Preoperative Frailty and Surgical Outcomes Across Diverse Surgical Subspecialties in a Large Health Care System

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BACKGROUND: Frailty is an emerging risk factor for surgical outcomes; however, its application across large populations is not well defined. We hypothesized that frailty affects postoperative outcomes in a large health care system.

STUDY DESIGN: Frailty was prospectively measured in elective surgery patients (January 2016 to June 2017) in a health care system (4 hospitals/901 beds). Frailty classifications—low (0), intermediate (1 to 2), high (3 to 5)—were assigned based on the modified Hopkins score. Operations were classified as inpatient (IP) vs outpatient (OP). Outcomes measured (30-day) included major morbidity, discharge location, emergency department (ED) visit, readmission, length of stay (LOS), mortality, and direct-cost/patient.

RESULTS: There were 14,530 elective surgery patients (68.1% outpatient, 31.9% inpatient) preoperatively assessed (cardiothoracic 4%, colorectal 4%, general 29%, oral maxillofacial 2%, otolaryngology 8%, plastic surgery 13%, podiatry 6%, surgical oncology 5%, transplant 3%, urology 24%, vascular 2%). High frailty was found in 3.4% of patients (5.3% IP, 2.5% OP). Incidence of major morbidity, readmission, and mortality correlated with frailty classification in all patients ($p < 0.05$). In the IP cohort, length of stay in days (low 1.6, intermediate 2.3, high 4.1, $p < 0.0001$) and discharge to facility increased with frailty ($p < 0.05$). In the OP cohort, ED visits increased with frailty ($p < 0.05$). Frailty was associated with increased direct-cost in the IP cohort (low, $7,045; intermediate, $7,995; high, $8,599; $p < 0.05$).

CONCLUSIONS: Frailty affects morbidity, mortality, and health care resource use in both IP and OP operations. Additionally, IP cost increased with frailty. The broad applicability of frailty (across surgical specialties) represents an opportunity for risk stratification and patient optimization across a large health care system. (J Am Coll Surg 2019;228:482−493. © 2019 by the American College of Surgeons. Published by Elsevier Inc. All rights reserved.)

Frailty has been described as "a state of increased vulnerability usually associated with aging and a decline in reserve such that the ability to cope with acute stressors is compromised."[1] Although previous studies have demonstrated prevalence of frailty in the elderly population,[2] there is an association with increased incidence of postoperative complications in people as young as 40 years of age.[3,4] With the national obesity epidemic, comorbidities typically seen later in life are increasingly prevalent in younger people. Frailty is being identified as an important risk factor affecting outcomes in younger surgical patients.[4]

In the current era of value-based surgical care, improving postoperative outcomes while reducing cost is the cornerstone of a successful strategy to provide value.[5] Initiatives have evolved from singular process improvement methods to comprehensive bundles aimed at reducing variation in practice.[6] Large-scale

Abbreviations and Acronyms

ASA	= American Society of Anesthesiologists
BSW-CTX	= Baylor Scott & White—Central Texas region
ED	= emergency department
IP	= inpatient
LOS	= length of stay
OP	= outpatient

standardization has spread to the entire perioperative episodes of care, as evidenced by Enhanced Recovery After Surgery (ERAS) pathways; this has led to a reduction of complications, length of stay (LOS), and cost.[7,8] However, complications still exist. The natural progression of continued improvement in quality has led to focusing on preoperative optimization with the primary variable being modifiable patient-specific characteristics such as comorbidities, physical fitness, and nutrition. Frailty is a reliable measure of perioperative risk assessment and holds significant potential.[3,9-13] Although there are a number of frailty assessment tools used for evaluation and risk stratification,[2,3,10] the optimal assessment would be objective, easy to implement, correlate with clinical outcomes, and scalable. The Modified Hopkins frailty score fits this description and has been previously validated in a limited number of high-risk patients.[10]

Frailty evaluation across multiple surgical subspecialties, its large-scale effect on outcomes, and the impact on cost of surgical care are not well defined. The purpose of this study was to determine the impact of frailty on postoperative outcomes in multiple surgical subspecialties across a large health care system.

METHODS

An Institutional Review Board-approved retrospective review of Baylor Scott & White Health—Central Texas Region (BSW-CTX) patients 18 years or older, undergoing elective surgery January 2016 through June 2017, was performed, evaluating the relationship between prospectively collected frailty and postoperative outcomes. All patients with a preoperative frailty score were included. The following surgical subspecialties participate in preoperative frailty assessment: cardiothoracic (CT), colorectal, general, oral and maxillofacial (OMFS), otolaryngology (ENT), plastics, podiatry, surgical oncology (Surg Onc), transplant, urology, and vascular surgery. The general surgery category includes all elective cases performed by minimally invasive, bariatric, and trauma and acute care subspecialty groups. Patients without a frailty score and those having surgery within 90 days of a previous procedure were excluded.

Patient selection

Baylor Scott & White Health—Central Texas Region includes 4 hospitals with a total of 930 beds. The sizes of hospitals 1 to 3 (H1 to H3) are 143, 46, and 101 beds, respectively. Hospital 4 (H4) is a 640-bed tertiary center that functions as the system referral center. A common electronic medical record platform is used across BSW-CTX, allowing for regional level data collection and analysis.

Demographics, outcomes, and cost data were abstracted from the electronic medical record database. Demographics included hospital location, surgical specialty, date of surgery, primary Current Procedural Terminology (CPT) code, age at time of surgery, BMI (in kg/m²), sex, race, American Society of Anesthesiologists physical status classification (ASA), and time in hospital (in hours). Operations were classified based on length of stay (LOS); patients with a less than 24 hours recorded stay were classified as outpatient (OP); while those staying 24-hours or longer were classified as inpatient (IP).

Thirty-day outcomes were collected. These included major morbidity, discharge disposition, emergency department (ED) visits, readmission, LOS, and mortality. Major morbidity was a composite variable representing the following diagnoses: acute respiratory failure or mechanical ventilation, pneumonia, cardiac event (myocardial infarction or cardiac arrest), deep vein thrombosis, pulmonary embolism, urinary tract infection, renal failure (acute or progressive), stroke, or systemic sepsis. Activation of hospital code teams (code rapid or code blue) was also included in the major morbidity variable because it represents an acute escalation in care and is considered a surrogate for post-morbidity. The listed diagnoses were abstracted from the electronic medical record using respective *International Classification of Diseases* codes (ICD-9, ICD-10). Emergency department visits and readmissions were identified to any facility within the Baylor Scott & White Health system. Financial data included 30-day direct cost per patient.

Prospective frailty assessment

Frailty was prospectively measured across BSW-CTX in elective surgery patients using the Modified Hopkins Frailty score.[10] The score was calculated based on shrinking (unintentional recent weight loss 10 pounds or greater in the last year), handgrip strength, hemoglobin, and ASA score. Risk stratification based on frailty scores included low (0), intermediate (1 to 2), and high (≥3), as previously reported.[10]

Statistical analysis

Categorical variables were reported as counts (percentages), and continuous variables as mean (standard deviation), if
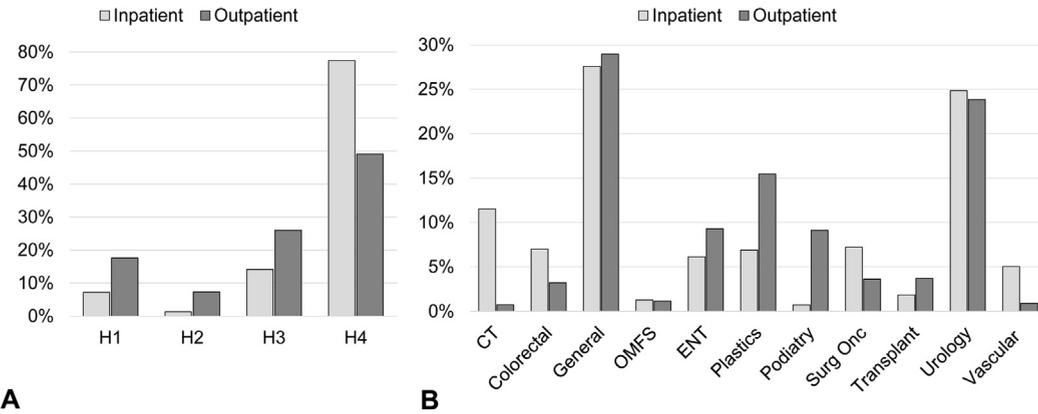
Figure 1. Distribution of cases based on hospital location (A) and subspecialty (B) for the inpatient and outpatient cohorts. Bed sizes of hospitals H1 to H4 are: 143, 46, 101, and 640 beds, respectively. Preoperative frailty measurements were collected for both inpatient and outpatient cases from all hospitals within the central region of the health care system and within 11 surgical subspecialties. Most cases were general or urology. CT, cardiothoracic; ENT, otolaryngology; OMFS, oral and maxillofacial; Surg Onc, surgical oncology.

normally distributed, or as median (minimum to maximum). A Kruskal Wallis test was used to test for associations in bivariate comparisons for continuous variables, and a chi-square test was used for categorical variables. A logistic regression model was performed estimating the odds ratio for frailty for each outcome, adjusting for demographics and comorbidities. Age and sex were not included in the model because they are reflected in the frailty score. Statistical significance was set at $p < 0.05$. Analyses were performed with SAS version 9.4 (SAS Institute Inc) and StatXact version 11 (Cytel Software Corporation) software.

Figure 2. Distribution of frailty classification by subspecialty for inpatient cohort. Low, intermediate, and high frailty was represented in both inpatient and outpatient procedures within 11 surgical subspecialties. CT, cardiothoracic; ENT, otolaryngology; OMFS, oral and maxillofacial; Surg Onc, surgical oncology.
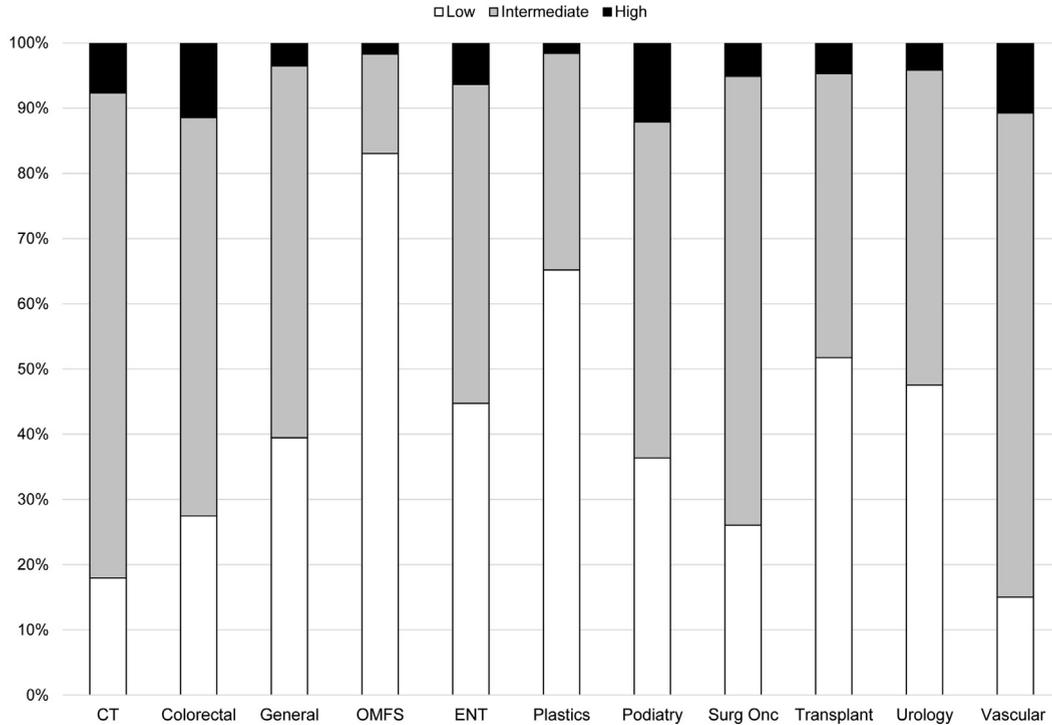
Figure 3. Distribution of frailty classification by subspecialty for outpatient cohort. Low, intermediate, and high frailty was represented in both inpatient and outpatient procedures within 11 surgical subspecialties. CT, cardiothoracic; ENT, otolaryngology; OMFS, oral and maxillofacial; Surg Onc, surgical oncology.
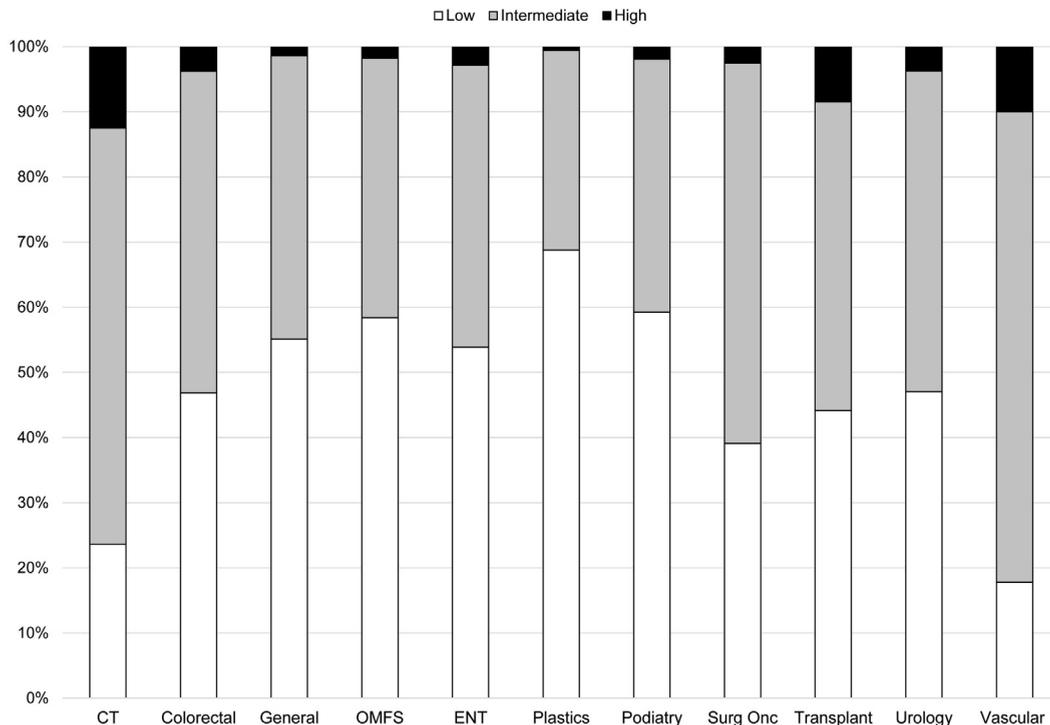
RESULTS

Demographics

There were 14,530 operations that met study criteria; 31.9% (4,632) were IP and 68.1% (9,898) were OP. Approximately 48% of patients in both cohorts were male. Median age was 61.0 years in the IP group and 56.0 years in the OP group. Most patients were obese, with a BMI ≥ 30 kg/m^2 (49.9% IP, 43.3% OP) or overweight with a BMI between 25 and 30 kg/m^2 (28.6% IP, 32.1% OP). Malignancy was the primary diagnosis in 28.3% of IP and 10.3% of OP procedures. Procedures were distributed across the regional system and across surgical specialties (Figs. 1A and 1B). The majority of patients were cared for at H4 (tertiary referral center). General surgery and urology represented more than 50% of cases.

Overall, nearly 500 high frailty patients underwent elective surgery in our health care system during the study period. Frailty distribution differed between IP and OP cohorts (low 38.8% vs 53.8%, intermediate 55.9% vs 43.7%, high 5.3% vs 2.5%; $p < 0.0001$). Figures 2 and 3 show the relative percentages of frailty classifications by subspecialty in the IP and OP groups. Frailty distribution differed by hospital location ($p < 0.05$) for both IP and OP cohorts. High frailty for IP cases ranged from 1.2% to 5.6%, and 0.5% to 3.8% for OP cases.

Demographics by frailty classification are listed in Table 1 (IP) and Table 2 (OP). Median age increased with higher frailty ($p < 0.0001$) in both IP and OP groups. Malignancy rates were significantly higher with increased frailty ($p < 0.0001$). Median obesity was 30.5 kg/m^2 for IP and 29.5 kg/m^2 for OP groups.

Outcomes

Outcomes by frailty classification for IP (Fig. 4 and Table 3) and OP (Fig. 5 and Table 4) show increased rates of major morbidity, discharge to facility, readmission, and mortality rates with higher frailty (all $p < 0.05$). Overall, major morbidity occurred in 6.5% of IP and 2.0% of OP cohort. Emergency department visit rates also differed with frailty in the OP cohort. Overall, 15.8% of the IP and 9.0% OP had a readmission (IP), an unplanned admission (OP), or an ED visit within 30 days after surgery. Median LOS for the IP cohort increased with higher frailty: low, 1.6 days; intermediate, 2.3 days; high, 4.1 days ($p < 0.0001$). Direct cost per patient increased

Table 1. Demographics by Frailty (Inpatient)

Variable	Low (n = 1,798)	Intermediate (n = 2,589)	High (n = 245)	p Value
Male sex, n (%)	850 (47.3)	1,237 (47.8)	146 (59.6)	0.001
Age, y, median (IQR)	56.0 (44.0−67.0)	63.0 (52.0−72.0)	68.0 (59.0−76.0)	<0.0001
<40, n (%)	327 (18.2)	265 (10.2)	8 (3.3)	<0.0001
40−59, n (%)	712 (39.6)	766 (29.6)	58 (23.7)	
60−79, n (%)	685 (38.1)	1,316 (50.8)	139 (56.7)	
80+, n (%)	74 (4.1)	242 (9.4)	40 (16.3)	
Race*, n (%)				0.2
Hispanic White or Caucasian	1,449 (81.4)	2,144 (83.4)	208 (85.3)	
Black or African American	221 (12.4)	294 (11.4)	27 (11.1)	
Other	111 (6.2)	132 (5.2)	9 (3.6)	
BMI, kg/m^2, median (IQR)[†]	29.6 (25.6−34.7)	30.5 (25.8−36.0)	27.1 (23.0−32.5)	<0.0001
<18.5, n (%)	13 (0.8)	43 (1.7)	15 (6.3)	<0.0001
18.5−24.9, n (%)	342 (19.9)	469 (19.0)	69 (29.1)	
25−29.9, n (%)	542 (31.4)	657 (26.6)	70 (29.6)	
30−34.9, n (%)	406 (23.6)	599 (24.2)	42 (17.7)	
35−39.9, n (%)	234 (13.6)	329 (13.3)	21 (8.9)	
40+, n (%)	184 (10.7)	377 (15.2)	20 (8.4)	
Hospital location, n (%)				<0.0001
H1	204 (11.4)	125 (4.8)	4 (1.6)	
H2	18 (1.0)	41 (1.6)	3 (1.2)	
H3	236 (13.1)	388 (15.0)	27 (1.1)	
H4	1,340 (74.5)	2,035 (78.6)	211 (86.1)	
Malignancy, n (%)	444 (24.7)	772 (29.8)	93 (38.0)	<0.0001

p Value significant at <0.05.
*Race missing for 37 patients.
[†]BMI missing for 200 patients.
IQR, interquartile range.

with frailty in the IP cohort (low, $7,045; intermediate, $7,995; high, $8,599; p < 0.05). No difference in direct cost based on frailty was detected in the OP group.

Logistic regression model

A logistic regression model for each complication was performed, with patient age, race, BMI, malignancy, hospital location, and frailty score as covariates. Adjusted odds ratios for each complication based on frailty classification are listed in Table 5 along with the c-statistic for the model. Odds of having major morbidity, a readmission (IP) or unplanned admission (OP), or discharge to facility (IP only) all show significant increases in intermediate and high frail patients.

DISCUSSION

Our study is the first to show applicability of preoperative frailty evaluation across a large health care system, and it provides useful prognostic information on outcomes in diverse surgical subspecialties for both major and minor procedures (IP and OP). Our data further suggest that

frailty is a predictor of increased direct cost after elective IP operations.

Frailty was initially introduced by geriatricians to describe a phenotype associated with falls, hospitalizations, and other adverse outcomes in elderly nonsurgical patients.[2,14-17] A number of scores exist that use objective and subjective measures to assess frailty. The Hopkins Frailty Score measures shrinking (unintentional weight loss), weakness (grip strength), exhaustion, activity, and walking speed,[18] and was used by Makary and colleagues[3] to study frailty in surgical patients as a novel application. Their results indicated frailty as an independent risk factor for poor outcomes after surgery with increased postoperative complications, prolonged LOS, and discharge destination other than home. The subsequent studies by Revenig and colleagues[10] found that using hand grip strength and shrinking produced similar results to the original 5-part Hopkins score and was further improved when adding ASA classification score and hemoglobin (Modified Hopkins Frailty Score). This allowed for easier implementation and objective measurement to facilitate adoption. Our results validate Revenig and associates'[10] findings through

Table 2. Demographics by Frailty

Variable	Low (n = 5,323)	Intermediate (n = 4,324)	High (n = 251)	p Value
Male sex, n (%)	2,374 (44.6)	2,185 (50.5)	168 (66.9)	<0.0001
Age, y, median (IQR)	50.0 (37.0−62.0)	62.0 (51.0−72.0)	69.0 (55.0−80.0)	<0.0001
<40, n (%)	1,542 (29.0)	515 (11.9)	24 (9.6)	<0.0001
40−59, n (%)	2,173 (40.8)	1,391 (32.2)	53 (21.1)	
60−79, n (%)	1,481 (27.8)	1,940 (44.9)	109 (43.3)	
80+, n (%)	127 (2.4)	478 (11.0)	65 (25.9)	
Race[*], n (%)				0.004
Hispanic White or Caucasian	4,244 (81.7)	3,597 (84.4)	207 (82.8)	
Black or African American	568 (10.9)	414 (9.7)	31 (12.4)	
Other	383 (7.4)	251 (5.9)	12 (4.8)	
BMI, kg/m^2, median (IQR)[†]	28.4 (24.7−32.7)	29.5 (25.5−34.6)	28.1 (24.2−33.6)	<0.0001
<18.5, n (%)	41 (1.0)	42 (1.3)	12 (7.0)	
18.5−24.9, n (%)	1,019 (25.5)	641 (20.4)	42 (24.4)	
25−29.9, n (%)	1,332 (33.3)	974 (30.9)	47 (27.3)	
30−34.9, n (%)	911 (22.8)	745 (23.7)	34 (19.8)	
35−39.9, n (%)	430 (10.8)	388 (12.3)	24 (13.9)	
40+, n (%)	265 (6.6)	359 (11.4)	13 (7.6)	
Hospital location, n (%)				
H1	1,279 (24.0)	461 (10.7)	8 (3.2)	
H2	344 (6.5)	359 (8.3)	17 (6.8)	
H3	1,278 (24.0)	1,252 (28.9)	43 (17.1)	
H4	2,422 (45.5)	2,252 (52.1)	183 (72.9)	
Malignancy, n (%)	417 (7.8)	566 (13.1)	38 (15.1)	

p Value statistically significant at <0.05.
[*]Race missing for 191 patients.
[†]BMI missing for 2,579 patients.
IQR, interquartile range.

the use and application of this simplified frailty score using a larger expanded cohort of elective surgical patients well beyond major intra-abdominal operations. Our results
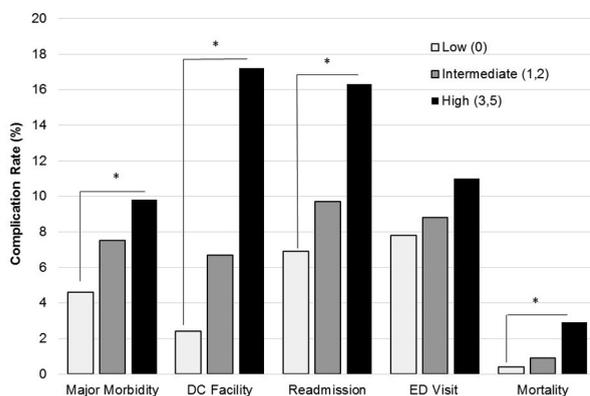

Figure 4. Inpatient (n = 4,632) 30-day morbidity and mortality stratified by frailty. A stepwise increase in complications was seen with increasing frailty. The risk of major morbidity, discharge to location other than home (DC facility), readmission, and mortality were significantly increased with increasing frailty. *P value statistically significant at ≤0.05. ED, emergency department.

show that this frailty score is associated with a stepwise increase in discharge destination other than home (IP only), readmissions (IP) or unplanned admission (OP), and mortality across frailty groups at all sites, within all specialties (IP and OP procedures). To date, this represents the largest study of its kind in surgical patients and has effectively validated the Modified Hopkins frailty score on a larger scale.

The average American will undergo approximately 9 surgical procedures over their lifetime,[19] with most performed in the latter half of life, when comorbidities and frailty are more prevalent. Frailty evaluation has the potential to be a risk stratification tool. Previous reports have shown that subjective assessment of patient frailty by surgeons and its application to risk has significant interobserver variability and accuracy.[20] There also remains a subset of patients, who, despite a more robust appearance, are indeed frail and at higher risk for complications. Although not every patient needs an extensive frailty evaluation, every patient's preoperative risk should be known in order to provide adequate preoperative counseling. The ideal frailty screening tool for a surgeon would be objective, reproducible, efficient, and easy to

Table 3. Thirty-Day Postoperative Complications, Use, and Cost Stratified by Frailty (Inpatient)

Outcome	Low (n = 1,798)	Intermediate (n = 2,589)	High (n = 245)	p Value
Acute respiratory failure, n (%)	9 (0.5)	45 (1.7)	5 (2.0)	0.0009
Pneumonia, n (%)	6 (0.3)	20 (0.8)	5 (2.0)	0.005
Cardiac, n (%)	1 (0.1)	5 (0.2)	0 (0.0)	NS
Deep vein thrombosis, n (%)	2 (0.1)	7 (0.3)	1 (0.4)	NS
Pulmonary embolism, n (%)	0 (0.0)	5 (0.2)	0 (0.0)	NS
Urinary tract infection, n (%)	10 (0.6)	14 (0.5)	1 (0.4)	NS
Renal failure, n (%)	26 (1.5)	51 (2.0)	14 (5.7)	<0.0001
Stroke, n (%)	1 (0.1)	2 (0.1)	0 (0.0)	NS
Systemic sepsis, n (%)	4 (0.2)	13 (0.5)	2 (0.8)	NS
Code blue/rapid, n (%)	34 (1.9)	92 (3.5)	6 (2.5)	0.005
Major morbidity, n (%)	82 (4.6)	195 (7.5)	24 (9.8)	<0.0001
Mortality, n (%)	7 (0.4)	22 (0.9)	7 (2.9)	0.0002
Hospital length of stay, d, median (IQR)	1.6 (1.3–3.5)	2.3 (1.3–4.1)	4.1 (1.4–6.5)	<0.0001
Discharge to facility, n (%)	43 (2.4)	174 (6.7)	42 (17.2)	<0.0001
Readmission, n (%)	124 (6.9)	252 (9.7)	40 (16.3)	<0.0001
ED visit, n (%)	141 (7.8)	227 (8.8)	27 (11.0)	NS
ED or readmission, n (%)	246 (13.7)	430 (16.6)	56 (22.9)	0.0003
Median direct cost/patient, $	7,045	7,995	8,599	<0.05

p Value statistically significant at <0.05.
ED, emergency department; IQR, interquartile range.

implement in a busy practice. We chose to use the Modified Hopkins Score,[10] which meets these criteria. The objective measures of this tool used to calculate frailty include hemoglobin, ASA, shrinking (involuntary weight loss), and grip strength using a dynamometer. These are easy to measure, most are frequently in the medical record, and grip strength can quickly be taken and recorded by a certified nursing assistant. The entire score can be calculated in 1 minute. This efficiency and consistency allowed for smooth incorporation of preoperative

Figure 5. Outpatient (n = 9,898) 30-day morbidity and mortality stratified by frailty. A stepwise increase in complications was seen with increasing frailty. The risk of major morbidity, unplanned admission, emergency department (ED) visit, and mortality were significantly increased with increasing frailty. *P value statistically significant at ≤0.05.

frailty evaluation in our clinic workflow at multiple sites across our health care network. It allowed patients to be stratified as low (0), moderate (1 to 2), or high (≥3) frailty before surgery, and showed that patients with moderate and high frailty had higher rates of complications and morbidity in both IP and OP cases. We previously showed that each complication has a unique effect on LOS and increases cost.[21] Similarly, we saw a stepwise significant increase in direct cost of approximately $950 per case for moderately frail and $1,500 per case for high frailty patients compared with the low frailty group (IP procedures only).

In our large health care system, we identified more than 7,400 cases as intermediate or high frailty. This means more than 50% of the patient population may have the potential for intervention before surgery. Modifiable risk factors that can be addressed preoperatively can improve quality and reduce cost, satisfying the Institute for Healthcare Improvement's triple aim.[22] Creation of a preoperative pathway to address modifiable factors of frailty in elective surgical patients would include conditions such as malnutrition, sarcopenia, and cardiopulmonary reserve. The opportunity for optimization and time allotted for intervention may be dependent on factors such as urgency (elective or emergent) and indication (malignant or benign process) for surgery. For non-urgent cases, strength training to improve sarcopenia, nutritional consultation and dietary plan to improve protein stores, tobacco cessation, and cardiopulmonary training might
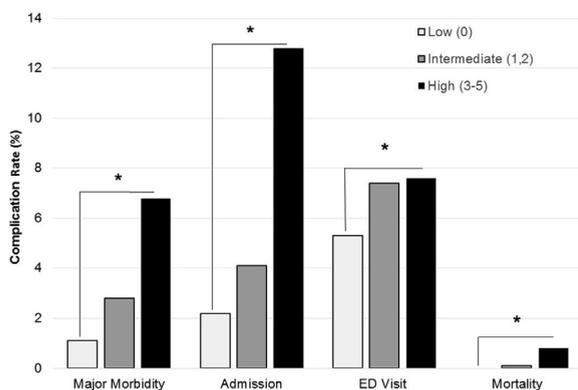
Table 4. Thirty-Day Postoperative Complications, Use, and Cost Stratified by Frailty (Outpatient)

Outcome	Low (n = 5,323)	Intermediate (n = 4,324)	High (n = 251)	p Value
Acute respiratory failure, n (%)	10 (0.2)	49 (1.1)	7 (2.8)	<0.0001
Pneumonia, n (%)	8 (0.2)	18 (0.4)	5 (2.0)	<0.0001
Cardiac, n (%)	1 (0.02)	4 (0.09)	0 (0.0)	NS
Deep vein thrombosis, n (%)	3 (0.06)	5 (0.1)	1 (0.4)	NS
Pulmonary embolism, n (%)	1 (0.02)	4 (0.09)	0 (0.0)	NS
Urinary tract infection, n (%)	11 (0.2)	15 (0.3)	2 (0.8)	NS
Renal failure, n (%)	32 (0.6)	53 (1.2)	10 (4.0)	<0.0001
Stroke, n (%)	0 (0.0)	2 (0.05)	1 (0.4)	0.02
Systemic sepsis, n (%)	5 (0.05)	10 (0.2)	5 (2.0)	<0.0001
Code blue/rapid, n (%)	1 (0.02)	1 (0.02)	0 (0.0)	NS
Major morbidity, n (%)	57 (1.1)	122 (2.8)	17 (6.8)	<0.0001
Mortality, n (%)	0 (0.0)	7 (0.07)	2 (0.8)	0.0002
Admission, n (%)	118 (2.2)	175 (4.1)	32 (12.8)	<0.0001
ED visit, n (%)	280 (5.3)	320 (7.4)	19 (7.6)	<0.0001
ED or readmission, n (%)	380 (7.1)	467 (10.8)	44 (17.5)	<0.0001
Direct cost/patient, $	2,260	2,255	2,288	NS

p Value statistically significant at <0.05.
ED, emergency department; NS, not significant.

reduce the level of frailty, improve physiologic reserve, and decrease postoperative risk. Using frailty screening to outline the expected postoperative course allows for shared decision-making, improved informed consent, and pre-emptive discussion of postoperative discharge destination.[23] Prognostic information may also be of benefit for patients considering both surgical and nonsurgical options in the treatment of their disease process. This allows for a natural segue to goals of care discussions and the involvement of nonsurgical subspecialties to provide high quality of life, optimize patient experience, and maintain autonomy.

The limitations of our study include those inherent to a large cohort analysis. Our outcomes were limited to 30 days rather than 60 or 90, as in previous studies.[10,12] Discrete complications did not show significance across frailty measurements, likely because the study was underpowered to show a difference across all frail groups and all types of surgery (major and minor). Case complexity likely played a role in outcome in combination with frailty, and this was not able to be determined with this analysis. We next plan to analyze the combined risk of surgical procedure (high vs low risk) with the risk stratification of frailty to determine where the greatest opportunity for intervention

Table 5. Multivariate Analysis of the Association Between Preoperative Variables and 30-Day Morbidity

	Inpatient surgery		Outpatient surgery	
Outcome	OR (95% CI)	C-statistic	OR (95% CI)	C-statistic
Major morbidity		0.63		0.75
Intermediate	1.6 (1.2–2.1)		2.6 (1.7–4.1)	
High	1.8 (1.1–1.9)		2.9 (1.2–6.4)	
ED visit				
Intermediate	*		1.7 (1.4–2.1)	0.61
High			2.2 (1.2–3.8)	
Readmission		0.62		0.71
Intermediate	1.4 (1.1–1.8)		1.9 (1.4–2.7)	
High	2.3 (1.5–3.5)		4.8 (2.7–8.3)	
DC facility		0.75		
Intermediate	2.4 (1.7–3.5)		NA	NA
High	5.6 (3.5–9.1)			

Low frailty is the reference group for each model.
*Logistic regression model for inpatient emergency department visit not performed as univariate analysis did not reach statistical significance.
DC, discharged to location other than home; ED, emergency department; NA, not applicable; OR, odds ratio.

may be. It is important to note that we do not offer a strategy for preoperative intervention, and the best method of approach at our system remains unclear.

CONCLUSIONS

In this study, we have shown that preoperative frailty measurement in a large cohort of elective surgical patients across many surgical subspecialties is strongly correlated with morbidity risk and direct cost. Mitigation of risk factors in frail patients could offer significant improvements in quality outcomes in a large patient population and provide cost savings. Our data suggest that the Modified Hopkins Frailty Score is an effective preoperative risk assessment tool that is easy to implement and may be used for preoperative planning, patient optimization, and informed shared decision-making.

Author Contributions

Study conception and design: Mrdutt, Papaconstantinou, Bird, Isbell

Acquisition of data: Mrdutt, Papaconstantinou, Bird, Isbell

Analysis and interpretation of data: Mrdutt, Papaconstantinou, Robinson, Isbell

Drafting of manuscript: Mrdutt, Papaconstantinou, Robinson, Bird, Isbell

Critical revision: Mrdutt, Papaconstantinou, Robinson, Bird, Isbell

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Discussion

DR JOHN F SWEENEY (Atlanta, GA): Briefly, using the Modified Hopkins Frailty Score, the authors prospectively measured frailty in elective surgery patients across the Baylor Scott & White Central Texas health care system, which is a large region and a large number