

Frailty Cost: Economic Impact of Frailty in the Elective Surgical Patient



Justin G Wilkes, MD, Jessica L Evans, MS, B Stephen Prato, MS, Steven A Hess, MD, FACP, FACCP, Dougald C MacGillivray, MD, FACS, Timothy L Fitzgerald, MD, FACS

BACKGROUND: Frailty in the surgical patient has been associated with increased morbidity, mortality, and failure to rescue. However, there is little understanding of the economic impact of frailty.

STUDY DESIGN: A prospective database of elective surgery patients at an academic medical center was used to create a modified version of the Risk Analysis Index (RAI), a validated frailty index. This included 10,257 patients undergoing elective operations from 2016 to 2017. Patients were classified as not frail (RAI = 0), somewhat frail (RAI = 1 to 10), or significantly frail (RAI > 10). Cost, revenue, and income data were procured from the finance department. Univariate and multivariate analyses were performed.

RESULTS: Frail patients were more likely to be older (65 years vs 50 years; $p < 0.001$) and inpatient (19% vs 36%; $p < 0.001$). General surgical, gynecologic, urologic, and cardiothoracic services operated on a higher percentage of significantly frail patients compared with orthopaedic, neurosurgical, and vascular ($p < 0.001$). On univariate analysis, frail patients were more likely to die (0% vs 0.4%; $p < 0.001$) and have increased length of stay (0.8 vs 2.1 days; $p < 0.001$), higher total cost (\$6,934 vs \$13,319), and lower net hospital income (\$5,447 vs \$3,129) ($p < 0.001$). On multivariate analysis, frailty was independently associated with increased direct cost (odds ratio [OR] 2.2; $p < 0.001$), indirect cost (OR 1.9; $p < 0.001$), total cost (OR 2.2; $p < 0.001$), and net income (OR 0.8; $p < 0.001$). Stratified by service line and inpatient vs outpatient status, frailty continued to be associated with increased direct cost, indirect cost, total cost, and decreased hospital income.

CONCLUSIONS: Although a significant number of data exist on the impact of frailty in the surgical patient, the economic impacts have only limited description in the literature. Here we demonstrate that frailty, independent of age, has a detrimental financial impact on cost and hospital income in elective surgery. (J Am Coll Surg 2019;228:861–870. © 2019 Published by Elsevier Inc. on behalf of the American College of Surgeons.)

Preoperative evaluation has expanded during the last 3 decades to include dementia and cognitive evaluations, measures of sarcopenia, and nutritional assessments.^{1–6} Underlying all preoperative evaluation has been an

intuitive “eye test” of ability to withstand a given operation. The assessment of physiologic reserve and vulnerability to external stressors is termed *frailty*.⁷

The phenotypes of frailty (ie unintentional weight loss, impaired grip strength, exhaustion, slowness, and low physical activity) along with accumulated deficits or comorbidities (ie oxygen dependence, heart failure, chronic kidney disease) have been combined to create frailty indices.^{8–15} These measures might require clinical testing (ie “get-up-and-go test,” sarcopenia measurements),^{2–5,16,17} chart review,^{16,18} questionnaire, or a combination of these measures.^{2,10–12,14,15,19–23}

The accumulation of deficits over time is quite variable, as demonstrated by the aged vs spry 80-year-old patient. Frailty is a better predictor of mortality than age alone.^{20,22,24–26} Indeed, the frail young patient can have worse outcomes than the frail elderly patient.²⁷

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From the Departments of Surgery (Wilkes, Prato, MacGillivray, Fitzgerald), Internal Medicine (Hess), and Division of Surgical Oncology (MacGillivray, Fitzgerald), Maine Medical Center, Portland, ME, and Tufts University School of Medicine, Boston, MA (Evans, Hess, MacGillivray, Fitzgerald).

Correspondence address: Timothy L Fitzgerald, MD, FACS, Department of Surgery, Division of Surgical Oncology, Maine Medical Center, 887 Congress St, #400, Portland, ME 04102. email: tlfitzgera@mmc.org

Frailty is directly associated with postoperative mortality, complications, length of stay, ICU admissions, hospital re-admission, oncologic outcomes, cardiac outcomes, and post-discharge institutionalization irrespective of age.^{2,4,5,9,11-16,18,19,23,25-35} Interventions aimed at improving the outcomes in the frail are being explored³³ and have been fruitful with regard to decreasing functional loss postoperatively and decreasing complication rates.³⁶

The cost associated with the frail elective surgical patient is poorly defined. It is expected that poorer outcomes associated with frailty would increase the cost of care. Using a simple clinical questionnaire and validated frailty index, along with actual financial data from our institution, we sought to define the increased cost associated with elective operation on the frail.

METHODS

A retrospective review of a prospectively collected database of elective surgical patients who presented to Maine

Medical Center during a 1-year period (June 2016 to June 2017) was conducted. Inclusion criteria were any elective operation. Data were analyzed by authors not involved in data collection or frailty assessment. The study was approved by the Maine Medical Center IRB.

Frailty score

Participants underwent a standardized questionnaire preoperatively conducted by a trained registered nurse. Demographic information, comprehensive medical history including current prescription medications, and the patient's preoperative living situation were obtained. Comorbidities were obtained from the electronic medical record (EMR). Results from the preoperative questionnaire along with comorbidities were operationalized to fit criteria in a validated frailty index known as the Clinical Risk Analysis Index.²¹ Briefly, patients are scored in 4 categories: age and cancer diagnosis, medical comorbidities, residence and activity of daily living, and cognitive

Table 1. Demographics and Frailty

Characteristic	Frailty score			Overall	p Value
	0	1–10	>10		
Age, y, mean ± SD	50 ± 13	68 ± 12	65 ± 14	58 ± 16	<0.0001
Race, %					<0.0001
White	96	97	98	96	
Non-white	4	3	2	4	
Sex, %					<0.0001
Male	45	49	41	45	
Female	55	51	59	55	
Service, %					<0.0001
General surgery	59	16	25	—	—
Orthopaedic	59	36	5	—	—
Gynecology	62	12	27	—	—
Neurosurgery	56	33	11	—	—
Vascular	18	64	18	—	—
Urology	39	23	38	—	—
Cardiothoracic	29	40	32	—	—
Other	61	27	12	—	—
Mortality, %	—	0.1	0.4	0.1	<0.0001
LOS, d, mean ± SD	0.8 ± 0.03	1.4 ± 0.04	2.1 ± 0.05	1.2 ± 2.1	<0.0001
Cost (SE), \$					
Direct cost	4,768 (132)	8,266 (180)	8,973 (223)	6,539 (98)	<0.0001
Indirect cost	2,167 (52)	3,329 (70)	4,346 (87)	2,900 (38)	<0.0001
Total cost	6,934 (180)	11,594 (245)	13,319 (304)	9,439 (134)	<0.0001
Net income	5,447 (146)	1,025 (200)	3,129 (248)	3,761 (108)	<0.0001
Patient type, %					<0.0001
Inpatient	19	36	36	27	
Outpatient	81	64	64	73	
Total, n	5,444	2,917	1,896	10,257	

Patients were classified as not frail (score = 0), somewhat frail (score 1–10), or significantly frail (score >10). LOS, length of stay.

Table 2. Direct Cost: Binary Cohort Comparison Median

Characteristic	<\$3,443	>\$3,443	Univariate analysis, p Value	Multivariate analysis	
				Odds ratio (95% CI)	p Value
Age, y, mean \pm SD	55 \pm 17	61 \pm 15	<0.0001	0.9 (0.8–1.1)	0.3
Race, %			0.0002		0.6
White	50	50		1.0	
Non-white	60	40		0.9 (0.8–1.4)	
Sex, %			0.5		
Male	50	50		—	—
Female	50	50		—	—
Service, %			<0.0001		<0.0001
General surgery	61	39		1	
Orthopaedic	37	63		1.6 (1.3–1.8)	
Gynecology	52	48		2.0 (1.7–2.3)	
Neurosurgery	38	63		2.2 (1.8–2.6)	
Vascular	36	64		2.2 (1.8–2.7)	
Urology	62	38		0.7 (0.6–0.9)	
Cardiothoracic	11	89		1.9 (1.3–2.9)	
Other	80	20		0.6 (0.5–0.7)	
Frailty, %			<0.0001		<0.0001
0	60	40		1	
1–10	40	60		1.6 (1.4–1.9)	
>10	37	63		2.2 (1.9–2.6)	
Patient type, %			<0.0001		<0.0001
Inpatient	2	98		69 (53–89)	
Outpatient	68	32		1	
Total, n	5,127	5,127	—	—	—

decline. The Clinical Risk Analysis Index yields a theoretical score of 0 to 81. Patients were classified as not frail (score = 0), somewhat frail (score 1 to 10), or significantly frail (score >10).

Information on other potentially confounding variables was collected, including age, race, sex, operation category (inpatient [typically requiring more than 1-night hospitalization] vs outpatient [typically performed the same day or discharge planned the following morning]), and surgical service (ie general surgery, neurosurgery, and orthopaedics).

The main outcomes were direct cost, indirect cost, total cost, total charges, net revenue, and net income. Direct costs include all items or services that are used in the provision of direct care to patients (eg medications, nursing care, laboratory tests, surgeon direct care time, hours in post-anesthesia care unit, IV fluids). Indirect costs include all services and processes that provide the infrastructure for the delivery of direct care (eg electricity, housekeeping, technology and depreciation, information technology services, EMR, and medical education). Total cost is the sum of direct and indirect costs. Charges are what the patient and insurance company are billed for hospital care. Net revenue is the income received (ie total reimbursement

or payments). Net income is the difference between net revenue and the total cost.

Cost variables are collected from the EMR and the general ledger. They are not estimates or extrapolations. Using the EMR, all items and services provided a patient are tracked, tallied, and costed out. The general ledger keeps account of many indirect costs (eg electricity, education, upkeep, and depreciation). In analysis, cost and income were operationalized as binary variables, divided into 2 groups at the median. Other dependent variables collected included death and post-discharge institutionalization. All statistical analyses were performed using JMP, version 13.0.0 (SAS Institute).

Statistical analysis

Data are provided as a mean and SEM for continuous variables. Frequency tables were produced for categorical variables. Statistical analysis was performed using chi-square or Fisher's exact test for categorical variables and compared characteristics of subjects within 3 categories of frailty (ie not frail, somewhat frail, significantly frail). Univariate logistic regression was used to determine the impact of frailty and other independent variables on the primary outcomes

Table 3. Indirect Cost: Binary Cohort Comparison Median

Characteristic	<\$1,800	>\$1,800	Univariate analysis, p Value	Multivariate analysis	
				Odds ratio (95% CI)	p Value
Age, y, mean \pm SD	56 \pm 17	61 \pm 15	<0.0001	1.0 (0.9–1.2)	0.7
Race, %			<0.0001		0.054
White	49	51		1.0	
Non-white	65	35		0.8 (0.6–1.0)	
Sex, %			0.2		<0.01
Male	51	49		1.0	
Female	49	51		1.2 (1.0–1.3)	
Service, %			<0.0001		<0.0001
General surgery	59	41		1.0	
Orthopaedic	39	61		1.1 (1.0–1.4)	
Gynecology	50	50		2.0 (1.6–2.3)	
Neurosurgery	27	73		3.6 (3.1–4.5)	
Vascular	51	49		0.9 (0.8–1.1)	
Urology	58	42		0.9 (0.7–1.1)	
Cardiothoracic	11	89		1.7 (0.6–1.4)	
Other	83	17		0.4 (0.4–0.5)	
Frailty, %			<0.0001		<0.0001
0	58	42		1.0	
1–10	43	57		1.4 (1.2–1.6)	
>10	38	62		1.9 (1.7–2.2)	
Patient type, %			<0.0001		<0.0001
Inpatient	1.6	98		112 (83–152)	
Outpatient	68	32		1	
Total, n	5,127	5,127	—	—	—

variables. Independent variables found to have a potentially significant impact on cost variables ($p < 0.2$) were analyzed in multivariable regression models and presented as ORs. Variables for univariate logistic regression were used as continuous variables whenever possible in this part of the analysis, but otherwise were divided into 2 groups at the median (eg median direct cost for all cases \$3,443. Groups are compared at more than and less than \$3443). Statistical significance was set at $p < 0.05$.

RESULTS

Among 10,257 elective surgical patients, 5,444 (53%) were not frail, 2,917 (28%) were somewhat frail, and 1,896 (18%) were significantly frail (Table 1). Of the significantly frail patients, 98% were white, 59% were female, and there was a 0.4% mortality. In-hospital mortality in the somewhat frail and not frail was 0.1% and 0%, respectively ($p < 0.0001$). Table 1 also describes the variability in frailty across service lines and inpatient vs outpatient procedures, with more inpatient procedures performed on the somewhat and significantly frail. There was a significant association of frailty with age, mortality, and length of stay

($p < 0.001$). There was also a significant positive correlation between frailty and direct cost, indirect cost, and total cost, and there was a significant negative correlation with frailty and net income ($p < 0.001$).

Cost variables

On univariate analysis, frailty, age, race, service line, and patient status (inpatient vs outpatient) were associated with all 3 cost variables (direct cost, indirect cost, and total cost) (Tables 2, 3, and 4). On multivariate, also regarding all 3 cost variables, age and race were not significant predictors, and frailty, service line, and patient status maintained significance. Odds ratios for direct cost, indirect cost, and total cost, above the median for somewhat frail patients compared with the not frail were 1.6, 1.4, and 1.7 respectively ($p < 0.0001$). Odds ratios for direct cost, indirect cost, and total cost, above the median for significantly frail patients compared with the not frail were 2.2, 1.9, and 2.2, respectively ($p < 0.0001$).

Net income

On univariate analysis frailty, age, race, service line, financial class, and patient status (inpatient vs outpatient) were

Table 4. Total Cost: Binary Cohort Comparison Median

Characteristic	<\$5,331	>\$5,331	Univariate analysis, p Value	Multivariate analysis	
				OR ratio (95% CI)	p Value
Age, y, mean \pm SD	55 \pm 17	61 \pm 15	<0.0001	1.0 (0.8–1.1)	0.4
Race, %			0.0002	—	0.7
White	50	50		1.0	
Non-white	60	40		0.9 (0.7–1.2)	
Sex, %			0.7		
Male	50	50		—	—
Female	50	50		—	—
Service, %			<0.0001		<0.0001
General surgery	61	39		1.0	
Orthopaedic	37	63		1.5 (1.3–1.7)	
Gynecology	52	48		2.1 (1.8–2.4)	
Neurosurgery	35	65		2.6 (2.2–3.1)	
Vascular	36	64		2.2 (1.8–2.7)	
Urology	61	39		0.8 (0.7–1.0)	
Cardiothoracic	11	89		2.0 (1.3–3.0)	
Other	82	18		0.5 (0.5–0.7)	
Frailty, %			<0.0001		<0.0001
0	60	40		1.0	
1–10	40	60		1.7 (1.4–1.9)	
>10	38	62		2.2 (1.9–2.5)	
Patient type, %			<0.0001		<0.0001
Inpatient	2	98		76 (59–99)	
Outpatient	68	32		1	
Total, n	5,127	5,127	—	—	—

all found to be significant predictors of net income (Table 5). Note that financial class was included in this analysis, as net income is highly dependent on the insurer. On multivariate, age and sex were not significant predictors of income, and frailty, financial class, service line, race, and patient type maintained significance. The odds ratio for net income below the median for somewhat frail patients compared with the not frail was 0.7 ($p < 0.0001$). The odds ratio for net income below the median for significantly frail patients compared with the not frail was 0.8 ($p < 0.0001$).

Inpatient analysis of the significantly frail by service line

Recognizing the profound impact of inpatient operations and variability across service lines, a subset analysis of total cost was performed by stratifying across service lines (Table 6). The ORs of total cost comparing the significantly frail to the not frail are demonstrated in Figure 1. At the most extreme, inpatient procedures on the significantly frail in urology, general surgery, orthopaedics, and gynecology were all higher than or approaching an OR of 10.0. Vascular and cardiothoracic

procedures trended toward significantly increased cost and neurosurgery was near 1.0.

To decrease the likelihood that a particularly costly operation only performed on the most frail would skew results, a subset analysis of the most common inpatient operations within the service lines identified here was performed (Table 7). This included open bowel cases in general surgery (69 colon, 37 rectal, and 33 small intestine), hip ($n = 559$) and knee ($n = 422$) replacement in orthopaedic surgery, open operations in gynecology (49 hysterectomy, 8 oophorectomy, 8 salpingectomy, and 23 other), and laparoscopic renal operation in urology (primarily nephrectomies). All comparisons had 8 or more patients in each frailty category, with the lone exception of the somewhat frail group in laparoscopic renal operations. All cost variables were significantly higher in the increasingly frail in open bowel operations, hip replacements, knee replacements, and open gynecology operations (with a trend toward significance in indirect cost for open gynecology operations). Total income was significantly lower in the increasingly frail in open bowel operations, hip replacement, knee replacements, and laparoscopic renal operations.

Table 5. Net Hospital Income: Binary Cohort Comparison Median

Characteristic	<\$1,557	>\$1,557	Univariate analysis, p Value	Multivariate analysis	
				Odds ratio (95% CI)	p Value
Age, y, mean \pm SD	63 \pm 16	53 \pm 14	<0.0001	0.9 (0.8–1.1)	0.2
Race, %			<0.0001		<0.0001
White	49	51		1.0	
Non-white	65	35		0.2 (0.2–0.3)	
Sex, %			0.0002		0.1
Male	52	48		1.0	
Female	48	52		1.1 (1.0–1.2)	
Financial class, %			<0.0001		<0.0001
Medicare	83	17		1	
Other	25	75		17 (14–20)	
Service, %			<0.0001		<0.0001
General surgery	46	54		1.0	
Orthopaedic	41	59		1.3 (1.1–1.5)	
Gynecology	41	59		1.2 (1.0–1.4)	
Neurosurgery	43	57		1.5 (1.2–1.8)	
Vascular	75	25		0.6 (0.5–0.8)	
Urology	62	38		0.7 (0.6–0.9)	
Cardiothoracic	62	38		0.5 (0.4–0.6)	
Other	59	41		0.8 (0.7–1.0)	
Frailty, %			<0.0001		<0.0001
0	35	65		1.0	
1–10	71	29		0.7 (0.6–0.8)	
>10	59	41		0.8 (0.7–0.9)	
Patient type, %			<0.0001		<0.0001
Inpatient	42	58		3.7 (3.2–4.2)	
Outpatient	53	47		1.0	
Total	5,127	5,127	—	—	—

DISCUSSION

Frailty is associated with an increased risk of postoperative complications, length of stay, post-discharge institutionalization, and mortality, in the elective surgery patient irrespective of age.^{3,12,19,29} Although increased cost is implied, few studies have gone so far as to define the cost of caring for the frail patient.^{37–44} Most studies that have analyzed cost in frail surgical patients to date have been in acute surgical patients,^{38,39,43,44} for specific procedures,^{37,40,41} using costly or time-consuming frailty measures,^{38,40,41,44,45} or using estimated costs based on CPT codes or patient questionnaires.^{39,41,42} To our knowledge, ours is the first study to formally analyze costs associated with all elective surgery in frail patients using a simple, validated, frailty index and real accounting data.

Given the known association of frailty with morbidity and mortality,^{3,12} it is not surprising to find that there is a correlation of frailty with increased direct, indirect, and total costs. Most importantly, as with other studies,

our study demonstrates that on multivariate analysis, frailty is a stronger predictor of cost than age (which loses significance). A limitation of our current database is the lack of complications data. It is unclear if frailty is associated with increased cost in the frail patient without complications. Given some of the resources necessary to take care of the frail (eg physical therapy, respiratory care, and consultants involved in care), it would be expected that even the frail patient without complication would incur increased cost compared with the not frail patient.

Given the expected increased cost of caring for the frail, it is important to examine the effect on income for the hospital. Because this is largely dependent on third-party payers (of which there are numerous), we included Medicare vs other payers in our income analysis. Even with this taken into account, OR for net income below the median for the frail was significantly lower than for the not frail. Interventions aimed at addressing frailty in the literature have been relatively few, but knowledge of

Table 6. Direct Cost Odds Ratios Across Service Line and Patient Status with Risk Analysis Index Score = 0 as Reference

Variable	Risk Analysis Index score	
	1–10	>10
General		
Inpatient	0.9	0.8
Outpatient	0.9	1.4 (0.03)
Orthopaedic		
Inpatient	0.5 (0.0002)	0.3 (0.0003)
Outpatient	0.8	1.2
Gynecology		
Inpatient	0.6	0.9
Outpatient	0.5	1.2
Neurosurgery		
Inpatient	0.7	0.8
Outpatient	0.6	0.2 (0.0063)
Vascular		
Inpatient	1.2	1.6
Outpatient	0.4 (0.0041)	0.4 (0.0062)
Urology		
Inpatient	0.3	0.4
Outpatient	0.7	0.7
Cardiothoracic		
Inpatient	0.5	0.4
Outpatient	0.7	2.0
Other		
Inpatient	4.7e+6	6.3e+13
Outpatient	0.6 (0.0048)	0.5 (0.0066)

Values are odds ratio. Numbers in parentheses represent p values for significantly different values in reference to Risk Analysis Index = 0.

the negative effect of frailty on the bottom line of a hospital justifies additional research and attempts at intervention that might seem costly.

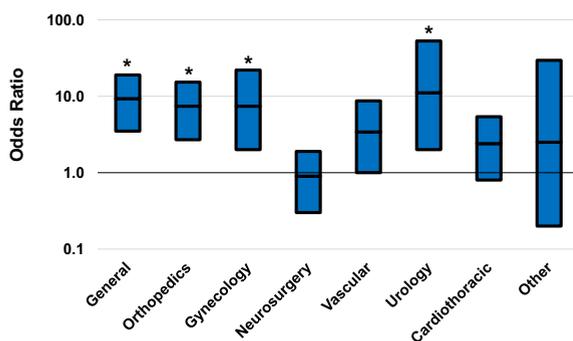


Figure 1. Total cost odds ratio (with 95% CI, as demonstrated by box plot) on logarithmic scale. Calculated as odds of significantly frail patients costing greater than the median cost for inpatient elective operations stratified by service and Risk Analysis Index with not frail patients (not depicted) as the reference value (* $p < 0.05$).

Of note in the multivariate analysis, there is significant variability across service lines with regard to cost and income when comparing the frail with the not frail. Even so, when stratifying across service lines for one of the variables, total cost, we demonstrate that most service lines spend more money on the significantly frail than on the not frail, with few exceptions. With this approach of stratification, specific services have been identified that might be ripe for intervention for improving care for the frail and decreasing institutional financial burden.

One of the weaknesses of this study is the high variability of procedures included across all of the surgical specialties. Subset analysis of the most common operations in general surgery, orthopaedics, gynecology, and urology, confirmed suspicion that when lumped into common inpatient operations, trends toward increased cost and decreased hospital income hold true. The impact of this analysis is 2-fold in that it also suggests that complex, costly, procedures only performed on the most frail are unlikely to skew results in individual service lines.

The cause of these cost and income differences is ripe to be studied. There are several possibilities. Pre-emptive consulting services, such as geriatrics, pharmacy medication reconciliation services, physical and occupational therapy services, and hospital elder life programs certainly increase cost. Without complications data incorporated, it is unclear if the most frail in this data set are having more complications, but were the incidence equal across groups, a complication in a frail patient is likely more costly than in a hardy patient. These questions, in the context of cost analysis, can guide future investment in preparing and treating frail elective surgery patients.

CONCLUSIONS

Frailty is a significant predictor of increased cost and decreased net hospital income in elective surgery patients. This was accomplished using a simple preoperative questionnaire operationalized to a validated frailty index that does not require cumbersome and costly frailty measures.³ This effect is independent of age, and it is true when stratified across most service lines. Our data are corroborated by studies that have assessed real cost associated with frailty for specific elective operations (eg total joint arthroplasty).³⁷ The power of this information is that it justifies the return on investment in attempts at mitigating contributing factors to complications in the frail (eg prehabilitation or hospital elder life programs).³⁶ Any number of factors could contribute to this cost, some of them are easier to measure (direct costs) than others (indirect). Additional study will be performed in teasing out which specific factors increase cost in these patients.

Table 7. Subset Analysis of Cost and Income in Comparison with Frailty among Most Common Operations in Chosen Subspecialties

Variable	Frailty score			p Value
	0	1–10	11–43	
General surgery, open bowel				
n	52	34	55	
Direct cost, \$, median (95% CI)	8,541 (7,944 to 9,770)	7,426 (6,426 to 9,068)	9,997 (9,514 to 13,292)	<0.01
Indirect cost, \$, median (95% CI)	5,388 (5,205 to 6,432)	6,198 (4,436 to 6,769)	6,654 (6,120 to 8,256)	<0.05
Total cost, \$, median (95% CI)	13,612 (13,154 to 16,198)	12,970 (10,869 to 15,260)	16,670 (15,671 to 21,511)	<0.01
Net income, \$, median (95% CI)	13,753 (9,527 to 17,019)	3,934 (2,057 to 7,668)	6,990 (5,736 to 16,444)	<0.05
Orthopaedic surgery, hip replacement				
n	239	280	40	
Direct cost, \$, median (95% CI)	9,423 (9,251 to 9,847)	9,962 (9,396 to 10,649)	11,317 (11,147 to 14,926)	<0.0001
Indirect cost, \$, median (95% CI)	3,137 (3,013 to 3,286)	3,416 (3,146 to 3,668)	4,505 (4,363 to 6,055)	<0.0001
Total cost, \$, median (95% CI)	12,565 (12,264 to 13,128)	13,388 (12,569 to 14,300)	15,723 (15,666 to 20,938)	<0.0001
Net income, \$, median (95% CI)	13,115 (10,767 to 15,237)	3,705 (2,211 to 5,749)	-928 (-4,312 to -583)	<0.0001
Orthopaedic surgery, knee replacement				
n	136	244	42	
Direct cost, \$, median (95% CI)	9,931 (9,871 to 10,518)	10,451 (10,151 to 11,306)	10,422 (10,309 to 15,819)	<0.01
Indirect cost, \$, median (95% CI)	3,755 (3,735 to 3,968)	4,017 (3,941 to 4,276)	4,181 (4,032 to 6,379)	<0.0001
Total cost, \$, median (95% CI)	13,694 (13,575 to 14,478)	14,480 (14,089 to 15,570)	14,491 (14,382 to 22,156)	<0.0001
Net income, \$, median (95% CI)	13,510 (10,055 to 16,497)	3,740 (1,392 to 5,996)	844 (-2,432 to 4,071)	<0.0001
Gynecology, open gynecology				
n	26	8	54	
Direct cost, \$, median (95% CI)	4,858 (4,439 to 5,805)	6,649 (3,527 to 16,499)	6,424 (6,174 to 9,396)	<0.05
Indirect cost, \$, median (95% CI)	3,409 (3,147 to 4,067)	4,428 (2,524 to 10,052)	6,106 (4,401 to 6,138)	0.07
Total cost, \$, median (95% CI)	8,266 (7,591 to 9,866)	11,011 (6,067 to 26,536)	10,850 (10,286 to 15,529)	<0.05
Net income, \$, median (95% CI)	6,960 (3,468 to 9,126)	622 (-6,415 to 4,195)	2,769 (601 to 6,561)	0.15
Urology, laparoscopic renal				
n	7	2	22	
Direct cost, \$, median (95% CI)	8,178 (6,384 to 12,314)	9,275*	9,561 (8,179 to 11,144)	0.6
Indirect cost, \$, median (95% CI)	3,981 (3,350 to 5,984)	5,075*	4,708 (4,174 to 5,811)	0.7
Total cost, \$, median (95% CI)	12,159 (9,745 to 18,287)	14,350*	14,269 (12,382 to 16,925)	0.6
Net income, \$, median (95% CI)	18,738 (5,938 to 27,289)	2,735*	4,387 (2,514 to 11,713)	<0.05

Subspecialties selected based on significant values in Table 1. All comparisons were performed with 1-way ANOVA unless otherwise noted. *95% CI not shown for 2 values. Student's *t*-test comparing not frail with most frail performed.

Author Contributions

Study conception and design: Wilkes, Evans, Prato, Hess, MacGillivray, Fitzgerald

Acquisition of data: Wilkes, Evans, Prato, Fitzgerald

Analysis and interpretation of data: Wilkes, Fitzgerald

Drafting of manuscript: Wilkes, Fitzgerald

Critical revision: Wilkes, Hess, MacGillivray, Fitzgerald

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Invited Commentary



Peter J Mazzaglia, MD, FACS
Providence, RI

In recent years, the concept of frailty, which encompasses a more total assessment of patient well-being and resilience, has found favor as a predictor of treatment outcomes. As demographic and socioeconomic forces combine to increase the number of frail patients in the population, medicine must develop better tools for identifying such patients so that appropriate interventions may be implemented. The goals of such steps should be 2-fold, improving patient care and wisely managing the cost of delivery. Although much investigation has occurred into the direct impact that frailty

has on well-defined medical outcomes, the actual differences in hospital cost and net income that result from increasing patient frailty have not been well studied.

In this original study from investigators at Maine Medical Center, the impact of patient frailty on cost of elective surgical care is examined. The authors were able to use a standardized preoperative questionnaire, routinely administered to all electively scheduled patients, and combine those answers with comorbidities to assign reproducible frailty scores. Patients were classified as not frail, somewhat frail, or significantly frail. Using multivariate analysis, the authors were able to assess the impact that individual patient frailty had on total cost and net income for individual elective surgical procedures across various specialties.

Not surprisingly, total cost was roughly 1.5 times greater than the median in somewhat frail patients, and more than 2 times greater in the significantly frail. Age was not a significant predictor. Increased total costs translated to significantly lower net incomes, with odds ratios of 0.7 and 0.8 in the somewhat and significantly frail groups, respectively. Recognition of such disparate profit margins, realized for what initially is booked as the same elective procedure, is certainly a major take-home message of this work. As the US population becomes increasingly frail, potential reductions in a hospital's revenue from the elective surgical revenue stream could have a negative impact on the institution's bottom line.

Going forward, it will take an informed coordinated team of health care providers and administrators to formulate strategies that will address this issue in a multifaceted approach. We need to continue to provide high quality elective surgical care to all patients, while recognizing that the subset will incur higher costs, and therefore, implement pre-emptive interventions for mitigating negative disparities.