## **Research Paper:**



# Coronary Artery Bypass Graft Compared to Percutaneous Coronary Interventions in Patients With Coronary Artery Disease: A Cost-Effectiveness Analysis

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### ABSTRACT

**Background and Aim:** Coronary Artery Diseases (CADs) affect different physical, social, and economic aspects of patients' lives. The cost-effectiveness analysis is a way to examine both the costs and health outcomes of one or more therapeutic interventions of this disease. In other words, it compares an intervention to another one by estimating how much it costs to gain a unit of a health outcome, for instance, a life-year gained or death prevented. This study aimed to compare Coronary Artery Bypass Graft (CABG) with Percutaneous Coronary Intervention (PCI) in patients with CADs.

Materials and Methods: This study is descriptive-analytical. It was conducted on 601 patients who underwent CABG (n=287) and PCI (n=314) in three aspects. The first aspect is to measure the effectiveness of CABG and PCI (cardiac mortality rate and quality of life). The second aspect is to estimate the direct costs (e.g. medical and non-medical costs) and indirect costs (e.g. productivity losses due to morbidity and mortality) based on a societal perspective. The third aspect is the cost-effectiveness analysis. The obtained data were analyzed with Markov cohort simulation using Excel and the TreeAge tool. Uncertainties related to model parameters were evaluated using 1-way and 2-way sensitivity analyses.

**Results:** During the follow-up period, 2% and 0.8% of patients died after CABG and PCI intervention, respectively. The Mean±SD EuroQol- 5 Dimension (EQ-5D) score after 12 months was 0.72±0.15 for the CABG group and 0.66±0.19 for the PCI group. All the therapeutic strategies yielded significant improvement in all dimensions during the follow-up. The mean annual total cost for the overall sample was \$6243 per patient. This cost was significantly higher among patients who underwent CABG (\$7234 per patient) than PCI (\$5252 per patient). Direct costs accounted for 90%, and indirect costs accounted for 10% of the total costs. And the cost-effectiveness threshold was \$14375. The Incremental Cost-Effectiveness Rate (ICER) in reducing mortality rate and increasing Quality of Life (QoL) was \$-942.7 and \$106050, respectively.

**Conclusion:** The present study found which intervention (PCI and CABG) had better cost-effectiveness in CAD patients. PCI intervention is more cost-effective than CABG in reducing mortality rate and increasing quality of life. This study tries to resolve the previous controversies regarding the most appropriate treatment for patients with coronary artery disease. It can have significant policy and clinical implications for health policymakers, cardiologists, and health managers.

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### 1. Introduction



ccording to the World Health Organization report, non-communicable diseases are the leading cause of mortality worldwide [1]. Nearly 71% of 56 million deaths that occurred in 2015 worldwide are attributed to non-communicable diseases and main-

ly due to Cardiovascular Diseases (CVDs). In Europe, CVDs account for 45% of the mortality rate (2.14 million deaths per year) and 37% within the 28 countries of the European Union (1.85 million deaths per year) [1, 2]. Well-known risk factors include tobacco smoking, lack of physical activity, overweight, hypertension, diabetes mellitus, and high cholesterol. It is estimated that 80% of premature heart disease, stroke, and diabetes can be prevented [1].

Cardiovascular diseases are the most common noncommunicable diseases globally and account for 17.8 million deaths in 2017, of which more than three-quarters happen in low-income and middle-income countries [3].

CVD is estimated to cost the EU economy €210 billion a year. Of the total cost of cardiovascular diseases in the EU, €111 billion (53%) is due to direct health costs, €54 billion (26%) to productivity losses, and €45 billion (21%) to informal care [2]. The restriction of the healthcare budget is prompting the need for developing alternative cost-efficient care strategies. CVDs have been the leading cause of death globally for decades [4]. Treating CVD is costly. In the US, the medical cost for treating CVDs was \$656 billion in 2015 and is predicted to reach \$1208 billion in 2030 [5]. The global cost of CVDs was estimated to be \$863 billion in 2010, which will grow by 22% to \$1044 billion by 2030 and is predicted to severely affect the productivity of the active labor force and reduce gross domestic product [6]. Treatment interventions for Coronary Artery Diseases (CADs) are Medical Therapy (MT), Percutaneous Coronary Intervention (PCI), and Coronary Artery Bypass Graft (CABG) [7].

The economic implications of treatments for CAD are increasingly important, as the direct and indirect costs are enormous. In the USA, the estimated direct and indirect cost for CADs treatment was \$204.4 billion in 2010, of which \$97.2 billion was due to indirect costs related to the loss of productivity or mortality. Furthermore, by 2030, the medical expenses of CADs are projected to increase by about 100% [8, 9].

The substantial costs in a patient with CAD include medical expenses, as well as costs due to loss of productivity [10, 11]. Previous studies evaluating medical costs have shown the total first-year treatment cost estimates as \$22528 to \$32345, with most of these costs due to hospitalizations [12-14].

The disease can have costs not only for patients and their families but also for the government, employers, insurance companies, and other society members. Therefore, to achieve a comprehensive analysis, this study was performed from the societal perspective, including all direct medical and indirect costs and outcomes interventions. However, better solutions and performance and cost-effective interventions can improve allocative efficiency and equality. Therefore, this study aimed to evaluate the Incremental Cost-Effectiveness Rate (ICER) of PCI and CABG for patients with CAD, using a Markov decision-analytic model.

### 2. Materials and Methods

This research was a descriptive-analytical study conducted on 601 patients diagnosed with CAD admitted to Tehran Heart Center Hospital, Tehran, Iran, in 2019. The patients were between 40 and 90 years old and categorized into the two intervention groups. The patients with concomitant valvular disease, predominant congestive heart failure, and no consent for a possible revascularization procedure were excluded. The statistical population comprised 1845 patients. After pretreatment assessments and screening, 601 patients with PCI (n=314) and CABG (n=287) were recruited in the study. All patients were followed for 12 months to collect robust and representative data. During the follow-up period, three visits (when admitted, after 6 months, and then 12 months later) were conducted. If the patients were unable to attend the follow-up visits, they were reached by the investigator over the phone to complete the questionnaire. Informed written consent was received from all patients.

This research has been done in three aspects. The first aspect is to measure the effectiveness of CABG and PCI (cardiac mortality rate and quality of life) in patients with coronary artery disease. The second aspect is to estimate direct costs (e.g. medical and non-medical costs) and indirect costs (e.g. productivity losses due to morbidity and mortality) from the perspective of society. The last aspect is using a Markov model to predict the outcomes for patients with CAD.



Figure 1. Markov decision analysis model

#### **Direct costs**

Direct costs were divided into medical and non-medical costs. To quantify the direct costs, we measured the costs of the resources used. Direct medical costs include hospital inpatient costs and outpatient costs (physician outpatient, rehabilitation care, specialists and other health professionals' cares, diagnostic tests, prescription drugs, and medical supplies). To obtain more accurate estimates, we measured the payments made by the insurance and direct payments by the patients received from the hospitalization and outpatient bills. Direct non-medical costs include transportation costs, using mobile, telephone, housekeeping, food cost, childcare or related items, and informal care.

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The Iranian Rial to US Dollar exchange rate was considered based on the official established rate announced by the Iranian Central Bank. It should be noted that according to the health care reform plan, one dollar was calculated for 42000 Rials.

#### Indirect costs

In this part of the study, we focused on estimating productivity losses. For the estimation of indirect costs and its subsequent conversion into monetary units, in most relevant studies, the human capital approach has been used [15]. The human capital method transforms years of life into monetary units using the average gross earning per worker



### Figure 2. Percentage of total cost attributed to each type of cost

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	Mean±SD/ (%)		
Baseline Characteristic	CABG Group	PCI Group	
Age (y)	62.2±9.4	59.6±10.9	
Male	78	67	
Hypertension	58	55	
Diabetes mellitus	39	34	
Dyslipidemia	52	56	
Overweight and obese	82	78	
Current smoker	21.2	24.5	

Table 1. Baseline characteristic of the study patients

CABG: Coronary Artery Bypass Graft; PCI: Percutaneous Coronary Intervention

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[16, 17]. The information regarding days of temporary disability, reduction in working time, permanent disability, and early retirement caused by CAD was obtained from the questionnaires filled out by the patients or the patient's caregivers. Information about employment and wages was obtained from the Iran National Statistics Institute.

### EuroQol-5D-3L (EQ-5D) health survey

The EuroQol-5D-3L (EQ-5D) covers five domains of mobility, self-care, usual activities, pain/discomfort, and anxiety/depression [18, 19]. An index score is produced ranging from -0.594 to 1, where a score below zero indicates a state 'worse than death' and a score of one means the optimal health state. The EQ-5D also administers a Visual Analog Scale (VAS) which asks patients to rate their pre- and postarrest health state on a scale from 0 to 100, where 0 indicates the worst imaginable health state and 100 indicates the best imaginable health state.

### **Statistical analysis**

We defined an intervention as "not cost-effective" if ICER (Incremental Cost-Effectiveness Ratio) was three times higher than the GDP (Gross Domestic Production) per capita and "cost-effective" if ICER was three times less than the GDP per capita [20]. The cost-effectiveness threshold was set according to the official dollar exchange rate in Iran in 2019. The data analysis method included Markov cohort simulation, and the data analysis tools were Excel and Tree-Age software. Uncertainties related to model parameters were evaluated using 1-way and 2-way sensitivity analyses. The simplified schematic of the Markov model structure is shown in Figure 1.

### 3. Results

In this study, 601 patients with CAD were studied, of whom 287 were in the CABG group and 314 in the PCI group, and the baseline characteristics of the patients are

%		
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Table 2. One-year outcomes in patients with coronary artery disease

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CABG: Coronary Artery Bypass Graft; PCI: Percutaneous Coronary Intervention; MI: Myocardial Infarction

	Mean±SD				
Outcomes _	PCI Group		CABG Group		
	Hospitalization Time	12 months After Treatment	Hospitalization Ttime	12 months After Treatment	
QALY	0.52±0.25	0.66±0.19	0.50±0.23	0.72±0.15	
VAS	61±15.2	71.9±19.1	61±16.2	79.8±17.4	
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Table 3. Mean EQ-5D and EQ-5D VAS score

CABG: Coronary Artery Bypass Graft; PCI: Percutaneous Coronary Intervention; VAS: Visual Analog Scale; QALY: Quality-Adjusted Life Year

shown in Table 1. The mean prevalence rates of CAD risk factors in the two interventions were 56.5%, 36.5%, 54%, 80%, and 23% for hypertension, diabetes mellitus, dyslipidemia, overweight and current smoking, respectively (Table 1). Regarding the patients assigned to receive CABG, 0.9% had an uncomplicated Myocardial Infarction (MI), 1.7% were referred for CABG, and 0.8% were referred for PCI. During the follow-up period, 2% of patients died. Whereas patients assigned to receive PCI, 1.3% had an uncomplicated MI, 3.4% were referred for PCI, and 1.5% were referred for CABG. During the follow-up period, 0.8% of patients died (Table 2).

# Health-Related Quality of Life (HRQOL) in patients with CAD

Of the 622 questionnaires collected, only 21 were excluded from the Health-Related Quality of Life (HRQOL) analysis because the information was inadequate. Lower scores on the EQ-5D index reflected poorer health status. The Mean $\pm$ SD EQ-5D index score of hospitalization time was 0.52 $\pm$ 0.25 for the PCI group and 0.50 $\pm$ 0.23 for the

CABG group patients; also, the mean EQ-5D index score 12 months after treatment was 0.66±0.19 for the PCI group and 0.72±0.15 for the CABG group and patients. It was observed that the values for HRQOL (measured by the EQ-5D) 12 months after treatment differed significantly according to disease severity. The greatest changes in scores were observed in the CABG group (Table 3).

### **Direct costs**

The mean annual direct cost per patient was about \$5612. This cost was significantly lower in the PCI group (\$4751 per patient) than calculated per patient with CABG (\$6473) (Table 4). Of the direct costs, 84.2% were related to medical costs, and 15.8% were non-medical costs. Hospital costs were the main part of CAD direct costs (72%), then outpatient cost (12.1%), non-medical cost (8%), and finally informal care (7.9%).

#### Indirect costs

The mean annual indirect cost for the total sample was \$631 per patient. This number was higher among pa-

Table 4. Mean costs (in Dollar) per patient according to the type of interventions coronary artery disease

Costs		Mean		
		PCI Group	CABG Group	P
Direct medical costs	Hospitalization	3370 (2609-3815)	4740 (4275-5480)	<0.001
	Outpatient	660 (333-860)	671 (374-882)	<0.001
Direct non-medical costs	Non-medical costs	349(167-488)	560(372-720)	
	Informal care	372(86-562)	502(114-895)	
	Total direct cost	4751	6473	<0.001
Indirect cost	Productivity loss	501 (195-805)	761(344-1199)	<0.004
	Total cost	5252	7234	

CABG: Coronary Artery Bypass Graft; PCI: Percutaneous Coronary Intervention

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### Figure 3. The greatest changes in scores

A: Cost-effectiveness plan for quality of life; B: Cost-effectiveness plan for cardiac mortality rate.

tients with CABG as it reached \$761 per patient (\$344-1199), while it was \$501 per patient (\$195-805) in the PCI group. However, a significant difference was detected in the indirect cost among these three interventions groups (P<0.004, Table 4).

#### Mean total cost

The mean annual total cost for the overall sample was \$6243 per patient. This cost was significantly higher in patients with CABG (\$7234 per patient) compared to PCI (\$5252 per patient) (Table 4). The total cost in all groups of patients was mainly attributed to direct costs (89.5% for patients with CABG and 90.4% for patients with PCI). Direct costs accounted for 90%, and indirect costs accounted for 10% of the total expenses (Figure 2).

#### **Cost-effectiveness analysis**

In this study, which was conducted on 601 patients with CADs in Iran's referral Hospital in 2019, the costeffectiveness threshold was \$14375, and the results of

the incremental cost-effectiveness graph were analyzed
based on this threshold. The cost-effectiveness plan is
presented in Figure 3, parts A and B. Also, the results of
the cost-effectiveness of two interventions in reducing
patients' cardiac mortality and increasing their quality of
life are summarized in Table 5.

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As shown in Table 5, ICER equals 106050 per unit of increase in quality of life, and willingness to pay is \$14375. As a result, none of the interventions are costeffective. However, the average cost-effectiveness of PCI is less than CABG, so PCI strategy is more cost-effective than CABG. Also, according to this Table, ICER is equal to -942.7 per unit of reduction in mortality rate. So, the PCI treatment is more cost-effective than CABG because the PCI cost is less than CABG, its effectiveness is more than CABG, and the average cost-effectiveness of the PCI is less than CABG.

Indicator	Intervention	Cost \$	Effectiveness	Average CE	ICER	EV
QOL	CABG	33995	6.58	5164	106050	5164
	PCI	29298	6.53	4480.6	0	4480.6
Cardiac mortal- ity	CABG	33995	38.7	877.1	-942.7	877.1
	PCI	29298	43.47	669.8	0	669.8

CE: Cost Effectiveness; ICER: Incremental Cost Effectiveness Ratio; EV: Expected Value; QOL: Quality of Life

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Sensitivity Analysis on Final mortal PCI and Final mortal CABG (Net Sensitivity Analysis on Final QALY PCI and Final QALY CABG (Net Benefit, WTP=14375.0) Benefit, WTP=14375.0) 0.9725 77 CABG mortal\_CABG QALY 0.885 70 CABG CABG PCI PCI PCI Final Final 0.7975 0.71 0.65 (7325 0.815 8975 ż È Final mortal PCI Final QALY PCI Journal of Vessels and Circulation Figure 4. Sensitivity analysis

A: Two-way sensitivity analysis for quality of life; B: Two-way sensitivity analysis for cardiac mortality rate

#### Sensitivity analysis

In this study, first, all variables related to the effectiveness and cost of two interventions were selected for sensitivity analysis using the tornado chart. Then, the variables with the most effect on the study result were selected and, the 1-way and 2-way sensitivity analyses were performed on it. Regarding the quality of life, the final-QALY-PCI and final-QALY-CABG strategies were selected for analyses, and they did not change the cost-effectiveness results. Also, regarding this variable, the 2-way sensitivity analysis did not alter the cost-effectiveness results (Figure 4-A). Regarding the cardiac mortality variable, the final-mortality-PCI and final-mortality-CABG indexes were selected for analysis. According to the 2-way sensitivity analysis, regarding the efficiency index change of final-mortality-PCI from 63 to 95 and the efficiency index change of final-mortality-CABG from 56 to 64, PCI intervention was more cost effective. Also, regarding the efficiency index change of final-mortality-CABG from 64 to 84, CABG intervention was more cost effective and did not change the results of the cost-effectiveness analysis (Figure 4-B).

### 4. Discussion

Guidelines based on clinical appropriateness criteria (optimizing net health benefits) are widely used to make informed decisions about practice but are insufficient grounds for allocating healthcare resources. Although all experts agree that cost-effectiveness analysis maximizes the health gains achieved from a limited budget, it is unknown how much the measured clinical appropriateness accords with cost-effectiveness. It is necessary to create tools to identify the most cost-effective treatments, which can assist clinicians in their therapeutic decisions so that the maximum possible benefit is reached with the lowest possible cost. Effectiveness must be measured by final treatment goals in which the most effective interventions are those with the lowest costs. In this review, all studies used valid and reliable measures. However, most of them used general rather than disease-specific measures. As there has been no agreement upon the definition of QOL, the results of various measurements may vary significantly because each instrument may include common or different variables, depending on the theoretical framework used by the authors.

In this study, for cost-effectiveness analysis of CABG and PCI in patients with coronary artery disease, we constructed a Markov model of treatments based on a societal perspective.

In our study, PCI in coronary artery disease patients is more effective than CABG in preventing cardiac mortality. Similarly, Brandao et al. assessed the cost-effectiveness of CABG, PCI, and MT in 611 patients with multivessel coronary artery disease using an MASS II trial. They showed that PCI was associated with a significant reduction in all-cause mortality [21]. Hueb et al., in a randomized, controlled clinical trial of three therapeutic strategies for multivessel coronary artery disease, found that the mortality rate in PCI was lower than that in CABG intervention and, as a result, PCI was more effective than CABG [22]. The results of all these studies are consistent with the results of the present study. While Stenvall et al. long-term clinical outcomes showed that during the 8-year follow-up, there were no statistically significant differences between the groups regarding the number of all-cause deaths [23].

In the present study, the analyses of QOL in those patients showed improvement with both therapeutic interventions. However, CABG was significantly better than PCI. This finding agrees with the results of a study conducted by Favarato et al. to assess Health-Related Quality of Life (HRQOL) after CABG, PCI, and Medical Therapy (MT) in patients with coronary artery disease. They found that the quality of life was better in the CABG group compared to PCI after one year of follow-up [24].

In our study, direct costs accounted for 90%, and indirect costs accounted for 10% of the total costs. Similarly, a study conducted in Greece showed that the direct costs were nearly 92%, and indirect costs were 8% of the total costs [25]. Also, in another study conducted in the enlarged European Union (EU), of the total cost of CVDs, 62% were due to healthcare, 17% due to informal care, and 21% due to productivity losses [26].

In this study, direct costs comprised the largest component of overall expenditure related to CAD, with inpatient hospitalization as the main cost driver of direct costs (72%). This finding is consistent with other studies' findings [26, 27] but differs from a Korean study [28] in which the cost of outpatient care accounted for the largest proportion of the total costs.

The result of this study revealed that both interventions are cost-effective. Regarding the mortality rate, PCI intervention is more cost-effective than CABG in patients with coronary artery disease. In contrast, Vieira et al. conducted a trial-based analysis using the MASS II trial (medical, angioplasty, or surgery study). The long-term economic analysis for preventing a composite primary endpoint showed that CABG was more cost-effective than PCI [28].

In our study on the quality of life index, PCI strategy was more cost-effective than the CABG in patients with CAD. Brandao et al. showed that the treatment options yielded improvements in quality of life, with comparable and acceptable costs. However, despite higher initial costs, the cost-effectiveness comparison after 5 years of follow-up among the three treatments showed that PCI intervention was a modestly cost-effective strategy compared with CABG [21]. Various factors can affect the cost-effectiveness, such as age and sex, threshold values in different countries, incidence and prevalence of heart diseases, methods of measuring costs and outcomes, and the amount of prices in different countries.

### 5. Conclusion

This study shows that the two treatment options (CABG and PCI) for CAD reduce cardiac mortality and improve the quality of life, with comparable and acceptable costs. Also, the cost-effectiveness analysis of CABG and PCI revealed that the PCI strategy was more cost-effective in reducing mortality rate and quality of life than the CABG. During the past few decades, CAD appears to be an important health-related problem with important social consequences, not only in Iran but also in industrialized countries. Because of the CADs impact on society in terms of mortality, morbidity, economic and social costs, health authorities and society, in general, should pay more attention to this problem. CADs impose a high health care cost on society. The healthcare officials should be aware of and consider it in the design, implementation, and evaluation of support programs for CAD patients, their families and the economic evaluation of new treatments.

### **Ethical Considerations**

### Compliance with ethical guidelines

There were no ethical considerations to be considered in this research.

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### Authors' contributions

Conceptualization and supervision: Saeed Sheikh Gholami and Farbod Ebadifard Azar; Metodology, data collection: Saeed Sheikh Gholami and Aziz Rezapoor; Investigation, writing-original draft, and writing-review: All authors; Data analysis: Saeed Sheikh Gholami.

### Conflict of interest

The authors declared no conflict of interest.

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### Refrences

- World Health Organization (WHO). The global health observatory [Internet]. 2018 [Updated 2018]. Available from: https:// www.who.int/data/gho
- [2] Wilkins E, Wilson L, Wickramasinghe K, Bhatnagar P, Leal J, Luengo-Fernandez R, et al. European cardiovascular disease statistics 2017. Brussels: European Heart Network; 2017. Available from: https://www.ehnheart.org/images/CVD-statisticsreport-August-2017.pdf
- [3] Roth GA, Abate D, Abate KH, Abay SM, Abbafati C, Abbasi N, et al. Global, regional, and national age-sex-specific mortality for 282 causes of death in 195 countries and territories, 1980-2017: A systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2018; 392(10159):1736-88. [DOI:10.1016/S0140-6736(18)32203-7]
- [4] Mozaffarian D, Benjamin EJ, Go AS, Arnett DK, Blaha MJ, Cushman M, et al. Executive summary: Heart disease and stroke statistics-2015 update: A report from the American Heart Association. Circulation. 2015; 131(4):434-41. [DOI:10.1161/ CIR.000000000000157] [PMID]
- [5] Chatterjee A, Roy UK. Non-invasive cardiovascular monitoring. J Environ Sci Comput Sci Eng Technol. 2018; 7(1):033-47. [DOI:10.24214/jecet.b.7.1.03347]
- [6] Hlatky MA, Boothroyd DB, Bravata DM, Boersma E, Booth J, Brooks MM, et al. Coronary artery bypass surgery compared with percutaneous coronary interventions for multivessel disease: A collaborative analysis of individual patient data from ten randomised trials. Lancet. 2009; 373(9670):1190-7. [DOI:10.1016/ S0140-6736(09)60552-3]
- [7] Allender S, Scarborough P, Peto V, Rayner M. European cardiovascular disease statistics 2012 [Internet]. 2014 [Updated 2012 September 29]. Available from: https://ehnheart.org/projects/ euroheart-ii/euroheart-ii-publications/673:european-cardiovascular-disease-statistics-2012.html
- [8] Go AS, Mozaffarian D, Roger VL, Benjamin EJ, Berry JD, Blaha MJ, et al. Heart disease and stroke statistics-2014 update: A report from the American Heart Association. Circulation. 2013; 129(3):e28-292. [DOI:10.1161/01.cir.0000441139.02102.80]
- [9] Turpie AGG. Burden of disease: Medical and economic impact of acute coronary syndromes. Am J Manag Care. 2006; 12(16 Suppl):S430-4. [PMID]
- [10] Gholami SS, Ebadi Fard Azar F, Rezapour A, Tajdini M. Costeffectiveness of coronary artery bypass graft and percutaneous coronary intervention compared to medical therapy in patients with coronary artery disease: A systematic review. Heart Fail Rev. 2019; 24(6):967-75. [DOI:10.1007/s10741-019-09811-3] [PMID]

- [11] Etemad LR, McCollam PL. Total first-year costs of acute coronary syndrome in a managed care setting. J Manag Care Pharm. 2005; 11(4):300-6. [DOI:10.18553/jmcp.2005.11.4.300] [PMID]
- [12] McCollam P, Etemad L. Cost of care for new-onset acute coronary syndrome patients who undergo coronary revascularization. J Invasive Cardiol. 2005; 17(6):307-11. [PMID]
- [13] Menzin J, Wygant G, Hauch O, Jackel J, Friedman M. Oneyear costs of ischemic heart disease among patients with acute coronary syndromes: findings from a multi-employer claims database. Curr Med Res Opin. 2008; 24(2):461-8. [DOI:10.1185/030079908X261096] [PMID]
- [14] Hodgson TA, Meiners MR. Cost-of-illness methodology: A guide to current practices and procedures. Milbank Mem Fund Q Health Soc. 1982; 60(3):429-62. [DOI:10.2307/3349801] [PMID]
- [15] Bastida JL, Aguilar PS, González BD. The economic costs of traffic accidents in Spain. J Trauma. 2004; 56(4):883-9. [DOI:10.1097/01.TA.0000069207.43004.A5] [PMID]
- [16] Lopez-Bastida J, Boronat M, Moreno JO, Schurer W. Costs, outcomes and challenges for diabetes care in Spain. Global Health. 2013; 9:17. [DOI:10.1186/1744-8603-9-17] [PMID] [PMCID]
- [17] Rabin R, de Charro F. EQ-SD: A measure of health status from the EuroQol Group. Ann Med. 2001; 33(5):337-43. [DOI:10.3109/07853890109002087] [PMID]
- [18] Ebadi Fard Azar, Solhi M, Chabaksvar F. Investigation of the quality of life of patients with hypertension in health centers. J Educ Health Promot. 2020; 9:185. [DOI:10.4103/jehp. jehp\_741\_19] [PMID] [PMCID]
- [19] Marseille E, Larson B, Kazi DS, Kahn JG, Rosen S. Thresholds for the cost-effectiveness of interventions: Alternative approaches. Bull World Health Organ. 2015; 93(2):118-24. [DOI:10.2471/ BLT.14.138206] [PMID] [PMCID]
- [20] Gonçalves Brandão SM, Rezende PC, Brunner-La Rocca HP, Ju YT, de Lima ACP, Takiuti ME, et al. Comparative cost-effectiveness of surgery, angioplasty, or medical therapy in patients with multivessel coronary artery disease: MASS II trial. Cost Eff Resour Alloc. 2018; 16:55. [DOI:10.1186/s12962-018-0158-z] [PMID] [PMCID]
- [21] Hueb W, Soares PR, Gersh BJ, César LAM, Luz PL, Puig LB, et al. The medicine, angioplasty, or surgery study (MASS-II): A randomized, controlled clinical trial of three therapeutic strategies for multivessel coronary artery disease: one-year results. Cost Eff Resour Alloc. 2018; 16:55. [DOI:10.1016/j.jacc.2003.08.065] [PMID]
- [22] Stenvall H, Tierala I, Räsänen P, Laine M, Sintonen H, Roine RP. Long-term clinical outcomes, health-related quality of life, and costs in different treatment modalities of stable coronary artery disease. Eur Heart J Qual Care Clin Outcomes. 2017; 3(1):74-82. [DOI:10.1093/ehjqcco/qcw024] [PMID]
- [23] Favarato ME, Hueb W, Boden WE, Lopes N, da Rocha Nogueira CRS, Takiuti M, et al. Quality of life in patients with symptomatic multivessel coronary artery disease: A comparative post hoc analyses of medical, angioplasty or surgical strategies-MASS II trial. Int J Cardiol. 2007; 116(3):364-70. [DOI:10.1016/j.ijcard.2006.06.001] [PMID]
- [24] Maniadakis N, Kourlaba G, Cokkinos DV, Angeli A, Kyriopoulos J. The economic burden of atherothrombosis in Greece: Results from the THESIS study. Eur J Health Econ. 2013; 14(4):655-65. [DOI:10.1007/s10198-012-0412-9] [PMID]



- [25] Leal J, Luengo-Fernández R, Gray A, Petersen S, Rayner M. Economic burden of cardiovascular diseases in the enlarged European Union. Eur Heart J. 2006; 27(13):1610-9. [DOI:10.1093/eurheartj/ehi733] [PMID]
- [26] Luengo-Fernandez R, Leal J, Gray A, Petersen S, Rayner M. Cost of cardiovascular diseases in the United Kingdom. Heart. 2006; 92(10):1384-9. [DOI:10.1136/hrt.2005.072173]
  [PMID] [PMCID]
- [27] Chang HS, Kim HJ, Nam CM, Lim SJ, Jang YH, Kim S, et al. The socioeconomic burden of coronary heart disease in Korea. J Prev Med Public Health. 2012; 45(5):291-300. [DOI:10.3961/ jpmph.2012.45.5.291] [PMID] [PMCID]
- [28] Vieira RDO, Hueb W, Hlatky M, Favarato D, Rezende PC, Garzillo CL, et al. Cost-effectiveness analysis for surgical, angioplasty, or medical therapeutics for coronary artery disease: 5-year follow-up of medicine, angioplasty, or surgery study (MASS) II trial. Circulation. 2012; 126(11 Suppl 1):S145-50. [DOI:10.1161/CIRCULATIONAHA.111.084442] [PMID]