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# The temporal trends of incidence, treatment, and in-hospital mortality of acute myocardial infarction over 15 years in a Taiwanese population

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ABSTRACT

*Background:* The study was conducted to examine the nationwide temporal trends of incidence, treatment, and short-term outcomes for acute myocardial infarction (AMI) over a 15-year period in Taiwan.

*Methods:* We identified patients who were hospitalized for incident AMI between 1997 and 2011 from the inpatient medical claim dataset of the National Health Insurance Research Database. Age- and sex-adjusted incidence and in-hospital mortality rates were calculated for AMI, and separately for ST-segment elevation and non-ST-segment elevation myocardial infarction (STEMI and NSTEMI).

*Results:* A total of 144,634 patients were identified. The incidence rates (per 100,000 population) of AMI increased from 30 in 1997 to 42 in 2011, which was mainly driven by the increase of NSTEMI. The in-hospital mortality rate after AMI decreased from 9.1% in 1997 to 6.5% in 2011, which was also driven by the case mortality rate for NSTEMI. Although the in-hospital mortality rates significantly decreased from 7.3% to 5.1% between 1997 and 2003 for STEMI, it did not change significantly from 2004 to 2011. Moreover, AMI patients undergoing revascularization treatment, particularly PCI, was the most important independent predictor for improved in-hospital survival.

*Conclusion:* The results of this study demonstrated a recent dramatic increase in the incidence rates and a decrease in short-term mortality in patients with NSTEMI; while the incidence and in-hospital morality of STEMI only modestly changed over time in Taiwan. Further quality improvement approaches for AMI prevention and treatment to favorably affect the incidence and outcomes from both major types of AMI are highly recommended.



## 1. Introduction

The management of acute myocardial infarction (AMI) has advanced significantly in recent years. Treatment options include but are not limited to timely coronary artery revascularization, especially primary percutaneous coronary intervention (PPCI) for ST-elevation myocardial infarction (STEMI), early invasive strategy for non-ST-elevation myocardial infarction (NSTEMI), antiplatelet therapy, early statin use, beta-blockers, angiotensin converting enzyme inhibitors (ACEIs) and angiotensin-II receptor blockers (ARBs) in selected patients, have generally been advocated by the contemporary guidelines [1–5]. The progressive uptake in aspects of those medical care demonstrated in randomized clinical trials has reduced both acute and long-term mortality subsequent to AMI worldwide [1–5]. For example, in the US, a national effort was introduced by the American College of Cardiology (ACC) in 2006 to reduce door-to-balloon time (D2BT), resulting in a significant improvement in quality of care observed in those hospitals providing guideline-based standardized care, including D2BT, compared with the control hospitals [6]. Before 2006, the 30-day mortality rates of AMI patients in the United States were 18.9% in 1995 and 17.6% in 2006 [7]. With the implementation of improved care for patients with AMI, the 30-day mortality rate decreased rapidly over a relatively short time, down to single digits of 7.8% in 2008 [8,9].

In Taiwan, the 30-day morality rates of AMI patients were similar to those of the US before 2006 [10]. In 2008, a countrywide campaign seeking to achieve the goal of administering PPCI treatment to 75% of patients with STEMI within 90 min of hospital presentation had yielded favorable results in Taiwan. Since 2009, the requirement of achieving a

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D2BT in 90 min or less, and in at least 75% of STEMI patients, has become an important measurement, which is also tied to hospital accreditation by the Taiwan Joint Commission on Hospital Accreditation. The hospitals' ability to provide PPCI facilities for patients with STEMI and guideline-driven medical therapy was mandated by the commission as a criterion for obtaining a high emergency accreditation score. This approach was also strongly recommended in the 2012 Guidelines of the Taiwan Society of Cardiology for the Management of STEMI [11]. During the past few years, reported D2BT has dropped significantly for patients with STEMI, as have the in-hospital and mid-term mortality rates [12–15]. Moreover, the Ministry of Health and Welfare encouraged district hospitals in the remote areas to provide PCI, and the in-hospital mortality rate of AMI patients has been reduced significantly in those areas that have utilized this approach [16]. Furthermore, an early invasive strategy in the management of high-risk NSTEMI recommended by current guidelines has also been adopted by Taiwanese medical centers, where in-hospital revascularization has been associated with significant benefits at the 1-year and 3-year post-procedure benchmarks in NSTEMI patients [17].

Although those studies support policies promoting the systematic application of evidence-based medicine in AMI, they were conducted over shorter time periods in modest sized cohorts in limited numbers of larger medical centers or general hospitals focusing on performing PPCI, which may be influenced by selection bias and thus may not be generally applicable to all STEMI patients. Studies to examine population-based trends in AMI epidemiology are important, although scarce [8,9,18–20]. Therefore, the aim of the present study was to examine nationwide temporal trends in the incidence, revascularization treatment, in-hospital mortality, and possible factors influencing in-hospital survival after AMI over a 15-year period in Taiwan using the National Health Insurance Research Database (NHIRD).

## 2. Methods

### 2.1. Data sources

This study used data from Taiwan's NHIRD, which is one of the largest database sets in the world. The applicable data set included all claims data from the NHI program in Taiwan, which finances the healthcare of all residents in Taiwan and offers unrestricted access to any healthcare provider that patients may choose. The single-payer NHI program was launched in Taiwan on March 1, 1995, and now approximately 99% of the country's entire population is enrolled [21].

Because the NHIRD was encrypted in order to protect the privacy of all patients enrolled, and the database consists of de-identified secondary data released to the public for research purposes, this study was exempted from full review by the Institutional Review Board. However, the Institutional Review Board of the Cheng Hsin General Hospital did approve the study and, due to the nature of the investigation, granted a waiver of informed consent.

### 2.2. Study population

This retrospective cohort study included all patients who were admitted to hospitals with the primary diagnosis of AMI (ICD-9-CM code from 410 to 410.92) for the first time between January 1997 and December 2011 (n = 146,045). However, we later excluded the patients whose data on length of stay were missing (n = 1197), whose gender was undetermined (n = 120) and whose age was under 20 years old (n = 94). Hence, altogether 144,634 patients were eventually included in this study. The total number of patients excluded from the analysis was 1411 (0.97%). According to the ICD-9-CM classification, the type of AMI was determined as follows: patients with 410.0×–410.6×, or 410.8× were defined as STEMI; patients with 410.7× and 410.9× were defined as NSTEMI [22].

Thrombolysis, coronary artery bypass grafting (CABG) procedures and PCI procedures were classified by the ICD-9 procedural codes in each admission record (up to five procedural codes for each admission record). Patients who underwent thrombolysis were defined when the ICD-9-CM procedure code during index admission was recorded as 99.10. Patients who underwent PCI were defined when any of the ICD-9-CM procedure codes during index admission were recorded as 36.0, 36.01, 36.02, 36.05, 36.06, or 36.09. Patients who underwent CABG were defined when any of the ICD-9-CM procedure codes during index admission were recorded as 36.1, 36.10, 36.11, 36.12, 36.13, 36.14, 36.15, 36.16, 36.17, or 36.19. Outcomes assessed included in-hospital mortality, postoperative or post-procedural complications, length of stay, and patient demographics such as age, gender, and comorbidities.

Because NHI in Taiwan is compulsory, there are very few circumstances when a patient, especially an ill patient, can be dropped from insurance coverage for any cause other than death. Moreover, given that the NHI premium is paid on a monthly basis, coverage can easily be dropped immediately after death. Thus, the ending date of coverage from NHI is generally a reliable proxy for the mortality date [23]. Because we used the inpatient medical claim dataset of NHIRD for analysis in the present study, the outcome indicator used in the present study was in-hospital mortality after AMI, which was defined as all-cause mortality during the index hospitalization. This parameter has been validated in previous studies [24,25]. In the present study, the in-hospital mortality after AMI is defined when the ending date of coverage from NHI minus the date of hospital admission is less than or equal to 360 days having occurred during the index hospitalization.

The ICD-9 coding system has specific codes for complications resulting from a procedure or operation, and these were used to determine the complication rates. The comorbidities were determined by the presence of ICD-9 diagnosis codes for diabetes mellitus, hypertension, preoperative renal insufficiency, chronic obstructive pulmonary disease, previous myocardial infarction, cerebrovascular occlusive disease, and peripheral arterial disease. The length of hospital stay was defined as the number of days a patient remained in the acute inpatient ward.

### 2.3. Statistical analyses

Data were transferred from the NHI database to our data systems, which utilized the Statistical Program for Social Sciences (version 18.0 for Windows, IBM Corporation, New York, NY, USA) for further analysis. We calculated the temporal trends in the age- and sex-adjusted incidence and in-hospital mortality rates of AMI, STEMI, and NSTEMI (per 100,000 standard population) for each year. Direct methods for adjustment were used on the basis of Taiwan's population age and sex distribution in the year 2000. The temporal trends of treatment for AMI, STEMI, and NSTEMI including thrombolysis, CABG and PCI for each year were also calculated.

Continuous variables were expressed as mean ± standard deviation and were compared using the student's t-test or the Wilcoxon rank-sum test. Categorical variables were presented as percent frequency and were compared using Pearson's chi-square test or the Fishers' exact test. Univariate comparisons of demographic parameters, treatment, complications, and time intervals between STEMI and NSTEMI patients were made, and survival analysis was performed by the Kaplan–Meier method. The AMI patients were then divided into two groups depending on whether a patient was determined to have survived during the index hospitalization or not. Univariate and multivariate Cox proportional hazards analysis were performed to identify independent prognostic determinants of in-hospital mortality and the hazard ratio (HR) and associated 95% confidence interval were measured for each determinant. A 2-tail P value of $<0.05$ was considered to be statistically significant.