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ORIGINAL ARTICLE

Economic burden of managing acute coronary syndrome at the cardiology department of Oran University Hospital - Algeria

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ABSTRACT

Introduction: Acute coronary syndrome (ACS) is a major cardiovascular emergency associated with considerable clinical and economic burden. In middle-income countries, data on hospital costs remain limited. **Objective:** To describe the components and direct hospital costs of ACS in an Algerian public hospital. **Methods:** A descriptive health economics study of the "cost of illness" type was conducted among 229 patients hospitalized for ACS in the cardiology department of Oran University Hospital. Only direct hospital costs, both medical and non-medical, were included. The estimation was based on the micro-costing method, incorporating clinical, organizational, and logistical expenses. Costs, expressed in Algerian dinars (DZD), were converted to euros (€). **Results:** The mean total hospitalization cost was DZD 315,921 (€2,368.80) for patients who received thrombolysis, DZD 241,550 (€1,811.10) for those who underwent coronary angiography/PCI, and DZD 180,413 (€1,352.70) for patients who did not undergo revascularization ($p < 0.001$). A strong positive correlation was observed between length of hospital stay and total cost ($\rho = 0.673$; $p < 0.001$). Non-medical costs (salaries, logistics, maintenance) constituted the predominant share. **Conclusion:** PCI appears to be the most efficient strategy in the context studied, combining shorter hospital stays and resource optimization despite high initial technical costs. These results highlight the need to integrate economic evaluation into national policies for ACS management and to encourage multicenter studies that include long-term costs.

Keywords: Acute coronary syndrome; Hospital cost; Microcosting; Algeria; Health economics.

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1. INTRODUCTION

Acute coronary syndrome (ACS) refers to a group of clinical manifestations of acute myocardial ischemia, including ST-segment elevation myocardial infarction (STEMI), non-STEMI myocardial infarction (NSTEMI), and unstable angina. It is a major cardiovascular emergency requiring rapid and specialized management to reduce the risk of serious complications, including sudden death [1]. ACS is one of the leading causes of morbidity and mortality worldwide, with an increasing incidence in many low- and middle-income countries. According to the World Health Organization, cardiovascular diseases are responsible for 17.9 million deaths annually, a significant proportion of which are attributable to acute coronary syndromes [2]. In addition to its clinical impact, ACS places a considerable economic burden on healthcare systems, particularly in hospital settings. In high-income countries, the average hospital cost of an acute coronary syndrome (ACS) is estimated to be between US$7,000 and US$20,000 per episode, depending on the type of care provided [3]. In low- and middle-income countries, data are less readily available but suggest a disproportionate economic burden relative to local budgetary capacities [4]. In a context of limited resources, an accurate assessment of the economic burden of ACS is essential to inform health policy decisions, optimize resource allocation, and identify the most cost-effective interventions [5].

A thorough understanding of the components of hospital costs—whether medical, organizational, or logistical—is indispensable for the rational management of the health response. This study aims to describe the components of hospital costs for ACS, based on data collected within the cardiology department of the University Hospital of Oran in Algeria. It aims to provide a factual basis for public health decision-makers and clinicians, enabling them to reconcile quality of care with financial sustainability.

2. METHODS

This is a descriptive medico-economic study of the "cost of illness" type, conducted to evaluate the direct hospital costs associated with the management of acute coronary syndrome (ACS). The aim was to analyze the total cost of hospitalization for ACS, to establish its main components, while taking into account associated determinants within the context of an Algerian public hospital.

The research was conducted on 229 patients in the cardiology department of the University Hospital (EHU) of Oran. *Inclusion criteria:* All patients hospitalized in the cardiology department with a diagnosis of acute coronary syndrome (ACS) during the study period, regardless of the therapeutic strategy implemented, were included. *Non-inclusion criteria:* Patients treated outside the cardiology department (intensive care units of other departments) were excluded to ensure the homogeneity of care pathways in a limited sample. *Exclusion criteria:* Patients who underwent post-thrombolysis rescue angioplasty were excluded due to their small sample size and the significant variability in their care pathways.

The analysis was conducted from the hospital's perspective, considering only direct hospital costs. Indirect costs, such as lost productivity, patient transport, post-hospitalization follow-up, etc., were excluded. The time horizon corresponds to the acute phase of ACS management, from admission to patient discharge. The study is limited to the cardiology department of the University Hospital of Oran. A standardized clinical data collection form was developed with methodological support from an epidemiologist at the University Hospital of Béjaïa. This form was used to collect information from medical records and hospital databases. Clinical data (type of acute coronary syndrome, revascularisation protocol, medication dosage, length of hospital stay, presence of comorbidities, etc.) and organizational data (evacuation and admission procedures, treatment decisions (thrombolysis vs. angioplasty), etc.) were collected from patient records, treatment chart, and various registers of the cardiology department in collaboration with the department team, under the supervision of an assistant professor. Economic data, namely medication costs, were provided by the central pharmacy team, while costs related to other hospital resources (accommodation, staff, equipment, maintenance) were collected in collaboration with the administrative team of the cost accounting department. Direct hospital costs were estimated using the micro-costing method. This method provides the most detailed possible breakdown of actual expenditures. It involves multiplying the quantities of resources used by their respective unit costs, based on the institution's internal classifications. The items included are as follows: Medical expenses: laboratory tests, imaging, medications, single-use medical devices, salaries of medical and paramedical staff; non-medical expenses: accommodation, food, maintenance, administrative supplies, salaries of non-medical staff.

Salary allocation method: salaries were estimated using a patient-day allocation method. The total annual salary of medical staff in the cardiology department (55,304,683.09 DZD) was divided by the total number of hospitalization days recorded during the study period (12,343 patient-days) to obtain an average medical staff cost per hospitalization day

The study was conducted in three successive phases : 1. Phase 1 : Data Collection (6 months): involvement of medical, pharmaceutical, and administrative teams in the collection and structuring of clinical, economic, and organizational data. 2. Phase 2: Data Analysis (1 month): data entry, cleaning, and processing using SPSS (version 25) and Microsoft Excel 2019. 3. Phase 3: Interpretation and Report Writing (2 months): interpretation of the results, discussion of the medico-economic implications, and drafting of the scientific manuscript.

The data were analyzed using SPSS and Excel 2019. Costs were initially expressed in Algerian dinars (DZD). To allow for international comparison, these figures were then converted into euros (€) for two main reasons: firstly, the recommendations and guidelines of the European Society of Cardiology (ESC) are frequently used in Algeria for the management of acute coronary syndrome; secondly, the costs compared in this study, as well as those found in the literature available on PubMed, are generally expressed in euros, which facilitates consistency and comparability of the results. This choice, therefore, aims to ensure better alignment with relevant scientific and economic sources. The average exchange rate observed between January and June 2025, i.e.,was €1 = 133.37 DZD (source: Bank of Algeria). Although the data distribution is not normal, average costs are presented. This approach reflects the overall economic impact, including the most costly cases, which are essential for financial planning.

Ethical Considerations: This study is a retrospective descriptive health economics study based on the analysis of existing medical records. It was conducted in accordance with the ethical principles of the Declaration of Helsinki. The collected data were fully anonymized before analysis, ensuring confidentiality and protecting patient identity. Given the retrospective nature of the study, individual informed consent was not required, in accordance with applicable regulations.

3. RESULTS

During the study period, 229 patients were hospitalized, of whom 54 (23.58%) underwent thrombolysis, 15 (6.55%) underwent coronary angiography and possible primary angioplasty, and 160 (69.87%) did not undergo revascularization. The mean length of their hospital stay was 6.9 days (standard deviation: 3.94 days), 4.87 days (standard deviation: 2 days), and 6.62 days (standard deviation: 3.03 days), respectively.

Sociodemographic and clinical characteristics of the patients*:* The study population had a mean age of 62.07 years, with a male predominance. The diagnosis at hospitalization was either ST-segment elevation myocardial infarction (STEMI), non-ST-segment elevation myocardial infarction (NSTEMI), or non-ST-segment elevation acute coronary syndrome (NSTE-ACS). Risk factors included smoking, age, hypertension, diabetes, chronic kidney disease, chronic obstructive pulmonary disease (COPD), dyslipidemia, and a history of ischemic heart disease and ischemic stroke. (Table 1).

Table 1. Socio-demographic and clinical characteristics of the study population.

Variable		**Population (N = 229)**
Age (years) (average (standard deviation))		62.07 (13.26)
Male sex		144 (62.61%)
NSTE-ACS		92 (40%)
STEMI		137 (60%)
Risk Factors		
Smoking	Active	62 (26.96%)
	Ceased	7 (3.04%)
Age (male > 45 years, female > 50 years)		192 (83.48%)
Hypertension		114 (49.57%)
Diabetes		89 (38.7%)
Chronic Kidney Disease		7 (3.04%)
Chronic Obstructive Pulmonary Disease		3 (1.3%)
Dyslipidemia		7 (3.04%)
Ischemic Heart Disease		35 (15.22%)
Ischemic Stroke		8 (3.48%)

Direct hospitalization costs:

Cost of paraclinical examinations: The following laboratory tests were performed, depending on availability, upon admission and during hospitalization: liver and kidney function tests, hemostasis panel, troponin level, complete blood count (CBC), blood glucose, electrolytes, C-reactive protein (CRP), and lipid profile. The average cost of these tests was 200.57 DA in patients who received thrombolysis, 138.2 DA in patients who underwent coronary angiography, and 201.53 DA in patients who did not undergo revascularization. Additional and radiological examinations included electrocardiograms (ECGs), transthoracic echocardiography, and chest X-rays. Their cost was 4472.79 DA for thrombolyzed patients, 3156.88 DA for coronary angiography patients, and 4291.28 DA for non-revascularized patients. (Table 2)

Cost of single-use medical devices: The single-use medical devices used were blood collection tubes, 5, 10, and 50 mL syringes, adhesive bandages, topical antiseptics, and catheters. The average cost of these devices during hospitalization was 84.78 DA for thrombolyzed patients, 65.35 DA for coronary angiography patients, and 82.30 DA for non-revascularized patients. (Table 2).

Cost of medications: Unless contraindicated, the medications provided by the hospital were low molecular weight heparins(LMWH) at a dose of 100 IU/kg every 12 hours or unfractionated heparin at a dose of 500 IU/kg every 8 hours. In case of signs of volume overload, injectable furosemide at a dose of 20 mg was prescribed. Isotonic saline 0.9% was prescribed as an infusion solvent or to correct hypovolemia or hypotension. In case of elevated blood glucose levels above 2.5 g/L, 10 IU of recombinant human insulin was administered. The average cost per patient of medications provided by the hospital during the stay was calculated for each patient subgroup. (Table 2).

Costs of Revascularization Procedures: Patients meeting the criteria for thrombolysis received thrombolysis with alteplase (50 mg, reconstituted with 50 mL of solvent and administered using a 50 mL syringe) or tenecteplase (20 mg/50 mL in a pre-filled syringe). A 0.3 mL intravenous bolus of enoxaparin was administered prior to thrombolysis, followed by a subcutaneous dose of 100 IU/kg 15 minutes after the bolus. Patients eligible for primary percutaneous coronary intervention received pretreatment with injectable 2%

lidocaine and nicardipine (10 mg/10 mL), provided by the facility. The insertion site was disinfected with a brush impregnated with 10% povidone-iodine, and a sterile drape was then applied. Coronary angiography is performed using the following devices: an arterial introducer (including a sheath with a hemostatic valve), a guidewire coupled to a puncture needle, two diagnostic catheters, and sometimes a vascular closure device. Coronary angiography determines the potential therapeutic indication for single or multiple stent implantation. (Table 2).

Table 2. Total hospitalization cost and its components according to the type of care.

Cost type	Revascularization Strategy		
	Thrombolysis (DZD/EURO)	**Percutaneous coronary intervention (DZD/EURO)**	**Non-revascularized patients (DZD/EURO)**
Cost of paraclinical examinations	4 673.36 (35.04)	3 295.08 (24.71)	4 492.81 (33.69)
Cost of single-use medical devices	84.78 (0.64)	65.35 (0.49)	82.30 (0.62)
Cost of medications	2 781.18 (20.85)	1 709.79 (12.82)	2 315.20 (17.36)
Cost of revascularization procedures	127 519.99 (956.14)	108 828.20 (815.99)	/
Other Costs	180 861.71 (1356.09)	127 651.67 (957.12)	173 522.39 (1301.06)
Average total cost	315 921.02 (2368.76)	241 550.09 (1811.13)	180 412.70 (1352.72)
Median	289040,25	236 026,11	160787,05
IQR (interquartile range)	54 037,39	81 448,41	78 114,15

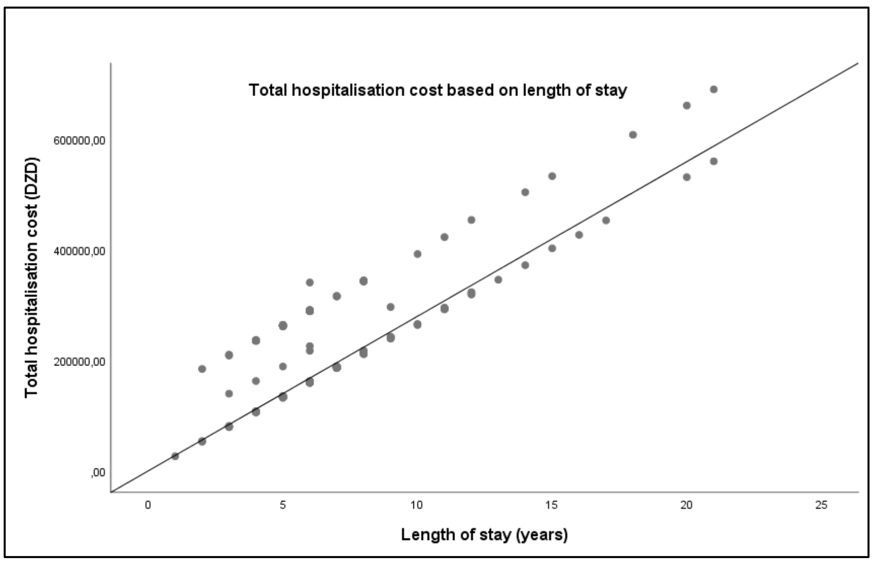

Figure 1. Relationship between length of hospital stay and total cost (scatter plot with trend line).

Other Costs: Other costs include the average salary per patient for staff involved in the care of this population (medical, paramedical, and non-medical staff), food expenses provided by the hospital, as well as other supplies (stationery and office supplies, linens and bedding, hygiene products, and non-medical equipment and furniture), maintenance and upkeep costs incurred at the hospital, and common expenses (energy, water, transportation, staff training, telephone, etc.). (Table 2).

Total cost of hospitalization: The total cost of hospital care for a patient with acute coronary syndrome is equal to the sum of the direct medical costs (medications, single-use medical devices, paraclinical examinations, revascularization procedures, medical and paramedical staff salaries) and direct non-medical costs (non-medical staff salaries, food expenses, upkeep and maintenance costs, miscellaneous supplies, and common charges). (Table 2).

The total cost of hospital care for acute coronary syndrome amounted to 315,921.02 DA (approximately €2,368.76) for patients who received thrombolysis, 241,550.09 DA (approximately €1,811.13) for patients who underwent coronary angiography, and 180,412.7 DA (approximately €1,352.72) for patients who did not receive revascularization. A comparison between the groups revealed a highly significant difference ($p < 0.001$; Kruskal-Wallis/Mann-Whitney test). The median and interquartile range were DZD 289,040.25 and DZD 54,037.39, respectively, for thrombolyzed patients; DZD 236,026.11 and DZD 81,448.41 for patients who underwent percutaneous coronary intervention (PCI); and DZD 160,787.05 and DZD 78,114.15 for non-revascularized patients. (Table 2) A Spearman correlation revealed a strong and highly significant positive relationship between length of hospital stay and total cost ($\rho = 0.673$; $p < 0.001$; $n = 229$). This trend is clearly visible on the scatter plot (Figure 1), which shows a progressive increase in costs with increasing length of hospital stay.

4. DISCUSSION

Our results, which utilize more recent local data, contribute to the existing medical literature by shedding light on the distribution of economic burdens in a resource-constrained setting. They also highlight significant disparities depending on the therapeutic strategies adopted, with a significantly higher total hospitalization cost in thrombolyzed patients, followed by those who underwent percutaneous coronary intervention (PCI), and finally in those who did not undergo revascularization.

The mean length of stay (LOS), a major determinant of cost, was also longer in thrombolyzed patients, which could be linked to a higher rate of acute complications in this group and, subsequently, in non-revascularized patients. A strong positive correlation between the mean length of stay (LOS) and the total hospitalization cost demonstrates the relevance of the strategy with the shortest LOS (PCI).

The breakdown of expenditure items shows that the cost of paraclinical examinations was relatively low because a large proportion of patients were transfers of patients who had already undergone their diagnostic tests, and because the length of hospital stay is generally short. Single-use medical devices represented a marginal but necessary cost. Their low relative impact is mainly due to their low unit cost (a 5 mL syringe costs 6 dinars, a 10 mL syringe costs 10.3 dinars, and a catheter costs 15 dinars, for example). The costs of medications, although clinically significant, remained relatively modest in the overall cost structure. This result is attributable to the availability of generic medications within the hospital system and to the fact that the vast majority of medications (beta-blockers, ACE inhibitors, antiplatelet agents, statins, etc.) are brought in by the patients themselves.

Other hospital costs (salaries, logistics, maintenance, etc.) represented the largest share of the total cost in all groups, reaching 180,861.71 DA in thrombolyzed patients. This predominance is consistent with other studies conducted in middle-income countries, where structural fixed costs represent a significant portion of healthcare expenditure [6]. The sum of the costs of paraclinical examinations, medications, single-use medical devices, and the salaries of medical and paramedical staff gives the direct medical cost, excluding the cost of revascularization procedures. This represented approximately one-quarter of the total hospitalization cost, which is primarily due to the salaries of medical and paramedical staff, which are based on time. This explains why the direct medical cost, excluding the cost of revascularization, is highest in thrombolyzed patients and lowest in patients who underwent percutaneous coronary intervention. The cost of revascularization procedures increased the direct medical cost by approximately 160%. It includes (for thrombolysis) the expensive alteplase or tenecteplase, or specific consumables (for PCI). This observation corroborates the data from the study by Zhang et al. (2022), which identified procedural costs as the main differentiating factor between types of ACS in public hospitals [7]. Thrombolysis was more expensive than PCI, and the direct medical cost was relatively higher in thrombolyzed patients. Analysis of the median total hospitalization cost according to the type of management of acute coronary syndrome (ACS) reveals an increasing median, ranging from non-revascularized patients (DZD 160,787) to patients who underwent coronary angiography (DZD 236,026) to patients who received thrombolysis (DZD 289,040). This progression reflects the increasing intensity of the resources mobilized. However, this trend is accompanied by a wide dispersion of costs, particularly among patients who underwent coronary angiography (interquartile range: 81,448 DZD).

This variability is partly explained by the heterogeneity of hospital stays (relatively high standard deviation). The strong and highly significant positive correlation ($\rho = 0.673$; $p < 0.001$) between length of hospital stay and total cost confirms that prolonged stay is a major factor in increased costs. This result aligns with the findings of multicenter studies, which have highlighted that even short variations in length of stay can generate significant additional costs, particularly in intensive care [8]. This finding supports percutaneous coronary interventions, which, despite the increased direct medical cost compared to non-revascularized patients, reduce the length of hospital stay.

In developed countries, the average cost of an acute ACS episode can range from €3,000 to €12,000, depending on the treatment modalities and length of stay [9,10,11,12]. The costs reported in our study are therefore lower. This disparity can be explained by several factors: most medications are paid for by the patient, single-use medical devices and medications have a low unit cost and are manufactured locally, and staff salaries are relatively modest. However, these results must be interpreted within the Algerian context, characterized by public pricing, low labor costs, and a predominantly state-run funding structure. However, when considered in relation to local purchasing power and the budgetary structure of public hospitals, these costs remain high and must be taken into account in national healthcare planning strategies.

Study Limitations: This study has several limitations. First, it is based on a single-center sample, which limits the generalizability of the results to other hospital settings. Second, post-hospitalization costs were not considered. Furthermore, data relating to complications (including bleeding events, heart failure, and arrhythmias) were not systematically coded, which could introduce bias into the interpretation of total cost. Also, the treatment strategy (thrombolysis, primary coronary angioplasty, or no revascularization) was not assigned randomly, but rather chosen based on clinical factors such as the type of acute coronary syndrome and time to access care. Consequently, the groups compared were clinically heterogeneous, which may introduce potential bias in the comparison of hospitalization costs, regardless of the unit cost of each approach.

In addition, due to the retrospective nature of the study and the type of information available in the medical records, the precise clinical criteria that guided the choice of therapeutic strategy (clinical presentation, time to access care, and availability of interventional infrastructure) were not systematically recorded. Finally, the limitations inherent in the descriptive nature of this study must be acknowledged. In the absence of an adjusted multivariate analysis, it is not possible to draw definitive conclusions about the independent factors associated with cost variations. A more analytical exploration, incorporating a larger number of clinical and organizational variables, could be considered in future work.

5. CONCLUSION

In summary, this study highlights significant disparities in hospital costs for acute coronary syndrome depending on the revascularization strategy, within a resource-constrained public health context. PCI is associated with a significant reduction in hospital stay, thus lowering costs related to prolonged bed occupancy, staff mobilization, and logistical resources. This shorter hospital stay would improve bed turnover, reduce the workload of medical and paramedical staff, and potentially optimize the patient care pathway in facilities with limited capacity. From the patient's perspective, a shorter hospital stay would reduce the risk of hospital-acquired complications and facilitate a faster return to active life.

Competing interests: The authors declare that they have no competing interest.

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