Treatment costs of acute myocardial infarction in the Netherlands

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Abstract

Background This study aimed to calculate the treatment costs of acute myocardial infarction (AMI) in the Netherlands for 2012. Also, the degree of association between treatment costs of AMI and some patient and hospital characteristics was examined.

Methods For this retrospective cost analysis, patients were drawn from the database of the Diagnosis Treatment Combination (Diagnose Behandelings Combinatie, DBC) casemix system, which contains data on the resource use of all hospitalisations in the Netherlands. All costs were based on Euro 2012 cost data.

Results The analysis was based on data of 25,657 patients. Mean treatment costs were estimated at € 5021, with significant cost increases for patients with percutaneous coronary intervention (PCI) treatment. ST-segment elevation myocardial infarction (STEMI) patients receiving thrombolysis incurred the lowest (€ 4286), while non-STEMI patients receiving PCI the highest costs (€ 6060). Length of stay and hospital type were strong predictors of treatment costs.

Conclusions This study is the most extensive cost assessment of the treatment costs of AMI in the Netherlands thus far. Our results may be used as input for health-economic models and economic evaluations to support the decision making of registration, reimbursement and pricing of interventions in healthcare.

Keywords Acute myocardial infarction · Cost analysis · PCI procedure · Treatment costs · the Netherlands

Introduction

Acute myocardial infarction (AMI) is one of the most common manifestations of coronary heart disease (CHD). About 1.2 million Americans suffered from AMI in 2006 [1]. In the Netherlands, the prevalence rate of AMI was estimated at 26,500 in 2007. The treatment costs of CHD in the Netherlands are currently estimated to represent about 26 % of the hospital budget for cardiovascular diseases. Owing to ageing of the population, however, treatment costs are expected to increase by 45 % between 2007 and 2025 [2]. It is therefore relevant to gain insight into the treatment costs of AMI.

Several studies have determined the treatment costs of AMI, but cost estimations vary extensively. In a single-centre Dutch study, treatment costs were found to be € 2495 [3]. At the other extreme, treatment costs in large private teaching hospitals were estimated at € 25,142 in Japan (both adjusted to 2012) [4].

Many studies have tried to explain the wide variations in the treatment costs of AMI. For example, the availability of percutaneous coronary intervention (PCI) is considered to have an important effect on treatment costs of AMI. Although published guidelines recommend PCI within 90 min after first diagnosis at home or in the ambulance [5–7], its costs are estimated to be about 1.5 times higher than those of thrombolysis [8–11]. Other potential factors influencing the differences in treatment costs include the patient casemix (e.g. ST-segment elevation myocardial infarction (STEMI) versus non-STEMI patients), medical practice patterns, financial incentives and relative and absolute prices between countries [12–14].

Earlier studies have determined treatment costs of AMI, but they did not compare patient subgroups, included only a limited number of patients and/or are outdated [3, 4, 8, 9, 11]. Therefore, the primary aim of the present study was to

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calculate the treatment costs of AMI in the Netherlands for 2012. As AMI patients require treatment that can vary considerably in type, duration and cost, it is desirable to have insight into determinants that are able to predict the treatment costs of individual patients. Hence, the secondary objective of the current study was to examine the degree of association between treatment costs of AMI and some routinely collected patient and hospital characteristics.

Methods

For this retrospective cost analysis, each patient admitted for the initial treatment of AMI in 2008 was included. Patient data were drawn from the database of the Diagnosis Treatment Combination (Diagnose Behandelings Combinatie, DBC) casemix system, a Diagnosis Related Group (DRG)-like system in which the resource use of all hospitalisations in the Netherlands is recorded.

Treatment costs in the acute phase of AMI were calculated for the total population as well as separately for the following patient subgroups: (1) STEMI patients receiving thrombolysis, (2) STEMI patients receiving PCI treatment, (3) non-STEMI patients receiving thrombolysis and (4) non-STEMI patients receiving PCI. Treatment costs for individual patients included costs for inpatient days, intensive care unit days, day-care admissions, outpatient and emergency room visits, laboratory services, medical imaging services, surgical procedures, medical devices, diagnostic activities, microbiological and parasitological services, pathology, blood products, paramedical and supportive services and rehabilitation services.

Resource use was valued by unit costs for 2012. Table 1 presents the unit costs of the most important cost items. Unit

costs for catheterisations, PCI procedures and coronary stents were based on detailed microcosting studies [8, 9]. The remaining unit costs were based on either reference prices of the Dutch Manual for Costing [15] or tariffs provided by the Dutch Healthcare Authority [16]. All unit costs reflected full hospital costs, including labour, drug, overhead and capital costs.

Regression analysis

Data were analysed using an ordinary least squares (OLS) regression analysis to explore the degree of association between treatment costs and some routinely collected patient and hospital characteristics. Treatment costs of AMI were taken as the dependent variable and ‘age’, ‘gender’, ‘length of stay’(in days), ‘type of hospital’ (small general hospital, medium-sized general hospital, large general hospital, non-university teaching hospital and university teaching hospital) and ‘patient subgroup’ as explanatory variables. The Pearson’s correlation coefficient investigated the ability of the patient and hospital characteristics to predict treatment costs.

Statistical analyses

In addition to descriptive statistics, tests for normal distribution were performed using the Kolmogorov-Smirnov test. Differences between patient subgroups were assessed by means of the independent sample t and one-way analyses of variance tests. All costs were based on Euro 2012 cost data. Where necessary, costs were adjusted to 2012 using the consumer price index of the Dutch Central Office of Statistics [17] and converted to Euro using average currency exchange rates for the year 2012 [18]. Statistical analyses were conducted with the statistical software programs SPSS for Windows version 18.0 and SAS version 9.0. In all cases $P < 0.05$ was taken as statistically significant.

Results

A total of 25,657 patients of age (mean $\pm$ SD) 66.3 ± 13.5 years with 67 % males were admitted for the initial treatment of AMI in the Netherlands in 2008. These included 6765 STEMI patients receiving thrombolysis, 8087 STEMI patients receiving PCI, 9005 non-STEMI patients receiving thrombolysis and 1800 non-STEMI patients receiving PCI.

The patient and hospital characteristics of the four patient subgroups are summarised in Table 2. STEMI patients were younger than non-STEMI patients ($P < 0.001$) and patients receiving PCI were younger than patients receiving

Table 1 Unit costs of the most important cost items (Euro 2012)

Resource use	Unit price	Source
Inpatient day		
General hospital	€ 462	[15]
Teaching hospital	€ 609	
Intensive care unit day	€ 2343	[15]
Outpatient visit	€ 77	[15]
Emergency room visit	€ 162	[15]
Day-care admission	€ 269	[15]
Exercise therapy	€ 39	[15]
Chest X-ray	€ 54	[16]
ECG	€ 22	[16]
Catheterisation	€ 383	[3]
PCI procedure	€ 378	[8]
Coronary stent	€ 1735	[8]

ECG electrocardiography, PCI percutaneous coronary intervention

Table 2 Patient and hospital characteristics of the four patient subgroups

	Total population <i>n</i> =25,657	STEMI patients receiving thrombolysis <i>n</i> =6765	STEMI patients receiving PCI <i>n</i> =8087	non-STEMI patients receiving thrombolysis <i>n</i> =9005	non-STEMI patients receiving PCI <i>n</i> =1800
Age years, mean $\pm$ SD	66.3 $\pm$ 13.5	65.8 $\pm$ 14.0	62.9 $\pm$ 12.8	70.2 $\pm$ 13.2	64.1 $\pm$ 12.0
Gender, <i>n</i> (%)					
male	17,289 (67)	4604 (68)	5889 (73)	5526 (61)	1270 (71)
female	8368 (33)	2161 (32)	2198 (27)	3479 (39)	530 (29)
Length of stay, mean $\pm$ SD	5.6 $\pm$ 5.8	6.5 $\pm$ 5.5	3.2 $\pm$ 5.1	7.6 $\pm$ 5.9	3.6 $\pm$ 4.1
Hospital type, <i>n</i> (%)					
Small general hospital	4275 (17)	1771 (26)	0 (0)	2503 (28)	0 (0)
Medium-sized general hospital	4859 (19)	2,059 (30)	0 (0)	2800 (31)	0 (0)
Large general hospital	3674 (14)	943 (14)	1064 (13)	1201 (13)	466 (26)
Non-university teaching hospital	8,402 (33)	1564 (23)	3964 (49)	2052 (23)	822 (46)
University teaching hospital	3742 (15)	243 (4)	2799 (35)	221 (2)	479 (27)
missing	705	185	260	228	33

STEMI ST segment elevation myocardial infarction, PCI percutaneous coronary intervention, SD standard deviation

thrombolysis ($P<0.001$). Non-STEMI patients receiving thrombolysis had a longer length of stay compared with patients in the other subgroups ($P<0.001$). PCI is associated with significant investments in infrastructure and running costs, which is why small and medium-sized general hospitals do not provide this treatment.

Figure 1 presents the breakdown of treatment costs in the acute phase of AMI for the total population and by patient subgroup. Mean treatment costs amounted to € 5021 $\pm$ 6906, with a substantial cost variation in the treatment costs of individual patients (range: € 34 to € 870,563 (median: € 4022)). STEMI patients receiving thrombolysis incurred

the lowest (€ 4286 $\pm$ 11,278 (median: € 3383)), while non-STEMI patients receiving PCI the highest costs (€ 6060 $\pm$ 4307 (median: € 5311); $P<0.001$). STEMI patients incurred significantly lower costs than non-STEMI patients and thrombolysis significantly lower costs than PCI ($P<0.001$).

Inpatient days, PCI procedures and coronary stents were the greatest contributors to treatment costs. Inpatient day costs accounted for 83 % of the treatment costs for patients receiving thrombolysis (STEMI: € 3502 $\pm$ 3636 (median: € 2837); non-STEMI: € 3977 $\pm$ 3394 (median: € 3125)) and 35 % of the treatment costs for patients receiving PCI (STEMI: € 2030 $\pm$ 3679 (median: € 1250); non-STEMI:

Fig. 1 Breakdown of treatment costs for the total population and by patient subgroup (Euro 2012). STEMI ST segment elevation myocardial infarction, PCI percutaneous coronary intervention. * laboratory services, medical imaging services, surgical procedures (except catheterization and PCI procedure), medical devices (except coronary stent), diagnostic activities, microbiological and parasitological services, pathology, blood products, paramedical and supportive services and rehabilitation services

€ 2183±2670 (median: € 1250)). STEMI patients had a shorter length of stay than non-STEMI patients ($P<0.001$). This is in agreement with the current medical practice in which STEMI patients are commonly enrolled in an acute program, whereas non-STEMI patient are enrolled in an elective program (including a coronary arteriography causing a longer length of stay when persistent anginal pain, delta ECG or ischaemia is present [19]. As PCI may be provided in the day-care setting, patients receiving PCI had more day-care admissions than patients receiving thrombolysis ($P<0.001$). Conversely, patients receiving PCI received fewer outpatient and emergency room visits ($P<0.001$). This may be due to evidence suggesting that patients receiving PCI show better medical outcomes, less medical uncertainty, lower short-term mortality and reduced re-infarction rates [1, 11].

Costs for catheterisation amounted to € 178±5428 (3 % of treatment costs (median: € 0)) and those for PCI procedure and coronary stent to € 1187±2172 (24 % (median: € 0)). While catheterisations were performed more often in patients receiving thrombolysis ($P<0.001$), the PCI procedure was solely performed in patients receiving PCI. Because PCI procedures are not believed to be beneficial to STEMI patients when the coronary artery is damaged and the CHD of non-STEMI patients is usually more complex, STEMI patients received fewer PCI procedures and coronary stents than non-STEMI patients ($P<0.001$).

Costs for the remaining cost components significantly differed between patient subgroups, with the exception of pathology ($P=0.945$). Compared with patients receiving PCI, patients receiving thrombolysis received more medical imaging services ($P<0.001$). This may be explained

by uncertainty of physicians about disease progression and their desire to confirm treatment effects during hospitalisation [20]. Finally, patients receiving thrombolysis received more exercise therapy ($P<0.001$) which is in agreement with published guidelines recommending exercise therapy to patients receiving thrombolysis, because their medical condition is poorer and their inpatient recovery longer than that of patients receiving PCI [6, 21].

Regression analysis

Table 3 shows the relationship between treatment costs and some patient and hospital characteristics. Model 1 included all determinants, of which ‘age’ ($P=0.954$), ‘gender’ ($P=0.751$) and ‘non-STEMI patients receiving thrombolysis’ ($P=0.111$) were not significantly associated with treatment costs. When these determinants were simultaneously left out (model 2), all other determinants remained significant. One additional inpatient day was associated with a cost increase of € 644 ($P<0.001$) and PCI with a cost increase of € 2963 for STEMI patients and € 3139 for non-STEMI patients. Overall, this analysis explained a modest 26 % of the treatment costs of AMI.

Discussion

This paper aimed to calculate the treatment costs of AMI in the Netherlands for 2012. Treatment costs in the acute phase of AMI averaged € 5021±6906 for the total population,

Table 3 Relationship between treatment costs and patient and hospital characteristics (Euro 2012)

Independent variable	Model 1 $R^2=0.264$		Model 2 $R^2=0.264$	
	Coefficient	SE	Coefficient	SE
Constant	−126	213	−212	97*
Patient characteristics				
Age	0	3		
Gender	26	81		
Length of stay	644	6*	644	6*
Hospital type				
Small general hospital	ref		ref	
Medium-sized general hospital	−242	120*	−241	120*
Large general hospital	397	134*	401	134*
Non-university teaching hospital	911	117*	914	117*
University teaching hospital	986	151*	991	151*
Patient subgroup				
STEMI patients receiving thrombolysis	ref		ref	
STEMI patients receiving PCI	2881	118*	2963	106*
Non-STEMI patients receiving thrombolysis	−154	96		
Non-STEMI patients receiving PCI	3057	168*	3139	160*

STEMI ST segment elevation myocardial infarction, PCI percutaneous coronary intervention, SE standard error, ref reference category

* $P<0.05$

with significant cost increases for patients receiving PCI. Furthermore, length of stay and hospital type were strong predictors of treatment costs. In agreement with earlier studies [13, 14], age and gender did not explain cost variation.

Several earlier studies have estimated the treatment costs of AMI in the Netherlands. A single-centre Dutch study conducted in the late 1980s found treatment costs of € 2495 [3]. More recent multi-centre studies have determined treatment costs to be about € 5967 (both adjusted to 2012) [8, 9]. It is likely that the length of stay and availability of PCI largely explained the higher treatment costs compared with our study, but methodological differences restricted a truthful cost comparison [22].

National registries have proven to be a unique data source to provide feedback and generate new ideas on how to improve and find the most appropriate care system for AMI [12, 23]. The database of the DBC casemix system enables the collection of resource use for individual patients from a single data source and encourages the comparability of health-economic outcomes. However, using the database to determine treatment costs also has several limitations. Firstly, the resource use in the database is not sufficiently distinct for some cost components. For example, no distinction is made between drug-eluting and non-eluting stents. Because costs of the stents vary widely depending on the type of stent, we used weighted average unit costs to reflect current practice (2:1; € 1735) [8]. Moreover, labour and drugs are not recorded as separate cost components but accounted for implicitly. For example, drug costs comprise 15 % of the unit costs of inpatient days [15]. Consequently, cost differences between patient subgroups cannot be detected for labour and drugs.

Secondly, the database contains only a limited number of patient and hospital characteristics. This prevented us from assessing other determinants that may be able to explain variability in the treatment costs of AMI. A recent study by Hakkinen et al. (2012), conducted in nine European countries excluding the Netherlands, suggested that information on in-hospital mortality, infections, adverse events, type of stent and thrombolytic agents may be able to explain resource use of AMI [10]. In the Netherlands, some Patient Safety Indicators are collected to serve as benchmarking tools for hospital performance (e.g. malnutrition and mortality after PCI) [24]. These indicators are only collected for subsets of patients, for specific treatments and at an aggregated level. A future study should examine the feasibility of introducing these indicators to the database of the DBC system.

Despite these limitations, we believe this study provides a reliable estimate of treatment costs of AMI. By including all patients admitted for the initial treatment of AMI in 2008, this study is the most extensive cost assessment of treatment

costs in the field of CHD in the Netherlands thus far. Extrapolation of estimated treatment costs per patient subgroup results in an economic burden of € 126 million per year. Similar to that in other European countries, this equals about 7 % of the treatment costs of CHD [2, 25]. Our results may be used as input for health-economic models and economic evaluations to support the decision making of registration, reimbursement and pricing of interventions in healthcare.

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Conflict of interests None declared.

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