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Hospital episode-of-care costs for hip fractures: an activity-based costing analysis

Antoine Denis, MD[a,*], Julien Montreuil, MD, MSc[b], Yasser Bouklouch, BS, MPH[c], Rudolf Reindl, MD, FRCSC[b], Gregory K. Berry, MDCM, MSEd, FRCSC[b], Edward J. Harvey, HBSc, MSc, MDCM, FRCSC[b], Mitchell Bernstein, MD, FRCSC[b]

Background: Despite the large impact of hip fracture care on hospital budgets, accurate episode-of-care costs (EOCC) calculations for this injury remains a challenge. The objective of this article was to assess EOCC for geriatric patients with hip fractures using an activity-based costing methodology and identify intraoperative, perioperative, and patient-specific factors associated with higher EOCC.

Material and Methods: This is a retrospective cohort study involving a total of 109 consecutive patients with hip fracture treated surgically at a Canadian level-1 trauma center from April 2018 to February 2019. Clinical and demographic data were extracted through the institution's centralized data warehouse. Data acquisition also included direct and indirect costs per episode of care, adverse events, and precise temporal data.

Results: The median total EOCC was $13,113 (interquartile range 6658), excluding physician fees. Out of the total cost, 75% was attributed to direct costs, which represented a median expenditure of $9941. The median indirect cost of the EOCC was $3322. Based on the multivariate analysis, patients not operated within the 48 hours guidelines had an increased length of stay by 5.7 days ($P = 0.003$), representing an increase in EOCC of close to 5000$. Higher American Society of Anesthesiology (ASA) scores were associated with elevated EOCC.

Conclusion: The cost of managing a patient with geriatric hip fracture from arrival in the emergency department to discharge from surgical ward represented $13,113. Main factors influencing the EOCC included adherence to the 48-hour benchmark surgical delay and ASA score. High-quality costing data are vital in assessing health care spending, conducting cost effectiveness analyses, and ultimately in guiding policy decisions.

Level of Evidence: Level III (3), retrospective cohort study.

Key Words: geriatrics, hip fractures, activity-based costing, episode-of-care costing

1. Introduction

Hip fractures in the geriatric population are common with over 30,000 cases every year in Canada.[1] The injury is associated with high rates of mortality, varying between 20% and 30% at 1 year after the injury.[2–6] In addition, there is a high rate of postoperative complications, unplanned readmission rates, and prolonged hospital stays.[7–17] This has resulted in significant economic impact on the health care system, which also serves as an opportunity to improve quality and decrease the cost of care. An episode of care (EOC) is defined as the set of services offered to patients suffering from a health problem from the first to the last encounter with a health care provider during a given period.[18] Despite the large impact of hip fractures on hospital budgets, accurate episode-of-care costs (EOCC) calculations for this injury remains a challenge in Canada. EOCC, defined as the total direct and indirect costs of an EOC, is fundamental to institute activity-based funding models for reimbursement which many other countries have started to implement.[19–22] In fact, universal health care systems, like those in Australia, France, Germany, the Netherlands, Sweden, Switzerland, and the United Kingdom use activity-based funding (ABF) to reimburse hospitals.[19,20,23–26] Previous methodologies involved approximations of costs through grouping systems and traditional accounting.[27,28] To more precisely define EOCC, activity-based costing (ABC) examines all elements of a medical act to estimate costs.[29] This method improves the ability of health care organizations to understand the economic implications of treating various medical conditions.[19,30–33]

The primary objective of this article was to assess EOCC for geriatric patients with hip fractures using an ABC methodology. Secondary objective was to identify intraoperative, perioperative, and patient-specific factors associated with higher EOCC. Based on approximations previously reported in the literature, it was expected that the average index perioperative hospitalization EOCC would range from $15,000 to 20,000$.[34] This itemized

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[a] Faculty of Medicine, McGill University, Montreal, QC, Canada, [b] McGill Division of Orthopaedic Surgery, Montreal, QC, Canada, [c] McGill University Health Center—Research Institute, Montreal, QC, Canada

** Corresponding author. Address: Division of Orthopaedics, Montreal General Hospital, 1650 Cedar Ave, Montreal, QC H3G 1A4, Canada. E-mail address: antoine.denis@mail.mcgill.ca (A. Denis).*

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costing approach will hopefully instigate change toward a more accurate, precise, and reliable value-based health care assessment. Providing policymakers the information to develop optimal financing methods based on patient complexity is paramount for the economic sustainability of our health care system.

2. Methods

This is a retrospective observational cohort study of 109 consecutive patients treated surgically for an acute hip fracture at the same institution, 1 of 3 tertiary trauma care centers in the province of Quebec, Canada. All patients older than 60 years operated for an acute proximal femur fracture from April 2018 to February 2019 were included. Patients aged younger than 60 years, polytrauma cases, and patients managed nonsurgically were excluded from this study. The study was approved by our local ethics board (F1-42387).

2.1. Costing data

Costing data were extracted using Project Portfolio Management (PPM) System (PowerHealth, Australia) which is led by finance analysts. This database oversees all expenses assumed by the hospital and is part of the institutional data warehouse. The software enables extraction of data including direct and indirect costs per episode of care, procedure codes, documented adverse events, and precise temporal data. For the present project, the surgical EOCC included all items received by and services offered to the patient throughout the entire hospital stay, from arrival in the emergency department to discharge from the hospital. Postoperative visits were excluded from the present analysis. Using the PPM software, itemized costs were extracted for each patient's EOC. These operational costs were classified as direct or indirect. Direct costs are defined as labor, equipment, implants, consumables, and lab testing that can directly be assigned to a service. Costs associated with these consumables were calculated based on purchase price by the hospital. These multiple items are classified by areas (Table 1). Indirect costs included management, information technology, finance, logistics, sterilization, biomedical, housekeeping, and others (Table 1). All fixed or periodic costs of support resources necessary to supply a service or a procedure were included as indirect costs. Allocation of these indirect costing inputs to each surgical encounter followed an ABC framework as provided by governmental authorities. Areas of care received indirect cost following equations allocating the amount based on time spent on each activity. If time is not applicable, for example, with consumables, indirect costs were distributed following ratios based out of utilization. Physician remuneration was excluded from cost analysis because those fees are borne by the provincial government and not the hospital, according to Canadian legislation, and therefore its calculation was of out of the scope of this study.[35]

TABLE 1

Direct and indirect costs for ABC

Direct costing areas	Indirect costing areas
Operating room	Billing
PACU (recovery room)	Information technology
Surgical unit	Central sterile processing
Laboratory testing	Maintenance
Supply, implants and consumables	Human resources
Pharmacy	Hospital administration
ICU (intensive care unit)	Nonclinical salaries
Professional (OT/PT)	
Durable medical equipment	
Emergency room	
Imaging	
Transport	

ICU = intensive care unit; OT = occupational therapist; PACU = postanesthesia care unit; PT = physical therapist.

2.2. Demographics

Demographic data included patient's age, sex, comorbidities, and the American Society of Anesthesiologists (ASA) classification. 109 patients (72 female patients and 37 male patients) were included in the study. Mean age of all subjects was 80.1 years (70.5; 89.7). Most patients (75.2%) had an ASA score of 3. The 3 most common procedures performed were arthroplasty, ORIF with sliding hip screw, and cephalomedullary nailing (Table 2). Over half of patients (52.3%) were discharged to an acute care rehabilitation center. The institution-specific surgical priority categorization was also retrieved. The anticoagulation status of patients was defined as the current use of any anticoagulation agent at the time of injury. The postoperative length of stay was defined as the number of days a patient spent in the hospital after the initial surgical intervention (Table 2). Demographics and perioperative metrics were extracted manually by 2 independent observers through the institution electronic medical record system.

TABLE 2

Demographics and injury characteristics

Characteristic	N (% of total)
Sample size	109
Age, mean (SD)	80.1 (9.6)
Sex	
Female	72 (66.1)
Male	37 (33.9)
ASA score	
1	0 (0)
2	14 (12.7)
3	82 (75.2)
4	13 (11.9)
5	0 (0)
Procedure	
Arthroplasty	36 (33.0)
DHS	33 (30.3)
CMN	28 (25.7)
CRPP	12 (11.0)
Injury side	
Right	53 (48.6)
Left	56 (51.4)
Anesthesia type	
Spinal	50 (45.8)
General	59 (54.1)
Anticoagulation	
Yes	39 (35.8)
No	70 (64.2)
Discharge location	
Home	27 (24.8)
Acute care/rehabilitation	57 (52.3)
Long-term care	20 (18.3)
Mortality	5 (4.6)

ASA= American Society of Anesthesiologists; CMN = cephalomedullary nail; CRPP = closed reduction percutaneous pinning; DHS = dynamic hip screw; SD = standard deviation.

TABLE 3

EOCC descriptive univariate analysis

Variables	N	Median ($)	IQR	P
Global EOCC	109	13,113	6658	
Direct		9941	5001	N/A
Indirect		3322	1672	
Age				0.62
60–70	20	12,701	7798	
70–80	33	13,065	7011	
	56	14,339	7160	
Sex				0.13
Male	37	14,262	7470	
Female	72	12,608	6820	
ASA				**0.008**
2	14	12,300	7630	
3	82	13,083	5572	
4	13	22,584	30,326	
Anesthesia type				0.28
General	50	15,059	7724	
Spinal	59	12,811	6090	
ACO				0.26
Yes	39	14,345	6058	
No	70	13,058	7806	
Procedure				**0.0001**
DHS	33	11,727	5388	
CMN	28	16,215	10,391	
CRPP	12	9378	2461	
Arthroplasty	36	14,315	4384	
TTI < 48 h				**0.003**
Yes	63	12,114	6391	
No	46	15,479	8644	
Discharge location				
Home	27	11,386	6064	**0.02**
Acute rehab	57	12,837	5338	
LTC	20	16,328	17,659	
Mortality	5	18,588	24,946	

Bold indicates statistical significance.
ACO = anticoagulation; ASA = American Society of Anesthesiologists; CMN = cephalomedullary nail; CRPP = closed reduction percutaneous pinning; DHS = dynamic hip screw; EOCC = episode-of-care cost; IQR = interquartile range; LTC = long-term care; TTI = time-to-incision.

2.3. Hip fracture treatments

All patients included in the study underwent either internal fixation or arthroplasty depending on the fracture characteristics and classification. Fixation was performed using either sliding hip screw (Dynamic Hip Screw [DHS]—Synthes, Paoli, PA), cephalomedullary nail (Trochanteric Fixation Nail- TFN, Synthes), or percutaneous screws (CRPP). Of note, the cost of implants presented in this article is contingent on the contractual terms negotiated within the hospital network and may differ in other regions. Patients with fractures requiring arthroplasty underwent either a hemiarthroplasty or a total hip replacement. Either spinal or general anesthesia (GA) was used during the procedure. The intervention's start and end times were recorded in the institutional operating room software. Perioperative blood loss volume was recorded. All participants followed an institution-specific postoperative protocol, comprised early full weight-bearing mobilization with physiotherapy, geriatric medicine assessment, and medical optimization. The discharge date was recorded.

2.4. Statistical analysis

Univariate testing was performed using Kruskal–Wallis tests and the Mann Whitney U tests to determine the magnitude of the effect of each variable on EOCC. Then, the screened variables were introduced in a multiple linear regression model. An exhaustive search using the "leaps" package on Ver3.1 was used to select the variable to be included in the model. Root mean squared error (RMSE), R-squared, and Akaike information criterion were used to select the best model. Models were adjusted for demographic variation when possible. The cost regression coefficient in the multivariate model represented the relative difference in cost for each variable. For continuous variables, the coefficient is the additional cost in Canadian dollars per year. Coefficients for categorical variables represent the difference in EOCC with the reference group. Statistical significance level was set at $P < 0.05$ and confidence interval at 95%. Continuous variables are presented as median (interquartile range [IQR]). All analyses were performed using R v3.6 (the R Project for Statistical Computing).

TABLE 4

Length of stay (LOS) descriptive univariate analysis

Variables	Median (d)	IQR	P
Overall LOS	9.9	7.8	N/A
Intervention within 48 h	8.3	6.8	**0.002**
Delayed (>48 h)	12.5	7.4	
Age			
60–70	9.0	9.0	
70–80	9.5	8.0	0.4
80	10.6	7.4	
Sex			
Male	11.4	9.5	0.06
Female	9.0	7.6	
ASA classification			
2	9.1	9.3	**0.02**
3	9.5	7.6	
4	16.6	21.6	
Procedure type			
DHS	9.4	7.3	**0.01**
CMN	11.5	8.6	
CRPP	5.7	3.5	
Arthroplasty	10.0	7.7	
Anesthesia type			
General	10.7	6.9	0.18
Spinal	9.4	8.0	
Discharge location			
Home	7.6	6.9	**0.01**
Acute rehabilitation	9.5	7.0	
LTC	13.0	19.0	

Bold indicates statistical significance.
ASA = American Society of Anesthesiologists; CMN = cephalomedullary nail; CRPP = closed reduction percutaneous pinning; DHS = dynamic hip screw; IQR = interquartile range; LOS = length of stay; LTC = long-term care.

TABLE 5

Multivariable EOCC regression analysis

	Coefficient ($)	IQR	P
Intercept	14,112	4904	
ASA 4	6489	1796	**0.0004**
Age	−115	58	**0.05**
LOS	865	58	**<0.0001**
Procedure—CMN	1616	1491	0.28
Procedure—CRPP	−2010	1958	0.31
Procedure—arthroplasty	−109	1375	0.94

Bold indicates statistical significance.
ASA = American Society of Anesthesiologists; CMN = cephalomedullary nail; CRPP = closed reduction percutaneous pinning; IQR = interquartile range; LOS = length of stay.

TABLE 6

Length of stay multivariable regression analysis

	Coefficient (d)	IQR	*P*
Intercept	12.82	2.34	
ASA 4	10.29	2.80	**0.0004**
TTI < 48 h	−5.72	1.86	**0.003**
Total blood loss	0.01	0.01	**0.03**
Procedure—CMN	2.88	2.41	0.24
Procedure—CRPP	−3.45	3.20	0.28
Procedure—arthroplasty	−3.28	2.37	0.17

Bold indicates statistical significance.
ASA = American Society of Anesthesiologists; CMN = cephalomedullary nail; CRPP = closed reduction percutaneous pinning; IQR = interquartile range; TTI = time-to-incision.

3. Results

The study included 109 participants, with an average age of 80.1 years. Most participants were female (66.1%), and most patients had an ASA score of 3 (75.2%). Surgical procedures varied, with arthroplasty (33.0%) and DHS (30.3%) being the most common. Injuries were fairly evenly distributed between the right (48.6%) and left (51.4%) sides. Anesthesia types included spinal (45.8%) and general (54.1%). Most (64.2%) patients were anticoagulated, and discharge locations ranged from home (24.8%) to acute care/rehabilitation (52.3%) and long-term care (18.3%), with a 4.6% mortality rate.

The median EOCC was $13,113 (IQR = 6658), excluding physician fees. Out of the total cost, approximately 75% was attributed to direct costs, which represents a median expenditure of $9941. The median indirect cost per episode of care was $3322. Only 63 (57.8%) patients were operated within the 48-hour benchmark. Patients who were operated within the 48-hour guidelines (TTI) had on average a significantly lower median EOCC; $12,114 compared with $15,479 for patients operated after 48 hours ($P = 0.003$). Patients discharged to a long-term care facility had a significantly higher EOCC at a median of $16,328 which is significantly higher than the $11,386 associated with patients who returned home and $12,837 who were transferred to an acute rehabilitation facility ($P = 0.02$). Higher ASA scores were associated with more elevated EOCC; a significant difference was observed in the median cost for patients classified as ASA 2, 3, and 4; $12,300, $13,083, and $22,584, respectively ($P = 0.008$). No statistically significant differences were found between oral anticoagulants (ACO) use nor sex on EOCC. Indeed, the median EOCC for male patients was $14,262 compared with $12,608 for female patients ($P = 0.13$). The median EOCC for patients on ACO was $14,345 compared with $13,058 for patients not anticoagulated ($P = 0.26$). Variations were found in the EOCC for the 4 procedure types: DHS, cephalomedullary nail, CRPP, and arthroplasty. The median EOCC was $11,727, $16,215, $9378, and $14,315, the latter showing a statistically significant difference between procedure types ($P = 0.003$). No significant differences were observed based on the method of anesthesia.

The median length of stay was 9.9 (IQR = 7.8) days. Patients with ASA 2 stayed a median of 9.1 days; ASA class 3 patients remained 9.5 days in the hospital before discharge and those with ASA class 4, 16.6 days ($P = 0.02$). Patients treated within 48 hours were discharged significantly earlier after surgery after a median of 8.3 days compared with 12.5 days for patients who were operated after the 48-hour benchmark ($P = 0.002$). No significant difference from the anesthesia type on the median length of stay was observed. Patients who underwent general anesthesia were discharged at a median of 10.7 days after their intervention compared with 9.4 days for patients with spinal anesthesia ($P = 0.18$). Univariate analysis revealed a significant difference on the length of stay based on the procedure type ($P = 0.01$) and did underline a difference based on the orientation at discharge ($P = 0.01$).

The screened variables presented in Table 3 and Table 4 were introduced in a multiple linear regression model (Table 5), which revealed ASA score and the length of stay as the 2 major factors driving EOCC. When controlling for age, ASA classification, and procedure type, extending the length of stay by 1 day represented on average an increased cost of $865 ($P < 0.0001$). In addition, patients with ASA score of 4 had EOCCs of 6489$ higher ($P < 0.0004$) when controlling for age, length of stay, and procedure type. Differences in EOCC based on procedure type were not statistically significant (Table 6).

This subanalysis was performed to further study the variables affecting the length of stay. Patients with ASA scores of 4 stayed on average 10.29 more days in the hospital compared with patients with an ASA 2 or 3 ($P = 0.0004$) when controlling for time to incision, total blood loss, and procedure type. Respecting the 48-hour benchmark was associated with a decrease in the length of stay by 5.7 days ($P < 0003$) when controlling for ASA score, total blood loss, and procedure type. Blood loss was found not to be a main driver of length of stay. Nonstatistically significant differences were observed between procedure type and length of stay.

4. Discussion

This study aimed at assessing the costs associated with the acute management of geriatric proximal femoral fractures of a Level 1 trauma center in Canada using an ABC methodology. This methodology provides a detailed analysis of both direct and indirect costs. For this cohort, the median EOCC for acute hip fractures in an elderly population cost was $13,113. Patients stayed a median of 9.9 days in the hospital before being discharged. These results are compatible with previously published large reviews and meta-analysis.[34,36,37] The costing methodology presented in this study differs in many ways from the ones used in the studies mentioned above. Instead of being approximated, direct cost of all items in this study were extracted, codified, and linked to an encounter. Costs associated with all consumables were calculated based on actual prices paid by the hospital. The total EOCC was completed by the inclusion of indirect costs following an ABC allocation methodology to provide a more precise calculation compared with the historical approximations used.[19] Indirect costs were calculated based on the unit cost of supplying capacity and the time required to perform the activity. This process analysis usually results in more accurate indirect costs compared with traditional accounting.[19] As mentioned above, physician fees were not part of the scope of this Canadian study because those expenses are not assumed by the hospital. These combined physician billing fees were previously estimated to range from $4000 to $5000 CAD$.[36,38]

The screened variables (Table 3) were introduced in a multiple linear regression model (Table 5). Among this cohort of patients with hip fracture, the major factors found to drive EOCC based on the multivariate analysis were the ASA score and the length of stay. On average, extending the length of stay by 1 day represents an increase cost of $865 ($P < 0.0001$). Owing to the strength and impact of LOS on the EOCC, a subanalysis was performed to further describe variables affecting the LOS. This second model

determined that ASA 4 patients stay on average 10 days, 3 days more than patients with an ASA 2 or 3 ($P = 0.0004$). When applied to the EOCC model, at 865$ per additional day, we can infer that it represents $8903. More importantly, this subanalysis also revealed that not respecting the 48-hour benchmark increases the length of stay by 5.7 days, representing an expense of $4948. This last finding, in addition to the known clinical benefits, reinforces the importance of intervening early for patients suffering from acute proximal femur fractures. Higher EOCC in patients not operated within the benchmark could have arisen from more frequent postoperative complications including hospital-acquired infections and deconditioning which are associated with delayed intervention.[16,17,39–41]

When controlling for other variables, the procedure type did not significantly impact the LOS or EOCC. Although specific patient comorbidities and perioperative complications certainly impact EOCC, fracture severity and its associated surgical procedures were also previously identified to influence EOCC.[42–44] In fact, CRPP is frequently performed for Garden 1 valgus impacted femoral neck fractures. This stable pattern and minimal surgical burden often permit rapid mobilization, which is reflected by a trend to lower EOCC in our cohort.

Patients who required a relocation to a long-term care facility had the highest median EOCC at $16,328 compared to all other discharge locations on the univariate analysis. This is unsurprising as Quebec continues to face severe hurdles to transfer patients to public long-term care facilities, called the *Centres d'hébergement de soins de longue durée* (CHSLD). With an average waiting time of 300 days for patients in Quebec to be attributed a bed in a CHSLD, a deplorable backlog is generated which becomes a hindrance to the discharge process from the orthopedic ward.[45]

There are limitations in this study that can be addressed in future research. Small sample size can exacerbate the impact of outliers and generalizability. Although the data were drawn from a single institution and restrict generalized conclusions, these institution-specific data should be disseminated for interinstitution comparisons and internal quality improvement initiatives. The retrospective nature of this study entails a potential selection bias for the composition of this cohort. Finally, procedural billing and salaries of the emergency room physician, surgeon, anesthesiologist, internist geriatrician, and radiologist were voluntarily excluded as mentioned above. Finally, the current methodology did not allow for analysis of cost of follow-ups after discharge nor time spent in rehabilitation facilities.

Ultimately, this observational study attempted to provide accurate episode-of-care costing analysis of a geriatric hip fracture cohort. With adequate funding allocation, it is believed that health institutions will be better equipped to provide optimal care to this fragile population. Nonetheless, hospital admissions for acute hip fractures result in emotional, psychological, and physical distress for the patient as well as the economic burden on the health care system. The importance of primary prevention through fall prevention programs and optimizing patient bone health should be reinforced. Despite best efforts, hip fracture occurrence is predicted to increase steadily,[46] resulting in a significant burden on our health care system. Therefore, efforts to reduce surgical delays and improve access to rehabilitation and long-term care facilities should be deployed.

5. Conclusion

To our knowledge, this is the first study published using an ABC approach in the assessment of acute geriatric hip fracture EOCC. For this cohort, the management of this condition from arrival to the emergency department to discharge represented a median $CAD 13,113, excluding physician fees. Main factors influencing the EOCC included adherence to the 48-hour benchmark and higher ASA score. On top of recent clinical studies, our value-based analysis also suggests that expediting TTI should continue to be a priority given its perioperative impact. High-quality costing data are vital in assessing health care spending, conducting cost effectiveness analyses, and ultimately in guiding policy decisions.

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