ORIGINAL ARTICLE

COMPARISON OF EXPECTED AND REAL-WORLD COSTS OF SUSPECTED ACUTE CORONARY SYNDROME MANAGEMENT USING A CLINICAL PATHWAY IN AN EMERGENCY DEPARTMENT

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ABSTRACT

As Malaysia transitions toward a case-mix system for Emergency Department (ED) reimbursement, establishing accurate cost-unit accounting is essential for economic survival and efficient resource allocation. This study focused on Acute Coronary Syndrome (ACS), a primary driver of hospital costs, which often exhibits wide variations in medical practice due to its clinical heterogeneity. The objective was to evaluate the expected costs derived from a standardized Clinical Pathway (CP) against actual real-world treatment costs incurred during ACS Clinical Pathway implementation. A cross-sectional study was conducted in which direct medical costs were estimated for 203 suspected ACS patients managed using established ACS CP between June and October 2023. Cost calculations utilised combined top-down and bottom-up activity-based costing (ABC), with overhead costs calculated using allocation method. Comparisons were made between theoretical "Expected Standard CP Costs" and "Real CP Costs". Theoretical expected treatment costs pervisit ranged from RM 380.85 (low-risk chest pain) to RM 1,458.42 (STEMI requiring thrombolysis). Actual treatment expenditures were consistently higher than theoretical estimates across all diagnostic categories. The most substantial variance occurred in Stable Angina cases (+RM 188.24 per visit), while non-thrombolysis STEMI cases showed the highest predictive accuracy (+RM 16.91). Standardising ACS management via CPs provides a replicable framework for hospital budgeting but reveals that theoretical models often fail to capture the exhaustive resources required for real-world clinical "rule-out" burdens and diagnostic uncertainty. Higher direct medical costs associated with standardised care represent a necessary strategic investment in quality to prevent expensive long-term complications.

Keywords*: *Acute Coronary Syndrome, Clinical Pathway, Activity-Based Costing, Emergency Department, Case-Mix.

INTRODUCTION

The fear of the coronavirus disease (COVID-19) In the current landscape of the global healthcare system, establishing a dependable cost-unit accounting system has become an essential requirement for economic survival. As healthcare financing shifts toward bundled payments based on patient populations or specific episodes of care, the proper accounting of costs in high-acuity settings like the Emergency Department (ED) becomes critical[(1).] For hospital managers, the knowledge of resource utilisation and associated costs is vital in an environment where reimbursement may be fixed, and local managers require accurate data to guide micro-level decision-making[(2)].

In Malaysia, the Ministry of Health is currently transitioning toward a prospective payment mechanism using a case-mix system. This system classifies patient care episodes with common clinical attributes and relatively homogeneous resource utilisation patterns[(3)]. For this system to be effective, standardised care must be established to ensure consistency in patient management across facilities. Clinical Pathways (CPs) serve as a comprehensive care plan that provides detailed steps for specific populations, translating evidence-based medicine into local practice[(4-6).] Importantly, a CP can function as a significant "cost unit," considerably increasing the precision of cost unit accounting as a strategic control mechanism in hospitals[(7).]

Acute Coronary Syndrome (ACS) is one of primary driver of hospital costs and resource consumption. In Malaysia, Ischemic Heart Disease (IHD) was the leading cause of death in 2024, accounting for 13% of medically certified deaths. Managing suspected ACS cases in the ED is inherently complex due to heterogeneous presentations, often resulting in wide variations in diagnostic approaches and treatment decisions. To improve the accuracy of case-mix implementation, it is necessary to evaluate the expected costs derived from standardised clinical pathways against the real-world treatment costs incurred during implementation. Hence, this study aims to quantify these costs.

METHODS

Study Design and Setting

A cross-sectional observational study was conducted to evaluate the direct medical cost of managing patients with suspected Acute Coronary Syndrome (ACS) in the Emergency Department (ED) using a standardised clinical pathway.

The study was carried out at Universiti Malaya Medical Centre (UMMC), a tertiary teaching hospital in Kuala Lumpur, Malaysia. Data were collected from June to October 2023 during the implementation phase of the ACS Clinical Pathway. The pathway was developed through a multidisciplinary approach and integrated into routine ED practice, supported by a standardised checklist for clinical documentation.

Participants

All adult patients aged 18 years and above who presented to the ED with chest pain or suspected ACS during the study period were eligible for inclusion. Patients with major complications requiring immediate deviation from the clinical pathway were excluded.
A total of 203 patients who were managed using the ACS Clinical Pathway checklist were included in the final analysis.

Variables

The primary outcome was the direct medical cost per ED visit for patients with suspected ACS.
Cost variables included:

- **Overhead cost per visit** (hospital general overhead and ED-specific overhead costs)
- **Activity-based costs** (laboratory investigations, radiological procedures, and medications)

Two cost measures were defined:

1. **Expected CP cost**: theoretical cost based on standardised resource utilisation defined in the clinical pathway
2. **Real CP cost**: actual cost based on observed patient-level resource utilisation

Data Collection and Sources

Clinical and resource utilisation data were obtained from manual ACS Clinical Pathway checklists completed by ED personnel and verified against electronic medical records from the iPesakit system.

Data verification was performed to ensure completeness and accuracy. In cases of discrepancy, electronic medical records were considered the reference standard. All documented investigations, procedures, and medications were included as actual resource utilisation.

Validated data were entered into a REDCap database for analysis.

Cost data were obtained from the UMMC financial report (2022), as well as from the pathology, radiology, and pharmacy departments. All costs were adjusted to 2023 values using the Malaysian Consumer Price Index.

Quantitative Variables

Costs were treated as continuous variables and summarised as mean cost per ED visit in Malaysian Ringgit (RM). Cost differences between expected and actual values were calculated for each diagnostic category.

Cost Analysis

The descriptive cost analysis was conducted from the healthcare provider's perspective, utilising a one-year time horizon. A combined top-down and bottom-up costing approach was applied. The reported figures represent the direct medical costs for each emergency visit episode, identifying every component and activity involved in care provision for suspected Acute Coronary Syndrome (ACS) patients.

To achieve the most accurate estimation of direct medical costs, all cost components were identified under each unit of analysis. The main units of analysis identified were total overhead cost and specific activity-based cost. The total cost was calculated by adding the total overhead cost and activity-based cost for each ED visit.

1. Overhead cost

The total overhead cost per visit was calculated by summing the hospital general overhead and the ED-specific clinical operation expenses.

Hospital General Overhead

Hospital general overhead costs comprised of all non-clinical expenditures for general operations, including salaries for non-clinical staff and the costs of general equipment, furniture, and vehicles. This institutional overhead value was provided by the Department of Research, Development, and Innovation at UMMC, which is responsible for institutional cost-related calculations.

Emergency Department Specific Overhead
Emergency department specific overhead was determined by identifying all direct clinical expenditures associated with ED operations. These cost components comprised ED-specific assets, utilities and communications, maintenance and housekeeping, clinical staff salaries, and medical consumables.

Emergency Department specific overhead was calculated by identifying and allocating several direct clinical cost components using standardised health economic methodologies[8-10]. Expenses for utilities and communication—including electricity, water, telephone, and internet services, along with maintenance and housekeeping costs were distributed to the department using a space ratio, calculated as the department's floor area relative to the total hospital indoor area. Expenditures for assets, such as furniture, equipment, and vehicles, were calculated based on a five-year lifespan and annualized using a 5% discount rate. Furthermore, consumable costs were allocated using a workload ratio determined by comparing the number of departmental visits to the total number of hospital users, supplemented by documented department-specific consumable purchases, while labour costs were determined by aggregating the total monthly salaries of all departmental employees.

After aggregation and inflation adjustment, the total overhead cost was estimated at RM 243.36 per ED visit.

2. Activity-Based Costing (ABC)
Activity-Based Costing (ABC) was utilised to identify traceable patient-level resources, assigning detailed costs to each laboratory investigation, radiological procedure, and medication administered. Unit costs for specific investigations, which include all relevant operating expenditures, were obtained directly from the pathology and radiology departments, whereas unit costs for all pharmaceutical agents were sourced from the hospital's pharmacy department.

Statistical Analysis
Descriptive statistics were used to summarise cost data. Mean costs were calculated for both expected and real CP cost categories across diagnostic groups.

Differences between expected and actual costs were reported as absolute mean differences to reflect variations in resource utilisation at the provider level. Reporting mean cost differences is consistent with standard practice in health economic analyses, where the primary objective is to estimate the magnitude of cost variation rather than to test statistical significance[11-13].

No formal hypothesis testing was conducted, as the analysis was primarily descriptive and exploratory in nature.

Ethical Considerations
Ethical approval for the study was obtained from the Medical Research Ethics Committee of Universiti Malaya Medical Centre (MREC ID: 2022727-11420).

RESULTS

During ACS Clinical Pathway implementation period, a total of 203 suspected ACS patients were treated using the ACS Clinical Pathway checklist when receiving treatment in ED and included in the analysis.

Theoretical Expected Costs by Diagnosis
Diagnosis-specific expected cost units were established by aggregating the calculated 2023 total overhead cost of RM 243.36 per visit with the activity-based costs (ABC) derived from the standard clinical pathway. As shown in Table 1, the total projected treatment costs per visit ranged from RM 380.85 for low-risk chest pain to RM 1,458.42 for STEMI patients requiring thrombolytic therapy.

Table 1. Total cost of treatment for patients suspected of ACS in the Emergency Department, UMMC

Diagnosis category	Activity-based cost (RM)	Total overhead cost (RM)	Total treatment cost (RM)
STEMI			
Not for thrombolysis	161.03	243.36	404.39
Thrombolysis	1,215.06	243.36	1,458.42
NSTE-ACS	177.87	243.36	421.23
Low-risk chest pain	137.49	243.36	380.85

Table 2: Comparison of treatment cost of emergency management for patients suspected of ACS in the Emergency Department between expected cost and real CP cost

Diagnosis	Cost (RM)		Cost difference*
	Expected	Real	
STEMI			
Non-thrombolysis (n=6)	404.39	421.30	16.91
Thrombolysis (n=24)	1458.42	1569.90	111.48
NSTEMI (n=39)	421.23	533.91	112.68
Unstable angina (n=97)	421.23	504.56	83.33
Stable angina (n=8)	380.85	569.06	188.24

* CP cost subtracts expected CP cost

The highest degree of predictive accuracy was observed in STEMI cases managed without thrombolysis, with a marginal mean increase of only RM 16.91 above the projected benchmark. Conversely, the most substantial variance occurred in cases of Stable Angina, where real-world management expenditures exceeded the theoretical model by RM 188.24 per visit. Similarly, significant cost escalations were noted in NSTEMI (+RM 112.68) and thrombolysis-treated STEMI (+RM 111.48) subgroups.

DISCUSSION

The primary finding of this health economic evaluation is that expected costs derived from standardised clinical pathways often fail to capture the full spectrum of resources consumed in real-world practice. This variability highlights the inherent challenges in accurately predicting healthcare costs for high-acuity cardiac care[5, 14, 15]. While pathways aim to standardise and control expenditures, real-world application requires clinical flexibility to address individual patient needs, which leads to necessary cost variations[16, 17]. These discrepancies are critical for the Malaysian healthcare system as it transitions toward Case-Mix and Diagnosis-Related Group (DRG) funding for emergency department. Accurate cost estimation is essential for determining cost weightage in these systems, helping administrators set realistic benchmarks and ensure fair reimbursement for tertiary care centres that manage higher clinical complexity.

The predictive accuracy of the newly developed pathway varied significantly across diagnostic categories. The close alignment observed in non-thrombolysis STEMI cases, with a mean difference of only RM 16.91, suggesting that the clinical pathway is highly effective at predicting costs for standardised procedures, such as stabilisation for Primary PCI. Because these cases involve a highly predictable and time-sensitive workflow, resource consumption remains relatively homogeneous[17, 18]. This demonstrates that in scenarios with high procedural consistency, theoretical economic models can serve as reliable benchmarks for hospital budgeting.

Conversely, the substantial cost discrepancies identified in Stable and Unstable Angina cases highlight the significant "rule-out" burden inherent in the Emergency Department setting[19-23]. In real practice, clinicians must manage high levels of diagnostic uncertainty, often resulting in the ordering of additional investigations or medications that are not captured in a "standard" pathway for a finalised diagnosis. This confirms that real practice consistently incurs higher costs than theoretical models regardless of pathway implementation. These findings suggest that for non-definitive presentations, economic models must be adjusted to account for the exhaustive resources required to safely rule out life-threatening conditions.

From a broader perspective, the increased real-world costs observed post-implementation are driven by enforced adherence to mandatory diagnostic panels and modern medications. For instance, shifting from older generic antiplatelets to modern agents like Ticagrelor necessarily increases upfront expenditures[24, 25]. However, from a public health standpoint, this represents a strategic quality investment. By ensuring that patients receive accurate, evidence-based care during the critical initial ED visit, the healthcare system can effectively reduce long-term downstream costs associated with cardiac failure and recurrent hospitalisations, both of which carry a far greater financial and mortality burden than the initial emergency management[26-28].

Limitation

This study has several limitations inherent to its design and methodological scope. Primarily, the economic evaluation was restricted to direct medical costs incurred during the ED visit. Consequently, it did not follow patients through inpatient care or assess long-term clinical outcomes, leaving a significant portion of the total economic burden unquantified, particularly given the high admission rates observed in this population. Second, the manual use of the CP checklist by ED personnel may have introduced selection bias, potentially affecting the representativeness of the implementation group. Finally, the study was conducted at a single center, and the overhead values were derived from institutional-specific data. As overhead costs and resource availability vary significantly across different healthcare facilities, the unit costs and cost-weightage benchmarks established here may not be directly generalisable to other public hospitals or clinical settings in Malaysia.

CONCLUSIONS

Standardising the management of suspected ACS in the ED through a multidisciplinary clinical pathway clarifies specific resource requirements and provides an accurate, replicable framework for hospital budgeting. This study demonstrates that while theoretical CP models serve as valuable benchmarks, actual treatment costs are consistently higher due to inherent clinical complexities and the necessity of real-world clinical flexibility. The observed discrepancies between expected and real costs highlight that rigid adherence to theoretical economic models may fail to capture the exhaustive resources required to manage diagnostic uncertainty in high-acuity environments.

Ultimately, the higher direct medical costs per visit, driven by adherence to modern investigations and potent pharmacotherapy represent a necessary strategic investment in evidence-based medicine. By ensuring that suspected ACS patients receive high-quality, standardized care during the initial emergency encounter, the healthcare system can potentially offset these upfront costs by preventing expensive long-term complications, reducing recurrent hospitalizations, and improving overall patient outcomes.

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Informed Consent Statement

Not applicable

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Conflicts of Interest

The author declares no conflict of interest.

REFERENCES

1. Lee MH, Schuur JD, Zink BJ. Owning the cost of emergency medicine: beyond 2%. Ann Emerg Med. 2013;62(5):498–505.e3.

2. Yun BJ, Prabhakar AM, Warsh J, Kaplan R, Brennan J, Dempsey KE, et al. Time-Driven Activity-Based Costing in Emergency Medicine. Ann Emerg Med. 2016;67(6):765–72.

3. Ministry of Health. Malaysian DRG - Benefit Realisation. Putrajaya2012.

4. Kinsman L, Rotter T, James E, Snow P, Willis J. What is a clinical pathway? Development of a definition to inform the debate. BMC Med. 2010;8(1):31.

5. Rotter T, Kinsman L, James E, Machotta A, Gothe H, Willis J, et al. Clinical pathways: effects on professional practice, patient outcomes, length of stay and hospital costs. Cochrane Database Syst Rev. 2010(3):Cd006632.

6. Campbell H, Hotchkiss R, Bradshaw N, Porteous M. Integrated care pathways. BMJ. 1998;316(7125):133–7.

7. Feyrer R, Rösch J, Weyand M, Kunzmann U. Cost Unit Accounting Based on a Clinical Pathway: A Practical Tool for DRG Implementation. Thorac Cardiovasc Surg. 2005;53(05):261–6.

8. Drummond MF, Sculpher MJ, Claxton K, Stoddart GL, Torrance GW. Methods for the Economic Evaluation of Health Care Programmes. Oxford: Oxford: Oxford University Press; 2015.

9. Kalman NS, Hammill B, Schulman K, Shah BR. Hospital overhead costs: The neglected driver of health care spending? J Health Care Finance. 2015;41.

10. Shepard DH, Hodgkin D, Anthony Y, World Health O. Analysis of hospital costs : a manual for managers / Donald S. Shepard, Dominic Hodgkin, Yvonne Anthony. 2000.

11. Nord E. Cost-Value Analysis of Health Interventions: Introduction and Update on Methods and Preference Data. Pharmacoeconomics. 2015;33(2):89–95.

12. Sittimart M, Rattanavipapong W, Mirelman AJ, Hung TM, Dabak S, Downey LE, et al. An overview of the perspectives used in health economic evaluations. Cost Effectiveness and Resource Allocation. 2024;22(1):41.

13. Turner HC, Sandmann FG, Downey LE, Orangi S, Teerawattananon Y, Vassall A, et al. What are economic costs and when should they be used in health economic studies? Cost Effectiveness and Resource Allocation. 2023;21(1):31.

14. Mudzingwa IT, Prior SJ, Griffin P, Tavender E, Tran V. The Use of Clinical Pathways in Emergency Departments: A Scoping Review. Health Serv Insights. 2025;18:11786329251328527.

15. Lawal AK, Rotter T, Kinsman L, Machotta A, Ronellenfitsch U, Scott SD, et al. What is a clinical pathway? Refinement of an operational definition to identify clinical pathway studies for a Cochrane systematic review. BMC Med. 2016;14:35.

16. Alp NJ, Bell JA, Shahi M. A rapid troponin-I-based protocol for assessing acute chest pain. QJM. 2001;94(12):687–94.

17. Rao SV, O'Donoghue ML, Ruel M, Rab T, Tamis-Holland JE, Alexander JH, et al. 2025 ACC/AHA/ACEP/NAEMSP/SCAI Guideline for the Management of Patients With Acute Coronary Syndromes: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. Circulation. 2025;151(13):e771–e862.

18. Ibanez B, James S, Agewall S, Antunes MJ, Bucciarelli-Ducci C, Bueno H, et al. 2017 ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation: The Task Force for the management of acute myocardial infarction in patients presenting with ST-segment elevation of the European Society of Cardiology (ESC). Eur Heart J. 2018;39(2):119–77.

19. Amsterdam EA, Kirk JD, Bluemke DA, Diercks D, Farkouh ME, Garvey JL, et al. Testing of low-risk patients presenting to the emergency department with chest pain: a scientific statement from the American Heart Association. Circulation. 2010;122(17):1756–76.

20. Mark DG, Huang J, Kene MV, Sax DR, Cotton DM, Lin JS, et al. Prospective Validation and Comparative Analysis of Coronary Risk Stratification Strategies Among Emergency Department Patients With Chest Pain. J Am Heart Assoc. 2021;10(7):e020082.

21. Yukselen Z, Majmundar V, Dasari M, Arun Kumar P, Singh Y. Chest Pain Risk Stratification in the Emergency Department: Current Perspectives. Open Access Emerg Med. 2024;16:29–43.

22. Shin YS, Ahn S, Kim YJ, Ryoo SM, Sohn CH, Kim WY. Risk stratification of patients with chest pain or anginal equivalents in the emergency department. Intern Emerg Med. 2020;15(2):319–26.

23. Pope JH, Aufderheide TP, Ruthazer R, Woolard RH, Feldman JA, Beshansky JR, et al. Missed diagnoses of acute cardiac ischemia in the emergency department. N Engl J Med. 2000;342(16):1163–70.

24. McCarthy CP, Steg G, Bhatt DL. The management of antiplatelet therapy in acute coronary syndrome patients with thrombocytopenia: a clinical conundrum. Eur Heart J. 2017;38(47):3488–92.

25. Russo I, Brookles CG, Barale C, Melchionda E, Mousavi AH, Biolè C, et al. Current Strategies to Guide the Antiplatelet Therapy in Acute

Coronary Syndromes. Int J Mol Sci. 2024;25(7).

26. Xiong W, Gao W, Zhou Q, Wu Z. Clinical impact of an emergency fast-track pathway on early intervention and outcomes in acute coronary syndrome: a prospective cohort study. Sci Rep. 2025;15(1):41509.

27. Damluji AA, Forman DE, Wang TY, Chikwe J, Kunadian V, Rich MW, et al. Management of Acute Coronary Syndrome in the Older Adult Population: A Scientific Statement From the American Heart Association. Circulation. 2023;147(3):e32–e62.

28. Gibler WB, Racadio JM, Hirsch AL, Roat TW. Continuum of Care for Acute Coronary Syndrome: Optimizing Treatment for ST-Elevation Myocardial Infarction and Non-St-Elevation Acute Coronary Syndrome. Crit Pathw Cardiol. 2018;17(3):114–38.