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Time-Driven Activity-Based Costing (TDABC) Analysis of Nursing Care for Elderly Patients Undergoing Hip Fracture Surgery in a Tertiary Hospital

Juthamard Yamnoun[1], Phechnoy Singchangchai[2*]

[1]Master of Nursing Science Program (Nursing Administration)

[2]Faculty of Nursing, Christian University of Thailand

ABSTRACT

Background: Cost management is a core responsibility of nursing administrators, who must allocate limited resources for maximum benefit. Time-driven activity-based costing (TDABC) identifies the true cost of each nursing activity from the time and resources it consumes, yet activity-level cost evidence for older patients undergoing hip fracture surgery in Thailand is scarce.

Objective: To analyze the time-driven activity-based cost of nursing care for elderly patients undergoing hip fracture surgery in a tertiary hospital.

Methods: This descriptive study used retrospective and prospective data collection in the female orthopedic ward of a tertiary hospital. Two samples were purposively selected: the cost reports of 24 nursing personnel and of 30 patients aged 60 years or older who underwent hip fracture surgery. Three instruments were used: unit-cost data recording forms, a nursing activity dictionary, and a nursing activity cost and time recording form (content validity index = 1.0; inter-observer reliability = 0.97). Labor, material, and capital costs, plus allocated utility costs, were calculated for five main nursing activities, with labor and capital costs assigned as cost per minute multiplied by observed activity time, and analyzed using descriptive statistics.

Results: The total nursing activity cost was USD 14,743.56 (USD 1 = 31.20 baht; mean USD 491.45 per patient). Surgical preparation nursing had the highest cost (USD 5,643.99; 38.28%), followed by postoperative nursing (USD 4,849.59; 32.89%). By cost component, materials accounted for the largest share (USD 8,797.05; 59.67%), followed by capital (32.21%) and labor (6.90%).

Conclusion: Nursing care for elderly hip fracture surgery patients is material-intensive, and cost is concentrated in the surgical preparation and postoperative phases. Activity-level cost data can help nurse administrators identify and control high-cost activities and remove redundant ones without compromising the quality of care.

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KEYWORDS:

Time-driven activity-based costing, Nursing activity cost, Hip fracture surgery, Older adults, Nursing administration

1. BACKGROUND

Cost management is a key responsibility of nursing administrators, who must allocate limited resources so as to obtain the greatest benefit, particularly in healthcare systems that are complex and financially constrained.[1] Activity-based costing (ABC) is recognized as a strategic tool that allows administrators to identify systematically the true cost of each type of nursing activity, and to plan human, equipment, and budget resources in line with actual needs.[2,3] Because professional nurses are the largest cost component of health services, nursing management systems that emphasize value for money and cost-effectiveness are essential.[1]

Hip fracture in older adults is a major global public health problem. Although age-standardized incidence has fallen in many countries, the annual number of hip fractures worldwide is projected to nearly double between 2018 and 2050 as populations age.[4] Thailand is no exception. A 10-year national

Corresponding Author: Phechnoy Singchangchai

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analysis under the Universal Health Coverage system showed that the number of hip fractures rose in all six regions between 2013 and 2022, and that annual hospitalization costs for hip fractures increased 2.5-fold, from USD 17.3 million to USD 42.8 million.[5] At the patient level, an earlier Thai cohort reported a median total cost of approximately USD 2,890 (116,458.6 Thai baht at the 2005 average exchange rate) for one year of hip fracture treatment, and pre-operative status was the only factor associated with direct cost.[6]

Hospital statistics from the tertiary hospital studied show the same trend. The number of patients undergoing hip surgery rose from 82 in 2022 to 112 in 2023 and 124 in 2024, a cumulative increase of 51.22% over three years, which indicates a considerable rise in nursing workload and resource use. Care of these patients covers four phases (admission, perioperative and postoperative care, rehabilitation, and discharge), all of which require substantial resources.

A review of the literature shows that comprehensive, activity-level cost analyses of nursing care for elderly patients undergoing hip fracture surgery are lacking.[7] To our knowledge, this study is one of the first in Thailand to apply the TDABC concept to this patient group. The resulting data can serve as an empirical basis for nurse administrators in planning staffing, allocating resources, and improving the efficiency of nursing services. The objectives were (1) to analyze the total nursing activity cost (five main activities), (2) to determine the cost of each nursing activity, and (3) to determine the nursing activity cost per patient, for elderly patients undergoing hip fracture surgery in a tertiary hospital.

2. METHODOLOGY

2.1 Study Design and Conceptual Framework

This descriptive study applied time-driven activity-based costing (TDABC), an extension of the ABC approach of Kaplan and Cooper,[2] as developed further by Shihab and Prasad[3] and Keel et al.,[8] using retrospective and prospective data. Nursing activities were defined by integrating the inpatient nursing standards of the Nursing Division, Department of Medical Services,[9] the orthopedic nursing manual of Lerdsin Hospital,[10] and the clinical nursing practice guidelines for patients undergoing hip arthroplasty of the Thai Orthopedic Nurses Association.[11] Three cost components were considered: labor cost, material (consumable) cost, and capital cost (Figure 1). TDABC identifies the actual cost of each activity from the resources actually used and the time spent on the activity, which suits complex health systems with limited resources.

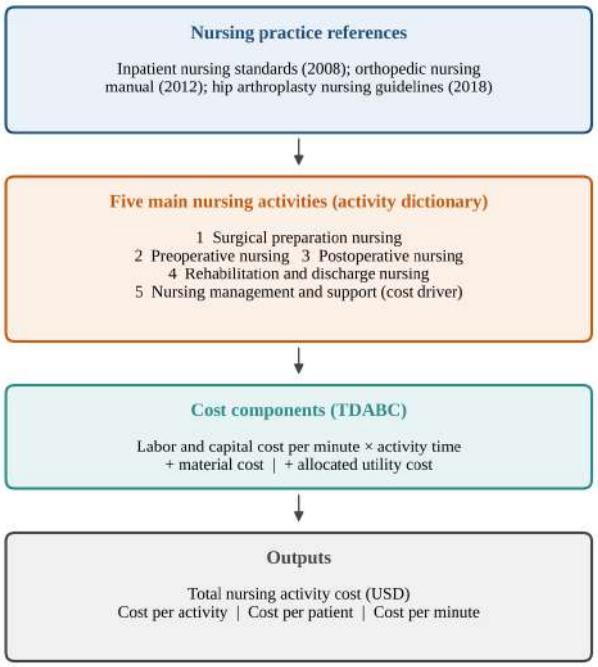


Figure 1: Conceptual framework of the study

2.2 Study Setting

The study was conducted in the female orthopedic ward (Ward 23B) of a tertiary hospital in Thailand. Data were collected retrospectively from secondary sources and prospectively by direct observation of nursing activities.

2.3 Population and Sample

The target populations were (1) the cost reports of all personnel who provided medical and nursing care to patients from admission to discharge from the orthopedic ward, and (2) the cost reports of elderly patients who underwent hip fracture surgery in that ward. The samples, selected by purposive sampling, were (1) the cost reports of 24 orthopedic ward personnel who performed nursing activities for elderly hip fracture surgery patients, and (2) the cost reports of services provided to 30 patients aged 60 years or older who underwent hip fracture surgery.

2.4 Research Instruments

Three sets of instruments were used. *Set 1, the unit-cost data recording forms,* were developed by the researcher from the literature and from concepts of time-driven activity-based costing. They comprise six forms: labor cost (LC1), materials and medical supplies (MC1), electricity (MC2), water supply (MC3), equipment depreciation (CC1), and building depreciation (CC2).

Set 2, the nursing activity dictionary for elderly hip fracture surgery patients, was developed in two steps. First, the researcher studied the nursing service process for these patients in the orthopedic ward to define the scope of activities in each phase of care. Second, activity data were collected through a focus group discussion with 14 professional nurses, who described the nursing activities actually performed; a research assistant observed and recorded the discussion. The activities

were then classified into five main activities, each divided into sub-activities: (1) surgical preparation nursing, (2) preoperative nursing, (3) postoperative nursing, (4) rehabilitation and discharge nursing, and (5) nursing management and support activities (cost driver).

Set 3, the nursing activity cost and time recording form, was used to record the time spent on each nursing activity and the associated cost data during observation.

2.5 Quality of the Instruments

All instruments were examined for content validity by three experts, giving a content validity index (CVI) of 1.0. The revised instruments were then tested for the reliability of recording the time spent on each activity, using the interobserver agreement index, which was 0.97.

2.6 Ethical Consideration

The research proposal was submitted to the Research Ethics Committee of Christian University of Thailand (reference no. 01/2568), and a letter requesting permission for data collection was sent to the director of the study hospital (reference no. 005/2569).

2.7 Data Collection

Data were collected in two ways. (1) Retrospective data were obtained from secondary sources: payroll and other income registers from the finance and accounting department; registers of supplies, equipment purchases, and buildings from the procurement department; and service statistics of Ward 23B (female orthopedics) for fiscal year 2026, which were used to calculate the labor cost of nursing personnel. (2) Prospective data were obtained by observing the nursing activities that nurses and other ward personnel performed for elderly hip fracture surgery patients admitted to the orthopedic ward.

2.8 Data Analysis

Data were analyzed using descriptive statistics (frequency, percentage, mean, and standard deviation). Costs were calculated in the following steps.

(1) Labor cost. Labor costs were classified as fixed costs (salary, position allowance, and professional allowance) and variable costs (overtime, performance-based pay, and out-of-hours compensation).[12] The labor cost of each nursing staff member was apportioned to activities according to the proportion of time actually spent on the direct nursing activities in the dictionary, and expressed in USD per minute per person (Equation 1). This rate was multiplied by the time spent on each activity to give the labor cost of the activity. The labor costs of all occurrences were summed and divided by the number of occurrences to give the mean labor cost per occurrence.

$$LC_{\text{min,i}} = ALC_{\text{i}} / T_{\text{i}} \quad (1)$$

where ALC_{i} is the labor cost of staff member i apportioned to direct nursing activities and T_{i} is the working time of staff member i in minutes.

(2) Capital cost. Depreciation of equipment and buildings was calculated from the capital cost forms using the depreciation criteria of the Ministry of Finance. Depreciation per minute was computed as in Equation 2 and multiplied by the time used in each activity.

$$DC_{\text{min}} = (P - S) / (L \times 365 \times 24 \times 60) \quad (2)$$

where P is the purchase price, S the salvage value, and L the useful life in years.

(3) Material cost. The costs of consumable materials recorded for each activity were summed and divided by the number of times the activity was performed (Equation 3).

$$MC_{\text{a}} = (\Sigma\, mc_{\text{a}}) / n_{\text{a}} \quad (3)$$

where mc_{a} are the material costs recorded for activity a and n_{a} is the number of times it was performed.

(4) Unit cost per activity. The labor, material, and capital costs were added to give the total cost of each activity, which was divided by the number of occurrences of the same activity. **(5) Main activity cost.** The cost of each main activity was the sum of the costs of all its sub-activities. **(6) Total nursing activity cost.** The total nursing activity cost of elderly hip fracture surgery patients was the sum of the costs of the five main activities of the orthopedic ward.

(7) Utility cost allocation. Utility costs (electricity, water, and other utilities) are indirect costs that cannot be traced to a particular patient or a single activity, so they were allocated systematically to the ward and to nursing activities (Equations 4–7).

$$UC_{\text{hosp}} = (E + W + O) / N_{\text{all}} \quad (4)$$

$$UC_{\text{study}} = UC_{\text{hosp}} \times N_{12} \quad (5)$$

$$UC_{\text{act}} = (UC_{\text{study}} / N_{12}) \times N_{\text{s}} \quad (6)$$

$$UC_{\text{pt}} = UC_{\text{act}} / N_{\text{s}} \quad (7)$$

where E, W, and O are the costs of electricity, water, and other utilities; N_{all} is the total number of patients served by the hospital; UC_{hosp} is the average hospital utility cost per patient during the study period; N_{12} is the number of patients over 12 months; N_{s} is the number of patients studied; and UC_{act} and UC_{pt} are the utility cost allocated to the study activities and to each patient, respectively.

(8) Currency conversion. All costs were calculated in Thai baht and converted to US dollars (USD) at 31.20 baht per USD, the approximate average exchange rate in February 2026, the month in which cost data were collected. Values were rounded to two decimal places after conversion, so totals may differ from the sum of their parts by about USD 0.01.

3. RESULTS

3.1 Characteristics of the Patients (Table 1)

The 30 patients had a mean age of 74 years (SD = 6.45), and half were aged 76–80 years (50.00%). Most were married (60.00%), had education below a bachelor's degree (93.33%), and worked in agriculture or trading (60.00%). Income was sufficient for 86.67%, and 73.33% were covered by the national health security (universal coverage) scheme. All patients (100%) had underlying diseases, and 73.33% had one caregiver.

Table 1: Characteristics of elderly hip fracture surgery patients (n = 30)

Characteristic	n	%
Age, mean ± SD (years)	74 ± 6.45	
Age group 76–80 years	15	50.00
Marital status: married	18	60.00
Education below bachelor's degree	28	93.33
Occupation: agriculture/trading	18	60.00
Income sufficient	26	86.67
Health coverage: national health security scheme	22	73.33
Underlying disease present	30	100.00
Caregiver: one person	22	73.33

The predominant category of each characteristic is shown.

3.2 Labor Cost of Nursing Personnel (Table 2)

The total labor cost of the 24 nursing personnel in February 2026 was USD 33,345.13 (mean USD 1,389.38 per person), of which fixed costs were USD 25,704.81 and variable costs USD 7,640.32. Salary was the largest fixed cost (90.39%) and overtime the largest variable cost (51.20%).

Table 2: Labor cost of nursing personnel in the female orthopedic ward, February 2026 (N = 24)

Labor cost	Total (USD)	Mean per person (USD)	%
Fixed cost			
Salary	23,233.65	968.07	90.39
Position allowance	1,750.00	72.92	6.81
Professional allowance	721.15	30.05	2.80
Subtotal	**25,704.81**	**1,071.03**	**100.00**
Variable cost			
Overtime (OT)	3,911.15	162.96	51.20
Performance-based pay (P4P)	1,089.74	45.41	14.25
Out-of-hours compensation	2,639.42	109.98	34.55
Subtotal	**7,640.32**	**318.35**	**100.00**

Percentages are calculated within the fixed and variable cost groups.

3.3 Total Nursing Activity Cost and Cost Components (Table 3)

The total cost of nursing activities for the 30 patients was USD 14,743.56, or USD 491.45 per patient. Material cost was the largest component (USD 8,797.05; 59.67%), followed by capital cost (USD 4,748.56; 32.21%) and labor cost (USD 1,016.65; 6.90%). Allocated utility cost contributed USD 178.38 (1.21%).

Table 3: Cost components of nursing activities for elderly hip fracture surgery patients (n = 30)

Cost component	Total cost (USD)	%	Mean per patient (USD)
Labor cost	1,016.65	6.90	33.89
Material cost	8,797.05	59.67	293.23
Capital cost	4,748.56	32.21	158.29
Allocated utility cost	178.38	1.21	5.95
Total*	**14,743.56**	**100.00**	**491.45**

*Percentages are calculated on the total of USD 14,743.56. The four component subtotals add to USD 14,740.64; the remaining USD 2.92 is included in the total for nursing management and support activities but is not itemized by component

3.4 Cost by Main Nursing Activity and per Patient (Tables 4 and 5)

Table 4: Time, frequency, and cost of the five main nursing activities for elderly hip fracture surgery patients (n = 30)

Main nursing activity	Mean time per occurrence (min)	Total time (min)	Times performed	Labor cost (USD)	Material cost (USD)	Capital cost (USD)	Allocated utility cost (USD)	Total cost (USD)	% of total cost
1. Surgical preparation nursing	54.54	13,090.40	240	168.70	4,463.70	958.28	53.31	5,643.99	38.28
2. Preoperative nursing	61.67	12,950.00	210	258.56	248.55	838.50	60.27	1,405.88	9.54
3. Postoperative nursing	45.34	19,044.20	420	192.22	2,936.07	1,676.99	44.32	4,849.59	32.89

Main nursing activity	Mean time per occurrence (min)	Total time (min)	Times performed	Labor cost (USD)	Material cost (USD)	Capital cost (USD)	Allocated utility cost (USD)	Total cost (USD)	% of total cost
4. Rehabilitation and discharge nursing	20.97	1,887.00	90	87.42	39.42	359.36	20.49	506.69	3.44
5. Nursing management and support activities (cost driver)	140.67	32,353.33	230	309.75	1,109.31	915.43	–	2,337.41	15.85
Total	**66.66†**	**79,324.93**	**1,190**	**1,016.65**	**8,797.05**	**4,748.56**	**178.38**	**14,743.56**	**100.00**

†Weighted mean (total time ÷ total frequency). Times performed is the number of occurrences of the activity across the 30 patients. Allocated utility cost was not itemized for activity 5.

Table 5: Unit costs and shares of time and cost by main nursing activity (n = 30)

Main nursing activity	Cost per patient (USD)	Cost per occurrence (USD)	Cost per minute (USD)	Share of total time (%)	Share of total cost (%)
1. Surgical preparation nursing	188.13	23.52	0.43	16.50	38.28
2. Preoperative nursing	46.86	6.69	0.11	16.33	9.54
3. Postoperative nursing	161.65	11.55	0.25	24.01	32.89
4. Rehabilitation and discharge nursing	16.89	5.63	0.27	2.38	3.44
5. Nursing management and support activities (cost driver)	77.91	10.16	0.07	40.79	15.85
Total	**491.45**	**–‡**	**–‡**	**100.00**	**100.00**

‡Unit costs per occurrence and per minute are not additive across activities. Overall averages were USD 12.39 per occurrence and USD 0.19 per minute. Percentages may not add to exactly 100.00 because of rounding.

Table 4 shows the time, frequency, and cost of the five main nursing activities. The 30 patients received 1,190 recorded activity occurrences requiring 79,324.93 minutes of nursing time, an average of 2,644.16 minutes (about 44 hours) per patient. Surgical preparation nursing had the highest total cost (USD 5,643.99; 38.28%), followed by postoperative nursing (USD 4,849.59; 32.89%), nursing management and support activities (USD 2,337.41; 15.85%), preoperative nursing (USD 1,405.88; 9.54%), and rehabilitation and discharge nursing (USD 506.69; 3.44%) (Figure 2).

Unit costs are shown in Table 5. Surgical preparation nursing also had the highest cost per occurrence (USD 23.52), cost per patient (USD 188.13), and cost per minute (USD 0.43). Materials accounted for 79.09% of the cost of surgical preparation nursing and 60.54% of the cost of postoperative nursing; together, these two activities accounted for 84.12% of all material cost. Figure 3 compares the share of time with the share of cost for each main activity.

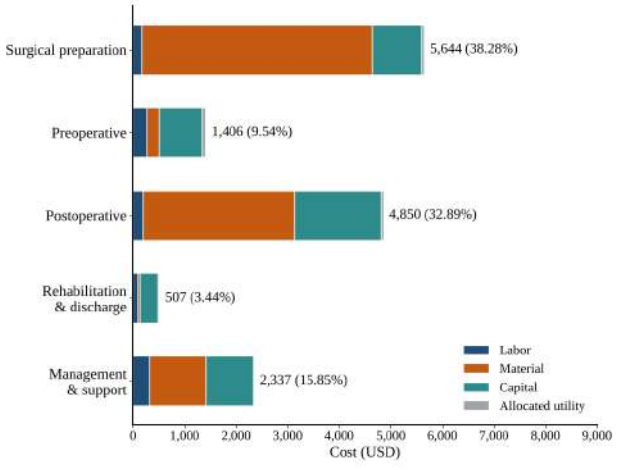


Figure 2: Nursing activity cost by main activity and cost component (n = 30)

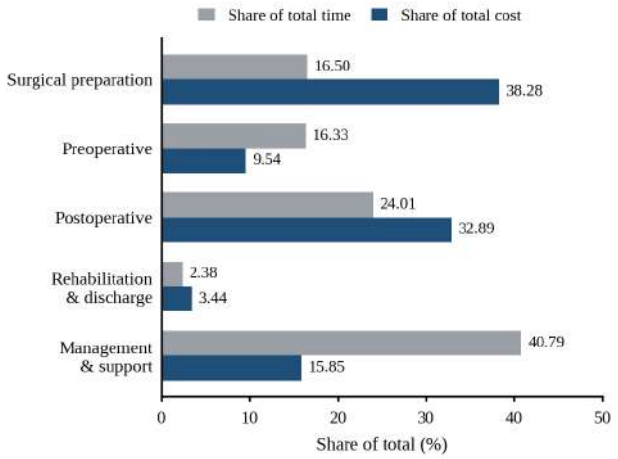


Figure 3: Share of total nursing time versus share of total cost by main activity

4. DISCUSSION

This study analyzed the time-driven activity-based cost of nursing care for 30 elderly patients who underwent hip fracture surgery in a tertiary hospital. The total nursing activity cost was USD 14,743.56, or USD 491.45 per patient. These figures describe ward-level nursing activity costs, and should not be compared directly with the total hospitalization or one-year treatment costs reported for hip fracture in Thailand,[5,6] which cover a much wider range of services.

Surgical preparation nursing was the largest cost item (USD 5,643.99; 38.28%), reflecting heavy resource use at the start of the care pathway. This phase requires a comprehensive physical, psychological, and social assessment together with preparation for surgery in accordance with the inpatient nursing standards[9] and the hip arthroplasty nursing guidelines,[11] and its activities must be carried out continuously and completely. The frequency of routine activities that recur many times was an important driver of cost: the 240 recorded occurrences (eight per patient) and the time spent on them are cost drivers that act directly on labor cost and total activity cost, as ABC predicts.[2]

Cost, however, did not simply follow time. Surgical preparation used 16.50% of all recorded nursing time but generated 38.28% of cost, whereas nursing management and support activities used 40.79% of the time but only 15.85% of cost (Figure 3). The difference lies in materials. Consumable supplies, medical devices, and specialized medical products made up 79.09% of the cost of surgical preparation, and this activity alone accounted for half (50.74%) of all material cost. This is consistent with the ABC principle that activities that consume resources intensively and occur frequently are the main cost drivers of a service,[2,13] and it explains why materials, rather than labor, dominated the cost structure.

The cost structure observed here differs from that of other ABC studies of surgical services. In an ABC analysis of cataract surgery, human resources were the largest cost component (54.24%) and consumables the second (32.57%).[14] In the present study, materials were the largest component (59.67%), followed by capital (32.21%), and labor accounted for only 6.90%. Two features probably contribute. First, only the nursing time apportioned to hip fracture patients was counted as labor, whereas the time of ward nurses is shared with all other patients in the ward. Second, orthopedic surgical preparation and postoperative care are inherently supply- and equipment-intensive; capital cost was also concentrated in these phases, with postoperative care accounting for 35.32% of all capital cost.

By main activity, costs ranked as follows: surgical preparation (USD 5,643.99), postoperative nursing (USD 4,849.59), nursing management and support (USD 2,337.41), preoperative nursing (USD 1,405.88), and rehabilitation and discharge nursing (USD 506.69). The same order applied to cost per patient (USD 188.13, 161.65, 77.91, 46.86, and 16.89), because all activities were performed for the same 30 patients. Surgical preparation also had the highest cost per occurrence (USD 23.52) and per minute (USD 0.43), which agrees with the TDABC principle that cost arises from the resources consumed over the time and volume of activity.[13] Postoperative nursing ranked second, driven by its high frequency (420 occurrences, or 14 per patient) and by material and capital costs. Rehabilitation and discharge nursing was the least costly (3.44%), with the lowest frequency and shortest total time, but its cost per minute (USD 0.27) was relatively high because capital cost accounted for 70.92% of its total.

The labor cost structure (Table 2) was dominated by salary among fixed costs (90.39%) and by overtime among variable costs (51.20%). Overtime and out-of-hours compensation together made up 85.75% of variable labor cost, and variable pay accounted for about 23% of the total monthly labor cost of the 24 staff. This reliance on extra-hours work may indicate that a rising workload, reflected in the growth in hip surgery patients from 82 in 2022 to 124 in 2024, is being absorbed through extended working hours rather than regular staffing, an issue that nurse administrators should examine when planning staffing.

These findings have several implications for nursing administration. Activity-level cost information makes it possible to identify and control the most expensive activities, namely surgical preparation and postoperative care, and to remove duplicated or non-value-adding steps while maintaining the quality of care. Because materials dominate cost, standardizing and reviewing supply use within these two phases is a logical first priority. The results also provide empirical inputs for staffing and budget planning, and a nursing-specific cost benchmark (USD 491.45 per patient) that can be linked to payment systems such as Diagnosis-Related Groups (DRG). Top-down cost allocation based on pre-determined weights has been shown to agree poorly with bottom-up ABC in surgical costing, and a shift towards TDABC, the approach used in this study, has been advocated.[15] TDABC, which estimates costs from standard times and capacity cost rates,[8,13] could next be refined by deriving standard times for each nursing activity from larger, multi-site samples.

5. CONCLUSION

The total nursing activity cost for elderly patients undergoing hip fracture surgery in a tertiary hospital was USD 14,743.56. Surgical preparation nursing and postoperative nursing were the most costly activities, and material cost was the largest cost component, followed by capital cost and labor cost. Nursing care for this patient group therefore relies mainly on materials and medical equipment. Nurse administrators should use activity-level cost data to identify and control nursing activities and to eliminate redundant ones, in order to reduce nursing costs without lowering the quality of patient care.

6. RECOMMENDATIONS

- Link TDABC results with Diagnosis-Related Groups (DRG) payment to improve the accuracy of cost analysis and support managerial decisions. TDABC can set standard times and unit costs for each nursing activity, while DRG provides the framework for setting revenue or reimbursement per case.
- Apply Lean management to analyze work processes and reduce waste, such as redundant steps, waiting, and activities that add no value.
- Integrate TDABC with Lean to redesign nursing processes that link time, resources, and activities, so that efficiency improves and costs fall while the quality of patient care is maintained.[13]
- Review supply use in surgical preparation and postoperative nursing, the two phases that account for most of the material cost.
- Future studies should include several wards or hospitals and larger samples, and should link activity costs with patient outcomes.

7. LIMITATIONS

This single-ward, single-hospital study used a purposive sample of 30 patients, so the findings may not represent other settings. Although TDABC reflects cost at the level of individual activities in more detail than traditional costing, the time needed to perform each activity varies with the workload at different times. In addition, nursing activities differ with the experience, skills, and expertise of individual nurses, which affects the duration and frequency of activities and produces variation in cost between individuals.

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