMI) or non-ST-segment elevation myocardial infarction (NSTEMI) based on international standards [12,13]. Cases of trauma related, drug overdose, or perioperative or procedure associated AMI were not included.

Computerized discharge printouts from the two participating hospitals were reviewed to identify patients with coronary heart disease related discharge diagnoses during 2018 using International Classification of Disease (ICD)-10 codes I20–I25. We included all patients hospitalized with a primary or secondary discharge diagnosis of ICD-10 codes I21, I24 and I25.2–I25.8, and an approximate 30% random sampling of ICD-10 code I20, which we have previously shown has yielded few confirmed cases of AMI [9–11]. All computerized ECG interpretations were independently confirmed by trained physicians.

The medical records of patients with suspect AMI were carefully reviewed for purposes of classifying the patient's index hospitalization during 2018 as either a first (initial) documented episode of AMI or

otherwise; if information in the hospital record was insufficient to indicate whether the present coronary event was an initial or recurrent episode, a category of indeterminate was used. For the purpose of our study, only patients with an initial AMI were included.

### 2.4. Data abstraction

For each patient with an initial confirmed AMI satisfying our geographic and clinical eligibility criteria, a variety of socio-demographic, clinical, medical care, and outcome related information was collected and entered onto a standardized case-report form based on our previous studies of AMI [9–11]. Information was collected about patient's age, sex, marital status, hospital transport by ambulance and medications administered en route, cardiovascular comorbidities (e.g., diabetes, hypertension, heart failure, stroke), admission clinical and laboratory parameters, AMI type (STEMI vs. NSTEMI), receipt of effective cardiac medications and coronary interventional procedures during the index hospitalization, clinically significant in-hospital complications (e.g., stroke, cardiogenic shock, heart failure, atrial fibrillation), hospital discharge status, and length of hospital stay. The variable of pre-hospital delay was defined as the duration (hours) from the time of onset of acute coronary symptoms (e.g., chest pain or pressure, shortness of breath, diaphoresis, syncope) to hospital emergency department arrival.

A set of representative medical records was used for training purposes. All field personnel were trained by study cardiologists at the two participating hospitals. Each data abstractor needed to satisfactorily complete at least ten practice cases which were verified by study cardiologists before abstracting actual data in the field.

Validated case report forms were entered into a RedCap database [14]. Audits and quality control visits were regularly performed at each of the participating hospitals to monitor the ascertainment of medical records and completeness of data abstraction activities. Any identified errors were discussed and adjudicated with all chart reviewers to ensure a high degree of accuracy in the review of hospital medical records.

### 2.5. Data analysis

Census data for 2010 published by the General Statistics Office of Vietnam were used to construct denominators to calculate population-based incidence rates of initial AMI [15].

We compared the socio-demographic and clinical characteristics, use of various therapies, and in-hospital outcomes of patients from the two provinces with *t*-tests or Wilcoxon sum rank tests for continuous variables and chi square or Fisher tests for categorical variables. Incidence rates of initial AMI, frequency of important hospital clinical complications (e.g., heart failure, atrial fibrillation, cardiogenic shock), duration of pre-hospital delay, and in-hospital case-fatality rates were calculated in a standard manner. All analyses were performed using STATA.16.0 (Stat Corp. TX).

## 3. Results

### 3.1. Study population characteristics

We identified a total of 785 patients who were admitted to the two study hospitals with an independently validated initial AMI during 2018; of these, 338 patients were from Thanh Hoa province (central Vietnam, rural area) and 447 patients were from Hai Phong province (northern Vietnam, urban area). The mean age of patients included in this study was 71.2 years, 64.7% were men, the majority (94.9%) were of Kinh ethnicity (Table 1). Nearly two-thirds of patients reported a history of hypertension while one-fifth reported a history of diabetes. Data on pre-hospital delay in hospital medical records were available for approximately three-quarters of study patients. Among these patients, nearly one-third presented to participating hospitals within 12 h of acute symptom onset. Type of AMI was classified as STEMI in 64.6% and

**Table 1**

Demographic and clinical characteristics of patients hospitalized with a first acute myocardial infarction according to participating hospitals.

Characteristics	Total (N = 785)	Thanh Hoa (n = 338)	Hai Phong (n = 447)	p-value*
Age (mean, SD), years	71.2(11.9)	71.1 (12.3)	71.3 (11.6)	0.88
Age group (years) (%)				0.92
<60	16.4	17.5	15.7	
60–69	30.1	29.3	30.6	
70–79	26.0	25.7	26.2	
80 +	27.5	27.5	27.5	
Male (%)	64.7	70.4	60.4	0.004
Kinh ethnicity (%)	94.9	96.1	94.0	0.17
Transferred from other hospitals (%)	71.1	76.3	67.1	0.005
Pre-hospital delay (%)				0.001
< 6 h	19.9	18.3	21.0	
6–11.9 h	10.4	9.5	11.2	
12–23.9 h	9.2	9.2	9.2	
24–47.9 h	5.7	5.9	5.6	
≥48 h	31.3	39.3	25.3	
No information available	23.4	17.7	27.7	
Comorbidity (%)				
Angina pectoris	7.3	10.1	5.1	<0.009
Atrial fibrillation	1.1	0.9	1.3	0.74
Diabetes	23.2	16.6	28.2	<0.001
Heart failure	13.1	17.5	9.8	0.002
Hyperlipidaemia	5.7	0.6	9.6	<0.001
Hypertension	61.9	53.8	68.0	<0.001
AMI type (%)				<0.001
STEMI	64.6	74.3	57.3	
NSTEMI	30.2	21.0	37.1	
Unknown	5.2	4.7	5.6	
Chest pain (%)	87.1	89.3	85.5	0.11
Findings on admission (median, IQR)				
Heart rate (beats/min)	83[74–96]	83[70–100]	83[77–95]	0.70
Systolic blood pressure (mmHg)	130 [118.5–150]	120 [110–140]	130 [120–150]	<0.001
Diastolic blood pressure (mmHg)	80[70–88]	80[66–80]	80[70–90]	0.62
Total cholesterol (mmol/L)	4.8[4.0–5.6]	4.8[4.1–5.7]	4.8[4.0–5.6]	0.86
LDL (mmol/L)	3.0[2.4–3.6]	3.1[2.5–3.8]	2.9[2.2–3.6]	0.009
Blood Glucose (mmol/L)	7.5 [5.8–11.1]	7.2 [5.6–10.6]	7.7 [6.0–11.7]	<0.018
eGFR (ml/mim/1.73 m <sup>2</sup> )	71.2 [55.5–88.2]	77.8 [57.9–96.3]	68.5 [54.0–83.4]	<0.001
Length of stay (median, IQR), days	7[5–10]	6[4–8]	8[6–11]	<0.001

AMI: acute myocardial infarction, STEMI: ST-elevation myocardial infarction, NSTEMI: non-ST-elevation myocardial infarction; LDL: low-density lipoproteins; GFR: Glomerular filtration rate.

\* p-values from t-tests or Wilcoxon sum rank tests for comparing continuous variables and chi-squared or Fisher tests for comparing categorical variables.

NSTEMI in 30.2%, while AMI type was unknown in 5.2% of study patients.

The socio-demographic and clinical characteristics of study patients are presented in Table 1. Patients hospitalized at Thanh Hoa as compared with Hai Phong hospital were more likely to be male, and to have been transferred from other hospitals. Pre-hospital delay beyond 24 or 48 h was more common in Thanh Hoa than in Hai Phong province. A history of angina pectoris or heart failure was more prevalent among residents of Thanh Hoa province while diabetes, hypertension, and hyperlipidemia were more frequently reported among residents of Hai Phong province. Patients hospitalized at Thanh Hoa hospital were more likely to have STEMI compared with those hospitalized at Hai Phong hospital. At the time of hospital admission, patients at Thanh Hoa hospital more likely to have lower systolic blood pressure, blood glucose levels but higher LDL cholesterol and eGFR levels compared with

patients treated at Hai Phong hospital. The median length of stay for patients hospitalized at Thanh Hoa hospital was approximately two days shorter than at Hai Phong hospital (Table 1). The estimated incidence rate (per 100,000 population) of initial AMI in Thanh Hoa province was 16 while it was 30 in Hai Phong province in 2018.

### 3.2. Hospital management practices

During the first 24 h after admission, most patients (~90%) received aspirin, clopidogrel and lipid lowering agents, approximately 80% were given heparin, 40% were treated with Angiotensin-Converting Enzyme Inhibitors (ACEIs) or Angiotensin Receptor blockers (ARBs), while 13% received beta-blockers (Table 2). More than one-half of patients with STEMI underwent a percutaneous coronary intervention (PCI). During the first 24 h of admission, patients hospitalized at Thanh Hoa hospital were more likely to be treated with aspirin, clopidogrel and heparin, but less likely to be treated with beta blockers, and have undergone a PCI (patients with STEMI), compared with those admitted to Hai Phong hospital (Table 2).

During the entire hospitalization, patients hospitalized at Thanh Hoa hospital were less likely to be treated with ACEIs or ARBs, beta-blockers, and to have undergone cardiac procedures, but more likely to be treated with clopidogrel compared with those admitted to Hai Phong hospital.

### 3.3. In-hospital clinical complications and mortality

Overall, the rates of clinically important in-hospital complications were low (Table 3). The most common clinical complications were heart failure (approximately 12%), cardiogenic shock (approximately 9%) and cardiac arrest (approximately 9%) among residents of both provinces. <3% of patients developed other important complications during their acute hospital stay (Table 3). Cardiogenic shock, ventricular fibrillation, ventricular tachycardia and cardiac arrest occurred more frequently in Thanh Hoa while recurrent angina, sinus bradycardia or

**Table 2**

In-hospital management for patients hospitalized with an acute myocardial infarction according to participating hospitals.

	Total (N = 785)	Thanh Hoa (n = 338)	Hai Phong (n = 447)	p-value*
First 24 h after admission (%)				
Aspirin	92.0	95.3	89.5	0.003
ACEIs/ARBs	38.3	39.3	37.6	0.61
Beta blockers	13.4	9.5	16.3	0.005
Lipid lowering agents	90.8	91.1	90.6	0.80
Clopidogrel	88.0	94.7	83.0	<0.001
Heparin	76.9	81.4	73.6	0.011
PCI among all patients	52.1	50.0	52.8	0.41
STEMI (n = 507)	57.8	52.6	62.9	0.019
NSTEMI (n = 237)	40.1	40.8	39.8	0.88
During hospitalization (%)				
Aspirin	95.0	96.1	94.2	0.21
ACEIs/ARBs	48.3	43.8	51.7	0.028
Beta blockers	18.6	12.1	23.5	<0.001
Lipid lowering agents	92.7	91.7	93.5	0.34
Clopidogrel	90.8	93.2	89.0	0.046
Heparin	81.3	83.4	79.6	0.18
Inotropic drugs	18.3	20.1	17.0	0.53
Coronary angiography	67.5	59.5	73.6	<0.001
PCI among all patients	64.1	58.1	68.7	0.003
STEMI (n = 507)	67.8	60.6	75.0	<0.001
NSTEMI (n = 237)	56.1	49.3	59.0	0.17

STEMI: ST-elevation myocardial infarction, NSTEMI: non-ST-elevation myocardial infarction, ACEI: angiotensin-converting enzyme inhibitors, ARBs: angiotensin receptor blockers, PCI: percutaneous coronary angiography. Inotropic drugs included dobutamine, dopamine, adrenaline, noradrenaline.

\* p-values from t-tests or Wilcoxon sum rank tests for comparing continuous variables and chi-squared or Fisher tests for comparing categorical variables.

**Table 3**  
In-hospital complications and case-fatality rates among patients hospitalized with an acute myocardial infarction according to participating hospitals.

	Total (N = 785)	Thanh Hoa (n = 338)	Hai Phong (n = 447)	p- value*
Atrial fibrillation (%)	2.2	1.8	2.5	0.51
Cardiogenic shock (%)	8.7	10.4	7.4	<0.001
Heart failure (%)	12.0	12.4	11.6	0.73
Recurrent angina (%)	1.8	0.0	3.1	<0.001
Stroke (%)	1.0	0.3	1.6	0.15
Ventricular fibrillation (%)	1.8	3.0	0.9	<0.001
Ventricular tachycardia (%)	1.7	2.4	1.1	<0.001
2nd degree atrioventricular block (%)	0.2	0.0	0.4	0.50
3rd degree atrioventricular block (%)	2.4	2.4	2.5	>0.99
Left bundle branch block (%)	0.2	0.0	0.4	0.50
Right bundle branch block (%)	0.5	0.3	0.7	0.46
Right ventricular myocardial infarction (%)	0.1	0.0	0.2	0.38
Sinus bradycardia (%)	2.5	1.2	3.6	0.04
Sinus tachycardia (%)	3.3	0.3	5.6	<0.001
Pericardial effusion (%)	0.1	0.3	0.0	0.43
Cardiac arrest (%)	8.8	9.5	8.3	<0.001
Death (%)	5.1	6.8	3.8	0.06

\* p-values from t-tests or Wilcoxon sum rank tests for comparing continuous variables and chi-squared or Fisher tests for comparing categorical variables.

sinus tachycardia occurred more frequently in Hai Phong. The overall in-hospital case-fatality rate (CFR) was 5.1% (Thanh Hoa: 6.8%; Hai Phong: 3.8%) (Table 3).

#### 4. Discussion

In the present study, we found relatively low incidence rates of AMI in the two large Vietnamese provinces studied as well as in-hospital complications and hospital death rates. Extent of pre-hospital delay in seeking acute medical care was prolonged and the prescribing of several in-hospital management practices was less than optimal.

##### 4.1. Characteristics of patients with a first AMI

There were differences in the demographic and clinical characteristics of patients hospitalized with an initial AMI in our two provinces compared with those in other Asian nations. Specifically, AMI occurred later and more frequently among women in our study (mean age of diagnosis 71 years, 37% in women) compared to national studies in Taiwan (63 years and 20% in women) [16], Korea (32% in women) [17], and China (62 years) [18]. We found that STEMI was more commonly diagnosed (approximately 64%) in patients hospitalized with a first AMI in the two populations under study.

Our prior population-based study in Worcester, Massachusetts, USA [19], and national data from Taiwan, showed that STEMI accounted for about one-third of all first AMIs [16]. Data from 64,654 patients in the 2011–2013 Single Disease Quality Control Information System reported by the Chinese Hospital Association showed that STEMI accounted for 85% of all AMI cases admitted to the hospital [18]. Reasons for these differences in the subtype of AMI between our study population and studies in the USA and Taiwan are unclear but may be due to the fact that patients in Vietnam may delay seeking medical care to a greater degree and only present for medical care when the symptoms become more severe (e.g., patients with NSTEMI are less likely to have chest pain compared to patients with STEMI) [7]; therefore, the proportion of patients with NSTEMI in our study was likely to be underestimated.

Data on the incidence rates of AMI in Vietnam are sparse, with only one previous study having provided data in this area. In that study, the

overall incidence rate of AMI was 14 per 100,000 population among residents of Khanh Hoa province (South-Central region) and 13 per 100,000 population in Thua Thien Hue and Quang Binh provinces (North Central region) during the eight-year period between 2008 and 2015 [20]. The estimated incidence rates of initial AMI in the present study were 16 (per 100,000 population) in Thanh Hoa province and 30 in Hai Phong province. We suspect that the reasons for the observed differences in the incidence rates of AMI were likely due to lifestyle-associated risk factors and to the degree of urbanization. This hypothesis was supported by a higher prevalence of modifiable risk factors for cardiovascular disease, including diabetes, hypertension, and hyperlipidemia noted in patients admitted to Hai Phong hospital compared with those admitted to the single hospital in Thanh Hoa province.

The incidence rates of AMI that were found in our study were lower than those of more developed Asian nations. These include Taiwan, which reported an incidence rate of 51 per 100,000 population in 2015 (using data from the Taiwan National Health Insurance Research Database) [16], Korea, which reported an incidence rate of 43/100,000 population in 2016 (using data from the National Health Insurance Service) [17]. However, these Asian countries have a more industrialized economy with significantly higher GDP per capita, and possibly a more westernized lifestyle compared to that of Vietnam. Given this background, we would expect a lower incidence rate of AMI in Vietnam compared to both Korea and Taiwan.

##### 4.2. In-hospital management practices

While the use of aspirin and statins in hospital appeared to be nearly universal in the two Vietnamese hospitals, the use of beta-blockers and ACEI/ARBs was relatively low despite strong clinical evidence and recommendations for the use of these therapies in the setting of AMI. The use of ACEI/ARBs after an AMI is indicated for patients with a reduced left ventricular ejection fraction (LVEF) [17], which may explain its lower use due to a small eligible patient pool. However, we did not collect information on LVEF, and are unable to assess the appropriateness of ACEI/ARBs use in the present study. Data from >300 patients hospitalized with an AMI at the National Vietnam Heart Institute in 2010 in Hanoi also showed a similar pattern to those that we observed, with lower use of both beta-blockers and ACEI/ARBs than aspirin and statins during hospitalization for AMI [10]. Although there are concerns for the development of cardiogenic shock associated with early beta-blocker initiation after AMI, which may explain the low use we observed in this study during the first 24 h of hospitalization, overall beta-blocker use remained low during hospitalization, likely indicating suboptimal management practices.

The use of PCI at the two participating hospitals was only 64%, which was lower than that reported in the National Vietnam Heart Institute study in Hanoi (approximately 70%) [10], which may be due to the lower proportion of patients diagnosed with a STEMI in the present study. Furthermore, the proportion of patients who delayed seeking medical care after >12 h from the onset of acute symptoms was higher in the present study compared to the study conducted at the National Heart Institute in Hanoi [11], which likely contributed to the lower utilization of PCI.

When compared with data from the United States, the use of PCI in the present study was considerably lower [21]. The costs associated with the performance of PCI in Vietnam remain high in comparison to average household income, which may limit its use for patients who cannot afford a copay fee. This observation is consistent with a lower rate of PCI utilization in Thanh Hoa province, which has a lower average household income than among residents of Hai Phong province. We also suspect that the relatively low rate of PCI was partially due to the fact that a large proportion of patients in the present study arrived to the hospital after considerable delay in seeking acute medical care, which may have disqualified them for the receipt of PCI. Irrespective of the reasons involved, the low rate of PCI in our study demonstrates the need



for further quality improvement and educational initiatives.

#### 4.3. In-hospital complications

We found that the frequency of serious in-hospital complications in the present study, including atrial fibrillation, cardiogenic shock, heart failure, stroke, recurrent angina, and cardiac arrest was relatively similar to those reported in the study conducted at the Vietnam National Heart Institute in 2010, in which heart failure, cardiac arrest and cardiogenic shock were the most common clinical complications [10]. However, the in-hospital death rates in the present study (5.1%) were considerably lower than were reported in the National Heart Institute study (6.9%) [10]. Higher hospital death rates observed in the national Vietnamese hospital are likely due to the greater acuteness and severity of patients who were transferred to this tertiary care hospital compared with our broader community-based pool of patients. It was encouraging to note the low hospital death rates observed in the present study despite relatively prolonged hospital stays compared with those seen in the United States.

Compared to our multi-hospital population-based study of AMI in central Massachusetts that was carried out during alternating study years between 2001 and 2011, the rates of atrial fibrillation (2.2% vs 15.1%), heart failure (12.0% vs 28.2%), and death (5.1% vs 6.5%) in the present study were much lower, but the rate of cardiogenic shock (9% vs. 5%) was higher while the rate of stroke was not significantly different [7]. We suspect that the lower rate of atrial fibrillation in the present study compared to that observed in central Massachusetts is partially due to the lower use of continuous telemonitoring in Vietnam. We do not have a clear explanation for the much lower rate of heart failure, and or higher rate of cardiogenic shock, and similar rate of stroke observed in the present study, but we suspect that differences in the use of echocardiography to diagnose heart failure, administration of beta blockers and other evidence-based therapies, as well as differences in the socio-demographic and clinical characteristics of the respective study populations may have contributed to these different rates.

#### 4.4. Study strengths and limitations

Our study is among the very few population-based studies of AMI in Vietnam. The respective study populations were selected to represent both rural and urban settings in two different geographic areas. The study was rigorously conducted across the study sites, which will hopefully serve as a model for establishing a national registry of AMI in Vietnam. The main limitation of our study was missing data on several key variables, such as extent of pre-hospital delay, thus limiting a more detailed exploration of our findings. Although most patients with AMI would be transferred to the provincial hospitals included in our study due to health insurance requirements, there was a possibility that some patients bypassed this transfer order and were not captured in our study.

### 5. Conclusions

In conclusion, patients who were admitted for an initial AMI in two provinces in Vietnam were older with higher percentage of women compared to adjacent East Asian countries. The incidence rates of AMI in these provincial registries were low while prolonged delay in seeking acute medical care was common. In-hospital use of cardioprotective medications and coronary reperfusion therapy was less than optimal, but the frequency of several in-hospital complications and mortality were low compared to other population-based studies in the United States. Our study suggests the feasibility of establishing population-based surveillance for AMI in Vietnam which would provide insights into the contemporary epidemiology of this condition and the need for more coordinated efforts of primary and secondary prevention.

### Availability of data and materials

The datasets and other study materials of the current study will be available from the corresponding author on reasonable request. All data will be de-identified before sharing.

### Authors' contributions

HLN, RJG, DAH, MHV conceived the study and participated in its design. HLN, QTB, TTL, and VTN participated in the development of the study protocol and data collection and data analysis. HLN, RJG, QTB, TTL, HVT, NDN, and HHT participated in writing the manuscript. All authors read and approved the final manuscript.

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### Statement of authorship

All author takes responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.

### Author statement

We would like to submit the revised manuscript entitled “Characteristics, In-Hospital Management, and Complications of Acute Myocardial Infarction in Northern and Central Vietnam” for consideration for publication in the International Journal of Cardiology. This manuscript represents research study, is not under consideration by another journal, and has not been previously published elsewhere. This manuscript would fall into category of a clinical investigation. All authors have read and approved the revised manuscript.

### Declaration of Competing Interest

The authors declare that they have no competing interests.

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