



## Original Research Article

# A STUDY ON COST ANALYSIS OF CARDIAC CATHETERIZATION STUDY IN CARDIAC CATHETERIZATION LABORATORY USING ACTIVITY BASED COSTING METHOD AT A TERTIARY CARE TEACHING HOSPITAL

Nimmala Sai Nikhil Goud<sup>1</sup>, N. Lakshmi Bhaskar<sup>2</sup>, M Charan Raj<sup>3</sup>, N. Satyanarayana<sup>4</sup>, Anees Ayesha<sup>5</sup>

<sup>1</sup>Senior Resident, Department of Hospital Administration, Nizam's Institute of Medical Sciences, Hyderabad, Telangana, India.

<sup>2</sup>Additional Professor, Department of Hospital Administration, Nizam's Institute of Medical Sciences, Hyderabad, Telangana, India.

<sup>3</sup>Assistant Professor, Department of Hospital Administration, Nizam's Institute of Medical Sciences, Hyderabad, Telangana, India.

<sup>4</sup>Senior Professor, Department of Hospital Administration, Nizam's Institute of Medical Sciences, Hyderabad, Telangana, India.

<sup>5</sup>Senior Resident, Department of Hospital Administration, Nizam's Institute of Medical Sciences, Hyderabad, Telangana, India.

Received : 21/03/2026  
Received in revised form : 12/05/2026  
Accepted : 29/05/2026

### Corresponding Author:

**Dr. N. Lakshmi Bhaskar,**  
Additional Professor, Department of  
Hospital Administration, Nizam's  
Institute of Medical Sciences,  
Hyderabad, Telangana, India.  
Email: drlakshimbhaskar@gmail.com

DOI: 10.70034/ijmedph.2026.2.635

Source of Support: Nil,  
Conflict of Interest: None declared

Int J Med Pub Health  
2026; 16 (2); 3869-3875

### ABSTRACT

**Background:** Cardiovascular diseases cause one-third of global deaths, with cardiac catheterization laboratories essential for diagnosis. Accurate procedure-level cost data from Indian tertiary hospitals remains scarce despite growing demand. **Objective:** To estimate unit costs of cardiac catheterization study using Activity-Based Costing at a major Indian teaching hospital.

**Materials and Methods:** Biphase observational study (July 2023–June 2024) at Nizam's Institute of Medical Sciences, Hyderabad, of 66 cardiac catheterization procedures across two cath labs (total 11,353 procedures). Costs comprised capital (depreciation) and operational (direct/indirect) components using ABC. Procedural times measured in three phases (pre-, intra-, post-procedure). Descriptive Statistics performed; correlation and regression assessed time-cost relationships.

**Results:** Mean unit cost was ₹11,716 for cardiac catheterization study (direct: 83%; indirect: 17%). Direct operational costs formed the major share of expenditure, contributing 83% in CCS. Among direct costs Consumables from surgical stores, and lab stores together contributed a major proportion (52%) of the total direct cost followed by Manpower costs which contributed to 44.4% (in which Cardiologists costs 88.7%). Total procedural time was 63.4±11.2 min (catheterization study).

**Conclusions:** ABC identifies consumables (43%) and time-driven factors as dominant in total cardiac catheterization costs. Costing figures (₹11,716) provide pricing benchmarks, highlighting efficiency gains from time reduction and volume optimization in resource-limited settings.

**Keywords:** Activity-Based Costing; Cardiac Catheterization Laboratory; Cardiac Catheterization Study.

## INTRODUCTION

Globally an estimated 17.7 million people died from cardiovascular diseases (CVDs) in 2015 representing 31% of all deaths and over 75% of these deaths take place in low- and middle-income countries.<sup>[1]</sup> A study estimating the burden of cardiovascular diseases in India revealed that from 1990 to 2016 prevalent cases of cardiovascular diseases increased from 25.7 to

54.5 million.<sup>[2]</sup> Cardiovascular diseases caused 20.5 million deaths globally in 2021 contributing to nearly one third of all deaths. 80% of these deaths approximately occur in low- and middle-income countries. 60% of adult deaths are due to non-communicable diseases in India out of which 26% are due to CVDs. Major risk factors for CVDs in Indian adults include tobacco use (15%), alcohol

consumption (4.3 liters per capita), and hypertension (21.1%).<sup>[3,4]</sup>

Cardiac catheterization laboratory performs diagnostic evaluation majorly through coronary angiography, hemodynamic studies, and therapeutic interventions majorly through percutaneous procedures. Coronary angiography (CAG) is done for visualizing coronary arteries and helps guiding further plan of management. Where as, Cardiac Catheterization Study (CCS) provides comprehensive hemodynamic assessment by visualizing coronary arteries along with measurement of pressure across cardiac chambers.<sup>[5,6]</sup> Cardiac catheterization laboratory plays critical role, despite which, comprehensive cost data from Indian hospitals is sparse. Traditional costing methods does not provide true resource consumption, leading to price discrepancies and financial unsustainability. Activity-Based Costing (ABC) addresses these limitations by allocating costs based on actual resource utilization across the activities involved.<sup>[7,8]</sup> ABC enables cost allocation by identifying activities and assigning costs based on actual resource consumption.

This study uses ABC methodology to calculate unit costs for Cardiac Catheterization Study procedure at a major tertiary care teaching hospital, providing insights for financial planning and resource optimization.

## MATERIALS AND METHODS

### Study Design and Setting

Biphasic observational study conducted at Cardiac Catheterization Laboratory, Nizam's Institute of Medical Sciences (NIMS), Hyderabad, India, from July 2024 to June 2025. NIMS is a 1,600-bed tertiary care teaching hospital performing approximately 11,000 catheterization procedures annually. The laboratory operates two Philips Allura Xper FD10C single-plane cardiovascular systems.

Phase 1 (Retrospective): July-December 2023 (record review)

Phase 2 (Prospective): January-June 2024 (direct observation, real-time data collection)

**Objective:** To carry out Activity Based Costing for diagnostic cardiac catheterization study performed in NIMS cath lab.

### Sample size calculation

Sample sizes were calculated using finite population formula:

$$n = \frac{N \cdot Z^2 \cdot p \cdot (1-p)}{[e^2 (N-1) + Z^2 \cdot p \cdot (1-p)]}$$

with 95% confidence level, 5% margin of error (e), Z-score: 1.96 for 95% confidence and p=0.5.

Based on retrospective data of 6 months (79 catheterization studies), calculated sample size is n = 66 (calculated from N=79)

### Statistical Analysis

- Analyses performed using Microsoft Excel.

- Descriptive statistics (mean, standard deviation, range)** calculated for all cost components and times.
- Pearson Correlation:** Strength between independent variable (time) and dependent variable (cost).
- Regression analysis:** To test the proportion of variance in dependent variable (cost) that can be explained by the independent variable (time).

### Activity-Based Costing Framework

ABC implementation followed eight systematic steps:

#### Step 1: Define Cost Objects

Cost objects: Cardiac catheterization study procedures.

#### Step 2: Identify Activities:

Three phases with in Cath Lab:

- Pre-procedure preparation (patient positioning, site preparation, equipment setup)
- Performing procedure (catheter insertion, navigation, contrast injection, imaging, Pressure and Hemo dynamic measurements)
- Post-procedure surveillance (catheter removal, hemostasis, recovery monitoring)

#### Step 3: Identify Resources

- Capital: Catheterization equipment (15-year life), building (100-year life), furniture (10-year life); [Life is as per The company's act 2013].
- Human: Cardiologists, nurses, technicians, Class IV workers, administrative staff;
- Consumables: Surgical supplies, medical supplies, laboratory supplies (contrast media);
- Support: CSSD, biomedical waste, Laundry services.

#### Step 4: Assign Costs to Resources:

- All costs obtained from institutional financial records (fiscal year 2023-2024).
- Consumables reflected actual procurement prices.
- Equipment depreciation calculated using Written Down Value method.
- Building, Furniture & Fixtures depreciation calculated using Straight Line Method.

#### Step 5: Determine Cost Drivers

- Time: Procedure duration (minutes) for allocation of time-dependent costs (equipment, manpower, electricity, opportunity cost)
- Volume: Number of procedures for allocation of volume-dependent costs (consumables, support services).

#### Step 6: Allocate Resource Costs:

- Direct tracing: Consumable costs and procedure-specific support services were directly traced to activities
- Allocation: Capital costs, maintenance, depreciation, electricity, and opportunity costs were allocated proportionally based on time spent in each activity phase

### Step 7: Calculate Activity Costs

Costs for each activity (pre-procedure, performing procedure, post-procedure) were calculated by adding up all allocated resource costs.

### Step 8: Calculate Unit Procedure Costs

Total unit cost for each procedure type was calculated as the sum of costs across all three activities.

### Procedural Volume

During 12 months (July 2023-June 2024), the laboratory performed 11,353 total procedures.

Cardiac catheterization studies: 172 procedures.

Monthly catheterization study volume averaged 14.3 (range 8-16).

## RESULTS

### Costing Assumptions and Cost Driver Allocation

According to the type of resource, different time bases were applied for cost computation. Equipment depreciation and cardiologist salaries were calculated based on 10 working hours per day over 295 working days (2,950 hours/year). Nursing, technical, class IV, and administrative staff costs were calculated based on 8-hour shifts over 295 working days (2,360 hours/year). Building depreciation, infrastructure depreciation, maintenance charges, electricity, and opportunity costs were calculated considering 24 hours per day and 365 days per year.

All time-based costs were apportioned equally between the two labs, because two catheterization laboratories were functioning during the study period, and per-minute costs were halved accordingly. Costs driven by service utilization (e.g., consumables, CSSD, biomedical waste, laundry, stationery) were calculated on a per-procedure basis using total annual procedure volume (n = 11,353). Thus, time-dependent resources were allocated using procedure duration as the cost driver, while volume-dependent resources were allocated per procedure.

During the study period (July 2023 – June 2024), a total of **11,353 procedures** were performed in two cardiac catheterization laboratories. The cost analysis was performed using a mixed time-driven and volume-driven activity-based costing approach.

### I. Capital Costs

The capital cost of both cath labs' equipment is ₹7,05,34,893, furniture and fixtures is ₹72,13,540, Building is ₹1,42,20,585.

- Capital Costs were included as per their Depreciation value. Equipment depreciation was treated as a direct operational cost, while building and infrastructure depreciation were treated as indirect operational costs.

### II. Direct Operational Costs

**1. Equipment Depreciation:** As per Schedule II of companies act 2013 using written down method of depreciation.

Annual depreciation for two cath labs was ₹37,92,626. Based on 2,950 working hours per year, the depreciation cost was ₹21.42 per minute (time-driven).

### 2. Consumables

- Consumables from surgical stores commonly used for all the procedures in Cardiac Catheterization Laboratory = ₹1,18,20,783. Cost incurred per procedure performed in laboratory =  $1,18,20,783/11,353 = ₹1041.2$ .
- Consumables from SURGICAL STORES exclusively used for Cardiac Catheterization Study (Swan Ganz catheters, Wedge pressure catheters, Pig Tail catheters and their Guiding wire): ₹2,920/-per CCS.
- Lab stores (Contrast): ₹70,34,410 annually (₹619.6 per procedure)

These were allocated on a per-procedure basis (volume-driven).

### 3. Manpower Costs

**Cardiologists (n = 37):** Consist of 3 Professors, 1 Associate Professor, 1 Assistant Professor, 3 Adhoc Assistant Professors, 8 Contract Assistant Professors, 21 Senior Residents (Pursuing DM).

Total annual salary was ₹7,70,03,352. Cost per minute was ₹435. Since only one-fourth of cardiologists operate a cath lab at a time, the effective cost attributable to one lab was ₹108.75 per minute (time-driven).

**Nursing Staff (n = 14):** Consist of In-charge Nursing Officer:1, Senior Nursing Officer: 1, Nursing officers: 4, Contract Nursing officers: 8

Total annual salary expenditure was ₹1,43,23,752. Per-minute cost attributable to one cath lab was ₹3.61 (time-driven).

**Technical Staff (n = 16):** Consists of 1 Senior Technical Officer, 2 Technical Officers, 2 Lab technician Grade 1, 1 Lab technician Grade 2, 10 On Job Trainees.

Total annual salary expenditure was ₹1,53,11,412. Per-minute cost attributable to one cath lab was ₹3.375 (time-driven).

**Class IV Workers (n = 12):** Consists of 7 Male and 5 Female workers.

Total annual salary expenditure was ₹23,58,720. Per-minute cost attributable to one cath lab was ₹0.69 (time-driven).

### III. Indirect Operational Costs

#### 1. Depreciation and Maintenance

- Building depreciation: ₹1,42,205 annually (₹0.135 per minute per lab)
- Infrastructure depreciation: ₹7,21,354 annually (₹0.68 per minute per lab)
- Building maintenance: ₹3,30,137.45 annually (₹0.31 per minute per lab)
- Equipment maintenance: ₹24,15,000 annually (₹13.6 per minute; time-driven)

#### 2. Opportunity Cost

Rental value of cath lab area (5,306.6 sq. ft.) was ₹10,41,685.5 per month, equivalent to ₹12 per minute per lab.

#### 3. Support and Utility Services

- **Nursing store consumables** used in Cardiac Catheterization Laboratory- Cost incurred per

year is ₹1,40,588.8. Hence, Cost incurred per procedure = ₹1,40,588.8/11,353 = ₹12.38.

- **Stationery** used in Cardiac Catheterization Laboratory- Cost incurred per year is ₹17,775. Hence, Stationery cost incurred per procedure = ₹17,775/11,353 = ₹1.56.
- **Laundry:** According to the study “Cost analysis of Laundry Services in NIMS”, the cost incurred in washing one kilogram of linen is ₹23. On an average, 980 grams of linen used per procedure. Hence, cost incurred per procedure = ₹22.57.
- **CSSD:** The consumables used for procedures in catheterization laboratory are sterilized in ethylene oxide sterilizer. Average number of loads sterilized per month is 10 (1000 packs). Cost incurred on CSSD per month towards catheterization laboratory is ₹61,483.6 per month and per year it is ₹7,37,803.2. Hence, Cost incurred per procedure is ₹65.
- **Bio-medical Waste Disposal:** As per the contract between NIMS and GJ Multi-clave, the

contract is ₹6/bed/day for 955 beds. Total cost incurred in Biomedical waste disposal for Cardiac Catheterization laboratory per year= ₹2,14,111. Cost incurred per procedure 2,14,111/11,353 = ₹18.86.

- **Electricity Costs:** Average total units of electricity consumption/Day = 954.694 KWH. Charges per unit of electricity in Telangana state is ₹9 per KWH. Charges incurred on electricity per day = 954.694 x ₹9= ₹8114.899 and ₹4.63 per minute per minute per lab it ₹2.3.

**4. Indirect Manpower cost (Administrative staff):** Consist of 1 Secretarial Assistant, 1 DPO and 1 Security personnel. The total annual salary expenditure is ₹14,21,004. Per-minute cost attributable to one cath lab was ₹5 (time-driven).

The Procedural times were recorded for all procedures in the prospective phase using digital stopwatches for the study sample (Cardiac catheterization study: n = 66).

**Table 1: Time taken for 66 Cardiac catheterization studies were observed and procedure wise average is as follows**

Procedure	Pre-procedure (min)	Performing Procedure (min)	Post-procedure (min)
Cardiac Catheterization Study 62±10.63 min	18±2 Patient prep, site prep	31±9.1 Catheter insertion (6±2), Contrast injection (8±4), Pressure measurements (17±8)	13±5 Catheter removal, hemostasis
<i>Costs Involved</i>	Class 4 workers Maintenance costs of building Depreciation cost of building Depreciation cost of Infrastructure Opportunity cost Electricity cost Administrative staff	Consumables Doctors 2 Nurses 3 Technicians Consumables Maintenance costs (Building & equipment) Depreciation costs (Building, equipment and Infrastructure) Support services (BMW, Laundry and CSSD) Electricity cost Opportunity cost Administrative staff	Class 4 workers Maintenance costs of building Depreciation cost of building Depreciation cost of Infrastructure Opportunity cost Electricity cost Administrative staff

**Table 2: Cost analysis: cardiac catheterization study**

Cost Head	Cost per minute or per procedure (₹)	Cost Driver (Time/ per procedure (min))	Cost per CCS (₹)
<b>Direct Operational Costs</b>			
Equipment depreciation	10.71	31 min	332.01
Cardiologists	108.75	31 min	3371.25
2 Nursing Staff	7.22	31 min	223.82
3 Technical Staff	10.125	31 min	313.875
Class IV Workers	0.69	31 min	21.39
Surgical Stores (common)	1,041.20	1041.2	1041.2
CathStudy-specific Consumables	2,920	2,920	2,920
Lab Stores	619.6	619.6	619.6
<b>Indirect Operational Costs</b>			
Building Depreciation	0.135	62	8.37
Infrastructure Depreciation	0.68	62	42.16
Building Maintenance	0.31	62	19.22
Equipment Maintenance	13.6	31	421.6
Opportunity cost	12	62	744
Administrative staff	5	62	310
Electricity	2.3	62	142.6
Nursing Store	12.38	per procedure	12.38
Stationery	1.56	per procedure	1.56
Laundry	22.57	per procedure	22.57
CSSD	65	per procedure	65
Biomedical Waste	18.86	per procedure	18.86
<b>Total unit cost per Cardiac Catheterization Study</b>			₹ 10,651.47

Overheads/Miscellaneous is calculated as 10% of the total cost i.e., ₹1,065  
Hence, **Total Cost Incurred per Cardiac Catheterization Study** = ₹11,716/-.

**Table 3: Descriptive Statistics (Time Analysis of Cardiac Catheterization Study in minutes)**

Phase	Mean	SD	Range
Pre-procedure	18.08	1.79	13.69–22.99
Procedure time	31.09	9.18	7.24–50.78
Post-procedure	13.16	4.91	4.00–26.01
Total time	62.33	11.19	39.29–90.39

The procedure phase occupied the maximum proportion of the total procedure duration and also showed the highest variability among all phases.

**Table 4: Percentage Distribution of Total Time**

Phase	Mean Time (min)	Percentage of Total Time
Pre-procedure	18.08	28.5%
Procedure phase	31.39	49.5%
Post-procedure	13.96	22.0%

Nearly half of the total procedure duration was spent during the active procedure phase.

**Correlation Analysis: Total Time vs Total Cost**

Pearson correlation analysis showed a very strong positive correlation between total procedure time and total procedure cost in Cardiac Catheterization Study.

- Pearson correlation coefficient ( $r$ ) > 0.90
- $p < 0.001$

This indicates that procedures with longer duration were associated with higher expenditure.

**Regression Analysis (Time Predicting Cost)**

Simple linear regression analysis was performed using total procedure time as the independent variable and total cost as the dependent variable.

**Regression Findings**

Regression equation:  $\text{Cost} = 153.94 \times \text{Time}$

- Regression coefficient ( $\beta$ ): 153.94
- $R^2 = 0.90$
- $p < 0.001$

For every one-minute increase in total procedure time, the overall procedure cost increased by approximately ₹154.

Simple linear regression analysis demonstrated that total procedure time significantly predicted total cost in Cardiac Catheterization Study procedures ( $\beta = 153.94$ ,  $R^2 = 0.90$ ,  $p < 0.001$ ). Approximately 90% of the variation in total procedure cost was explained by procedural duration.

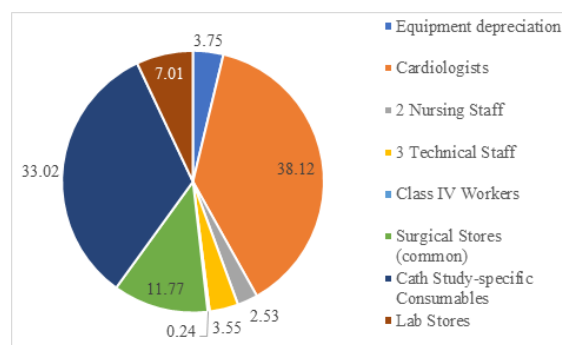
**DISCUSSION**

The present ABC analysis provides a detailed understanding of the cost incurred during diagnostic cath lab procedures at a tertiary care teaching hospital. The total unit cost was ₹11,716 for CCS consistent with Indian benchmarks and lower than international figures after PPP adjustment.<sup>[9,11]</sup> Lower costs reflect bulk procurement and high case volumes. Nearly half of the total procedure duration was spent during the active procedure phase.

Consumables and stores together formed a significant proportion of the total cost, confirming that inventory utilization is one of the major financial drivers in cath lab services, consistent with previous reports.<sup>[14,15]</sup>

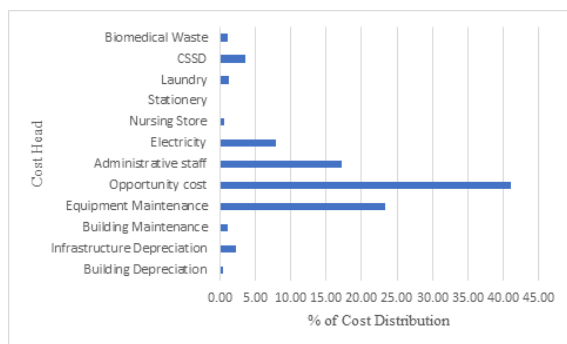
Direct operational costs formed the major share of expenditure, contributing 83% in CCS. This finding is in line with earlier literature Rashid et al.'s report of 92.73% direct costs,<sup>[12]</sup> showing that cath lab procedures are largely driven by procedure-related operational expenses rather than indirect hospital overheads. Among direct costs Consumables from surgical stores, and lab stores together contributed a major proportion (52%) of the total direct cost followed by Manpower costs which contributed to 44.4% (in which Cardiologists costs 88.7%), highlighting that material utilization remains one of the major cost-driving factors in diagnostic cardiac services followed by manpower costs.

Cardiologist cost alone contributed to nearly one-third of total expenditure in the procedure, emphasizing the specialist-driven nature of cardiac diagnostic services similar to Western studies, where personnel costs often exceed 30%.



**Figure 1: Pie Diagram Depicting Direct Operational Costs (% of Cost Distribution)**

Indirect operational costs accounted for 17% in CCS. Opportunity cost formed a notable component among indirect costs, contributing 41% respectively. Hence, Opportunity cost (the potential revenue from alternative use of laboratory space) represents a real economic consideration for hospital administrators evaluating service line profitability.



**Figure 2: Bar Graph Depicting Indirect Operational Costs (% of Cost Distribution)**

Inclusion of opportunity cost and support service expenses such as electricity, CSSD, biomedical waste management, laundry, and administrative services provides a more realistic estimate of actual resource consumption compared to studies considering only direct procedural expenditure.

## CONCLUSION

The study demonstrates that Activity Based Costing is an effective method for estimating the actual cost incurred during diagnostic cardiac catheterization procedures. The total cost was found to be ₹11,716 for Cardiac Catheterization Study, with direct operational expenses forming the largest share of expenditure (83%). Procedural time significantly influences resource consumption.

These findings enable evidence-based pricing ensuring financial sustainability while maintaining access. Cost optimization should prioritize consumable procurement efficiency, procedural time reduction, and volume optimization. The ABC framework provides a replicable model for other Indian tertiary hospitals seeking to understand catheterization laboratory economics.

In resource-constrained healthcare systems, granular cost understanding is essential for delivering sustainable, high-quality cardiovascular care.

### Management Implications

**Pricing:** ABC cost set minimum ₹11,716 (catheterization study) for sustainable tariffs.

**Benchmarking:** Times match global norms, affirming efficiency.<sup>[8,10]</sup>

**Strengths:** Reasonable prospective samples (n=66), full ABC with time-driven elements, robust stats.

### Limitations

- **CSSD Sterilization:** The number of times consumables were sent for ETO sterilization in the CSSD was unclear, and the absence of a systematic color-coding or marking process made tracking and accurate cost allocation challenging.
- Land cost was not considered.
- The building's life was assumed to be 100 years, and maintenance, depreciation costs and Opportunity Costs were calculated using Central Public Works Department (CPWD) rates.

However, the actual market value may be higher than these calculated estimates.

- **Electricity Consumption:** The Cardiac Catheterization Laboratory does not have sub-meters to accurately measure electricity usage. Therefore, an average estimate is determined based on the electricity load, as provided by the electricity department.
- The stock-in-hand inventory data was taken on indenting basis and stock in hand on the specific date in the past was unclear and not accurate. This may have affected the precision of inventory-related cost calculations.
- Doctors in the Cardiac Catheterization Laboratory typically work 10 hours per day in working days. Few days, their average working hours on working days may exceed these usual hours.
- The time consumed for emergency procedures was not observed, and the utilization of the Cath Lab facility during emergencies was not specifically accounted for. It was assumed that emergency procedures utilized resources in the same manner as elective procedures.

**Ethical Considerations:** Study involved retrospective record review and prospective observational data without patient intervention or identification. Institutional ethics committee approval obtained prior to initiation.

## REFERENCES

1. World Health Organisation (WHO). Cardiovascular diseases (CVDs). 17 May. 2017. <https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-cvds>
2. India State-Level Disease Burden Initiative CVD Collaborators. The changing patterns of cardiovascular diseases and their risk factors in the states of India: the Global Burden of Disease Study 1990–2016. *Lancet Glob Health*. 2018; Dec;6(12):e1339–e1351. doi: 10.1016/S2214-109X(18)30407-8 Epub 2018 Sep 12. ; PMID: PMC6227386.
3. World Heart Federation. World Heart Report 2023: Confronting the World's Number One Killer. Geneva: World Heart Federation; 2023.
4. India State-Level Disease Burden Initiative CVD Collaborators. The changing patterns of cardiovascular diseases and their risk factors in the states of India. *Lancet Glob Health*. 2018;6(12):e1339–e1351.
5. Smeltzer, S. C., Bare, B. G., Hinkle, J. L., Cheever, K. H., Townsend, M. C., & Gould, BLipincott Williams & Wilkins. Brunner and Suddarth's textbook of medical surgical nursing 10th edition. In: 10th ed. 2008.
6. Javid M, Hadian M, Ghaderi H, Ghaffari S, Salehi M. Application of the Activity-Based Costing Method for Unit-Cost Calculation in a Hospital. *Glob J Health Sci*. 2015 May 17;8(1):165–72.
7. Cooper R, Kaplan RS. The promise--and peril--of integrated cost systems. *Harv Bus Rev*. 1998;76(4):109–19.
8. Niasti F, Fazaeli AA, Hamidi Y, Viaynchi A. Applying ABC system for calculating cost price of hospital services case study: Beheshti hospital of Hamadan. *Clinical Epidemiology and Global Health*. 2019 Sep;7(3):496–9.
9. Cohen DJ, Becker ER, Culler SD, Ellis S, Green LM, Schnitzler RN, et al. Impact of patient characteristics, complications, and facility volume on the costs and time of cardiac catheterization and coronary angioplasty in 70

- catheterization laboratories. *The American Journal of Cardiology*. 2000 Sep;86(6):595–601.
10. Senior Resident, Department of Hospital Administration, SKIMS, Soura., Rashid R, Khalil I, Senior Resident, Department of Hospital Administration, SKIMS, Soura., Mushtaq Y, Associate Program Manager, National Health Mission J&K., et al. COST ANALYSIS OF CATH LAB PROCEDURES DONE AT A TERTIARY CARE HOSPITAL OF NORTH INDIA. *IJAR*. 2023 Aug;11(08):83–91.
  11. Becker ER, Cohen D, Culler SD, Ellis S, Green LM, Schnitzler RN, et al. Benchmarking cardiac catheterization laboratories: the impact of patient age, gender and risk factors on variable costs, device costs, total time and procedural time in 53 catheterization laboratories. *J Invasive Cardiol*. 1999 Sep;11(9):533–42.
  12. Rashid R, Bhat MA, Yousuf A, et al. Cost analysis of catheterization laboratory procedures at a tertiary care hospital. *Int J Appl Res*. 2017;3(1):736-740.
  13. Shilpashree CR, Chaitra R. A cost analysis of CAG and PTCA in a catheterization laboratory. *IOSR J Dent Med Sci*. 2018;17(7):76-82.
  14. Sukin CA, Baim DS, Caputo RP, Ho KKL, Laham RJ, Flatley MG, et al. The Impact of Optimal Stenting Techniques on Cardiac Catheterization Laboratory Resource Utilization and Costs. *The American Journal of Cardiology*. 1997 Feb;79(3):275–80.
  15. Banerjee S, Monteleone P, Novak S. Catheterization Laboratory Activity-Based Costing. *Circ: Cardiovascular Interventions*. 2021 Mar;14(3):e010228.