THE IMPACT OF PREOPERATIVE FRAILTY ON SURGICAL MORBIDITY IN ELECTIVE SURGERY PATIENTS: OPPORTUNITY FOR INTERVENTION?

A Thesis

by

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ABSTRACT

Minimizing complications after surgery is important for patients and systemically to minimize cost and health care utilization. Frailty represents physiologic reserve in patients. Designed to assess mortality and resource utilization in elderly populations, a correlation to post-operative complications in surgical patients is now known. Thus, frailty represents a more complete approach for prospective risk assessment. The number of metrics for assessment and varying definitions limit the widespread application of frailty assessment in patients, as does the paucity of data regarding how to intervene. We successfully implemented pre-operative frailty assessment across a healthcare system. We describe the presence of frailty across surgical populations, including all age groups and demonstrate an increase in post-operative morbidity and healthcare utilization for inpatient and outpatient elective surgery populations. A novel approach to improve pre-operative ambulation according to Health Promotions ideology is presented. Finally, future efforts to address frailty pre-operatively are presented.

DEDICATION

I would like to dedicate this work to my patients: past, present and future. Thank you for trusting me with your lives and providing a source of constant learning. Each of you have made me a better surgeon and a better human.

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NOMENCLATURE

ACS	American College of Surgeons
ADLs/IADLs	Activities of daily living; instrumental activities of daily living
AIDS	Acquired immunodeficiency syndrome
ARF	Acute renal failure
ASA	American Society of Anesthesiologists
BMI	Body mass index
BSW	Baylor Scott & White
BSW-CTX	Baylor Scott & White Central Texas Region
CCI	Charlson Comorbidity Index
CDC	Centers for Disease Control and Prevention
CHF	Congestive heart failure
COPD	Chronic obstructive pulmonary disease
CPR	Cardiopulmonary resuscitation
CPT	Current procedural terminology
CSHA	Canadian Study of Health and Aging
CVA	Cerebrovascular accident
DC	Discharge
ECOG PS	Eastern Cooperative Oncology Group Performance Status
EMR	Electronic medical record
HBM	Health Belief Model
IRB	Institutional Review Board

IQR	Interquartile range
LOS	Length of stay
MI	Myocardial infarction
NSQIP	National Surgical Quality Improvement Program
NCDB	National Cancer Database
OR	Operating room; odds ratio
PATOS	Present at time of surgery
PVD	Peripheral vascular disease
QI	Quality improvement
RBC	Red blood cells
SCT	Social Cognitive Theory
SEER	Surveillance, Epidemiology and End Results Program
SIRS	Severe inflammatory response syndrome
SSI	Surgical site infection
SWMC	Scott & White Medical Center
TIA	Transient ischemic attack
US	United States
UTI	Urinary tract infection
VA	Veterans Affairs
VASQIP	Veterans Affairs Surgical Quality Improvement Program

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1. INTRODUCTION

1.1. Overview

Surgical practice is no longer a question of *can* an operation be done. Previous decades are filled with an abundance of surgical milestones: on-pump cardiac surgery, transplant of solid organs from deceased and living donors, surgical de-escalation for breast cancer. Minimally invasive techniques—endoscopy, laparoscopy and robotic surgery—were pioneered and quickly became standard of care for many disease processes ranging from appendectomy to colectomy and esophagectomy. Advances with systemic therapy expanded the number of cancer patients with resectable disease.

The goal of surgical procedures, and much of healthcare, is no longer binary. Rather than life versus death, quality of life is forefront in patient and provider decision making. Innovative practices are now those minimizing risk, improving outcomes and individualizing care. Rather than *can* this operation be performed, surgeons should be asking s*hould* it be. Although the benefit of an operation is difficult to define given the subjective and highly personalized nature of quality of life, frank discussion regarding risk is paramount to shared-decision making.

As with many aspects of healthcare, performance metrics and national benchmarking now exist. The Agency for Healthcare Research and Quality (AHQR) is a key component of the Department of Health and Human Services, with a mission to provide evidence to make health safer in all settings.[1] To accomplish this enormous task, the AHQR has 3 domains of focus: health systems research, practice improvement and data analytics. It provides funding for research, quality improvement tools and numerous data sources of outcomes data, consumer assessment and health utilization. The existence of an AHRQ illustrates the national emphasis on improving healthcare.

Critical to improving outcomes is identifying at-risk populations who will benefit from targeted interventions. Risk is decreasingly attributed to individual comorbidities such as smoking or obesity, and there is less emphasis on original risk metric—age. Rather, the concept of an individual's composite health or physiologic reserve, termed frailty, has emerged as a promising risk assessment metric.

1.2. Surgical Outcomes Benchmarking

1.2.1. Post-operative Complications and National Initiatives

Optimal surgical care provides a mechanical solution without complications. Complications and death occurring after surgery are known as morbidity and mortality, respectively. Patients experiencing post-operative complications have longer hospital stays, increased health care costs and higher mortality.[2-6]

Remarkable national quality improvement efforts were implemented in the early 2000s and were aimed at minimizing the burden associated with surgical morbidity.[7] The Surgical Infection Prevention Program (SIP) represented a combined effort from the Centers for Medicare & Medicaid Services and the Centers for Disease Control and Prevention (CDC) and successfully targeted post-operative surgical site infections (SSIs) with education initiatives and national surveillance and performance reporting. The next generation—Surgical Care Improvement Project (SCIP)—represents an on-going collaboration of 10 organizations, including the Centers for Medicare & Medicaid Services, the CDC and the American College of Surgeons (ACS), and more than 30 supporting organizations, to further minimize complications and improve surgical outcomes. SCIP incorporated education components with performance measures, aiming to prevent complications with high incidence and cost: SSIs, venous thromboembolism, cardiac events and respiratory complications.

1.2.2. NSQIP

Critical to the success of SIP and SCIP and foundational to improving outcomes for surgical patients is the ACS's National Surgical Quality Improvement Project (NSQIP). NSQIP provides performance outcomes for contributing hospitals. The concept was designed and validated in Veterans Health Administration (VA) hospitals, with the program known as the Veterans Affairs Surgical Quality Improvement Program (VASQIP).[8, 9] It was subsequently introduced to non-military hospitals, starting with a pilot of academic centers, known as NSQIP.[10, 11] The power lies in the risk-adjusted nature of reporting, providing insight into hospital performance accounting for practice setting, patient comorbidities as well as case type and complexity. Additionally, the platform is based on over 20 years of data abstracted directly from patient charts, rather than insurance claims data. NSQIP is now used across a variety of surgical practices and healthcare systems: urban, rural, academic, and private practices. It continues to capture contemporary complication rates, highlight differences in emergency and elective surgery, and provide non-penalized identification of high and low outlier performance. It also enabled the development of the NSQIP risk calculator, which provides prospective individualized risk assessment and is further discussed below. To date there is participation from over 500 hospital systems nationally and nearly 700 world-wide.[12] Follow up studies at participating hospitals demonstrate an improvement in care delivered with a decrease in adverse event, with length of participation related to the amount of improvement observed.[13-15]

1.2.3. Other Outcomes Databases—Society and National Registries

NSQIP truly functions as the foundation for outcomes reporting, performance benchmarking and quality improvement work in the surgical community. It is not the only ACS approach to improving care. Other notable programs include the Commission on Cancer, Committee on Trauma, Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program, and the National Accreditation Program for Breast Centers. Each represents a specialty-focused effort to improve care and provides outcomes data unique to the patient population.[16]

In additional to ACS programs, additional databases exist that provide insight into morbidity and data to assess progress. Examples of surgical society efforts include the Society of Thoracic Surgeons (STS) database[17] which that provides a clinical registry and public reporting on designated cardiothoracic procedures, along with the American Society of Breast Surgeons registry[18] which prospectively collects oncologic and aesthetic outcomes for breast cancer procedures. Likewise, national databases such as the National Cancer Institute's Surveillance, Epidemiology, and End Results Program (SEER)[19] and the ACS's National Cancer Database (NCDB)[20] provide insight into incidence, treatment and outcomes for numerous malignant procedures. Without these and many other registries and databases, risk factor identification and efforts to mitigate risk would not be possible.

1.3. Assessment of Risk

1.3.1. Traditional Assessment

Pre-operative risk has long been considered to be comprised of independent and unrelated risk factors—colloquially *in silos*—evidenced by attention to individual behaviors and comorbidities such tobacco use, excessive alcohol consumption, diabetes and obesity, each known to convey surgical risk.[21-24] Metrics exist however to assess a more global sense of health. While some were designed to communicate health status in the preoperative setting, others were created to predict longitudinal outcomes and survival or quantify performance status. Three commonly used are listed in

Table 1 and briefly discussed below.

The American Society of Anesthesiologists (ASA) Physical Status Classification System was designed in 1941 to communication medical co-morbidities.[25] It is based on provider clinical decision making, with concern being subjectivity. The ASA criteria were revised in 2014, with updated schema including examples to standardize definitions and minimize subjectivity.[26] Even after inclusion of examples, non-anesthesiology providers (surgeons, proceduralists and internist) are demonstrated to be less accurate in assessment,[27] reiterating the variability of clinical judgement. Another growing critique is the absence of functional capacity. Commonly referred to as "ASA", it remains a critical part of pre-operative assessment for elective and emergent cases ASA with increasingly incorporation into pre-operative risk assessment models such as the NSQIP risk calculator in the United States along with 3 risk assessment tools used in the United Kingdom—Surgical Risk Scale, Surgical Outcome Risk Tool, National Emergency Laparotomy Audit.[26]

The Charlson Comorbidity Index (CCI) was developed in 1987 to classify comorbidities and predict 1-year mortality after hospitalization.[28] It is currently used to predict 10-year estimated survival based on multiple comorbidities and incorporates 17 factors including age, cardiac disease, thromboembolic events, dementia, diabetes, pulmonary disease, hepatic and renal function and malignancy, each with assigned point values. Quan et al. validated CCI in contemporary populations from 6 countries, along with presenting an updated and simplified approach using 12 versus 17 components with similar predictive value.[29] The original CCI model remains in daily use across healthcare practice and is readily available online.[30]

The Eastern Cooperative Oncology Group Performance Status (ECOG PS)[31] provides insight into an individual's functional ability. It was designed as a method to ensure uniformity in clinical trial populations, beyond standard demographics such as age, gender, comorbidities and disease status, and to standardize how treatment and/or disease progression is impacting activities of daily living (ADLs). Like ASA, there are set clinical metrics and examples to assist in grading patients. ECOG PS is focused on function and the ability to tolerate a treatment, similar to what frailty attempts to capture.

ASA, CCI and ECOG PS cannot be removed from a conversation regarding frailty. They comprise the groundwork for assessing reserve, each present in studies either designing and/or comparing frailty metrics, as discussed in Section 1.4.

Table 1. Traditional Assessment Metrics

Assessment	Components	Comments
ASA Physical Status Classification System[25, 26]	I – normal health patient II – mild systemic disease III – severe systemic disease IV – severe systemic disease, constant threat to life V – moribund patient, not expected to survive without operation VI – medically brain-dead patient, organ donor	Clinical assessment aided by standardized examples
Charlson Comorbidity Index (CCI)[28]	Age (1 point for every decade 50 or older, maximum 4 points) MI, CHF, PVD, CVA/TIA, dementia, COPD, connective tissue disease, peptic ulcer disease history (yes, each 1 point) Liver disease (Mild 1 point, moderate-severe 3 points) Diabetes mellitus (none/diet-controlled 1 point, uncomplicated 1 point, end-organ damage 2 points) Hemiplegia, moderate to severe (yes, each 2 points) Solid tumor (localized 2 points, metastatic 6 points) Leukemia, lymphoma (each 2 points) AIDS (6 points)	Calculates a 10-year estimated survival for 17 data points
Eastern Cooperative Oncology Group performance status (ECOG PS)[31]	0—Fully active, able to carry on all pre-disease performance without restriction 1—restricted in physically strenuous activity but ambulatory and able to carry out work of a light or sedentary nature 2—ambulatory and capable of all selfcare but unable to carry out any work activities; up >50% waking hours 3—capable of only limited selfcare; confined to bed or chair >50% waking hours 4—completely disabled; cannot provide any selfcare; confined to bed or chair 5—Dead	Assessment of function, used to determine ability to tolerate treatment

MI, myocardial infarction; CHF, congestive heart failure; PVD, peripheral vascular disease; CVA, cerebrovascular accident; TIA, transient ischemic attack; COPD, chronic obstructive pulmonary disease; AIDS, acquired immunodeficiency syndrome

1.3.2. NSQIP Calculator

NSQIP serves as the platform for the ACS NSQIP Surgical Risk Calculator, commonly known as the NSQIP calculator. Using algorithms from previous NSQIP data, the NSQIP calculator provides an estimate of an individual's surgical risk for a specific procedure.[32] This can be done prior to surgery and supports shared decision making with the patient. Based on 21 clinical factors and the Current Procedural Terminology (CPT) code, percentages for predicted risk of each complication are provided along with feedback if the estimate is below, at or above average risk.[33] Input variables and complication risks addressed are listed in Table 2.

The NSQIP Risk Calculator is arguably the best pre-operative metric we have. A query of the National Library of Medicine online database[34] reveals over 400 publications evaluating the prognostic ability since Bilimoria et al. first described its design in 2013.[32] It synthesizes many aspects of traditional assessment metrics into risk prediction that is prospective and individualized for a patient and procedure. Anecdotally, there is significant merit to providing a patient with their own risk profile to during a surgical consult to aid decision making.

Table 2. NSQIP Calculator Input Variables and Output Risks

Input Variables	Outcome Risk Reported
Age	
Sex	
Functional Status	Serious Complication*
Emergency Case	Any Complication**
ASA Class	Pneumonia
Steroid Use, chronic	Cardiac Complication (MI or cardiac arrest)
Ascites, within 30 Days	Surgical Site Infection***
Systemic Sepsis, within 48 hours	Urinary Tract Infection
Ventilator Dependent	Venous Thromboembolism
Disseminated Cancer	Renal Failure
Diabetes	Readmission
Hypertension, requiring medication	Return to OR
Congestive Heart Failure, within 30 days	Death
Dyspnea	Discharge to Nursing or Rehab Facility
Current Smoker, within 1 year	Sepsis
History of Severe COPD	Predicted length of hospital stay (days)
Dialysis	
Acute Renal Failure	
BMI (Height, Weight)	

*serious complication = cardiac arrest, myocardial infarction, pneumonia, progressive renal insufficiency, acute renal failure, pulmonary embolism, deep vein thrombosis, return to OR, deep incisional SSI, organ space SSI, systemic sepsis, unplanned intubation, urinary tract infection, wound disruption
**any complication = serious + superficial incisional SSI, ventilator > 48 hours, stroke
***surgical site infection (SSI) = superficial incisional, deep incisional, organ space
COPD, chronic obstructive pulmonary disease; BMI, body mass index; MI: myocardial infarction; OR, operating room
Adapted from current online calculator[33]

1.4. Frailty

1.4.1. Why Do We Need frailty?

The NSQIP calculator represents acceptance from the surgical community that outcomes are influenced by factors outside what occurs in the operating room. So, if it works, why do we need an alternative? One critique is the uncertainty of actionable items. Inputs can be adjusted to reflect improved pre-operative health (i.e., better glucose control, lower BMI, etc.) but beyond above average risk for a given procedure, a clear indicator for intervention is absent.

Now, start considering some of the factors of the calculator. Age—younger patients should do better, however this is not true. A 65-year-old retired Marine who still runs and lifts weights daily may in fact be a better surgical candidate than a 35-year-old with a sedentary job and lifestyle. Layer in other components—body mass index (BMI), diabetes, hypertension—Who is healthier: an individual with a BMI 15 with an eating disorder consuming a significant amount of diet soda daily or a weightlifter with a BMI of 30 and low body fat composition who eats a high protein plant-based diet? Both individuals are outside the World Health Organization's normal BMI (18.5-24.9) however one is more likely to have wound healing complications. Non-compliance with hypertension medications, a poorly controlled diabetic on oral medications versus an insulin-requiring diabetic with a pristine A1c level—as we explore the layers of complexity in the NSQIP risk calculator, a key concept emerges—*frailty.*

1.4.2. Origins of Frailty

There is not one accepted definition of frailty, but the reoccurring theme is a composite measure of physiologic reserve.[35-37] The importance of frailty first emerged from the geriatric medicine literature. It was pioneered and popularized by Fried and colleagues at John Hopkins University. Fried et al. used data from 5000 older adults in a longitudinal health study to standardize what constitutes frailty and demonstrated it as an independent predictor of outcomes such as falls, worsening mobility or self-care ability, hospitalization and death.[35] Patients were assessed using five criteria: unintentional weight loss of 10 pounds in the last year, exhaustion, weakness (as measured by handgrip strength), slow walking speed and low physical activity. Patients were defined as frail if 3 or more criteria were met. Patients with 1 or 2 criteria were considered as an intermediate or pre-frail. This pre-frail stage was demonstrated as a risk factor for frailty, laying groundwork for a continuum rather than a binary frail phenotype.

Rockwood et al. proposed a prospective assessment of frailty in community-dwelling elderly populations using a comprehensive assessment of function and medical comorbidities.[36, 37] This was based on data from the Canadian Study of Health and Aging (CSHA) and used a 70-item assessment to demonstrate frailty was associated with survival.[38] Given the exhaustive nature and number of components, the CSHA Frailty Index is understandably not feasible in all scenarios. A subsequent 7-component assessment, the CSHA Clinical Frailty Scale, was developed as an easier use tool based on clinical judgement to streamline the many CSHA Frailty Index factors into the spectrum of very fit to severely frail, described in Table 3. Like the CHSA Frailty Index, the CSHA Clinical Frailty Scale correlates with risk of death or hospitalization or institutionalization, referring to non-independent living environment.[36] The pivotal work from the CSHA demonstrates that what they term "rules-based definitions" and clinical assessment are different but appropriate approaches to assessing frailty.

While clearly far from exhaustive in available frailty metrics, Fried and Rockwoods' work represents two key approaches to frailty developed in the geriatric population. Both have been applied to surgical populations and comprise important aspects of subsequently developed frailty metrics.

1.4.3. Assessment of Frailty in Surgical Patients

To a surgeon, frailty and the concept of reserve translates to: *can this patient withstand the physiologic insult or trauma of this surgery*? Although many surgeons pride themselves on the "eye-ball test" or a quick assessment of a patient, we know surgeons and oncologists are far from perfect when clinically assessing health and predicted life expectancy.[39] Anecdotally, we are good at identifying the extremes: those healthy with minimal risk and those patients with prohibitive risk who "wouldn't tolerate a haircut" to quote my residency program director.

The literature does suggest we can and do measure frailty in surgical patients, the issue being the sheer number of ways employed and heterogeneous definitions. Examples of frailty metrics, including components and scoring, are listed in Table 3. Aspects of traditional preoperative health and risk assessment discussed above, mainly ASA and CCI appear within various assessments of frailty. NSQIP metrics are also critical in tailoring frailty assessment to surgical populations. The modified Frailty Index (mFI) represents an interesting extrapolation of the CSHA Frailty Index to the surgical population: 11 NSQIP variables were matched to the original 70 items with predictive capability for morbidity and mortality across surgical subspecialties and varying complexity of operations.[40, 41] Similarly, Hall et al. present the Risk Analysis Index (RAI) with 2 methods for calculation: clinical assessment and using administrative data from VASQIP/NSQIP.[42] Alternative musculoskeletal metrics, including the Study of Osteoporotic Fractures frailty index and sarcopenia with psoas assessment, are additional ways to assess frailty.[43, 44]

Table 3. Common Frailty Assessments Used in Surgical Populations

Assessment	Components	Resulting Scale
Fried Frailty Index (Hopkins)[35]	Shrinking (weight loss) Weakness (grip strength) Exhaustion Low activity Slowed walking speed	0-1 Not Frail 2-3 Intermediate Frail 4-5 Frail
CSHA Clinical Frailty Scale (Rockwood)[36]	Clinical judgement, global examples provided	1 Very Fit 2 Well 3 Well, with treated comorbid disease 4 Apparently vulnerable 5 Mildly frail 6 Moderately frail 7 Severely frail
Modified Frailty Index (mFI)[40, 41]	11 ACS-NSQIP variables derived from CSHA Frailty Index Diabetes Functional status (partial or total dependence) Severe COPD or pneumonia Hypertension requiring medication CHF MI within 6 months Cardiac comorbidity PVD or rest pain Impaired sensorium TIA/stroke	Maximum score 11 or ratio of 1, depending on analysis Larger number/ratio suggests higher frailty
Risk Analysis Index—Clinical (RAI-C)[42]	Interview & psychical exam: Age Sex Malignancy Medical comorbidities (5 questions) Cognition, Residence & ADLs (2 questions) ADLs & Cognitive Decline (5 questions)	Score 0-81, high score with increased frailty
Risk Analysis Index—Administrative (RAI-A)[42]	11 VASQIP/ACS-NSQIP Variables	
Edmonton Frail Scale[45]	11 questions regarding cognition, general health, functional independence, social support, medication use, nutrition, mood, continence, functional performance (Timed Get Up and Go Test)	Maximum score 17; higher score equals increased frailty
Multidimensional Frailty Score[46, 47]	Malignant disease Charlson Comorbidity Index Albumin level ADLs IADL	Maximum score 11, higher score equals increased frailty

Assessment	Components	Resulting Scale
	Dementia screen Delirium screen Nutritional assessment Mid-Arm Circumference Measurement	
Robinson Assessment[48-50]	7 Frailty Characteristics Timed & Go test Katz Score (ADLs) Mini-Cog Charlson Comorbidity Index Anemia Albumin Falls	0-1 nonfrail 2-3 prefrail 4-7 frail

ADLs, activities of daily living; IADLs, instrumental activities of daily living

1.4.4. Frailty and Outcomes in Surgical Populations

Growing literature supports a relationship between increased frailty and worse outcomes after surgery. This is true for traditional surgical morbidity such as infectious complications, mortality and resource utilization as defined by readmission, prolonged hospitalization and visits to the Emergency Department in the post-operative period. Regardless of how we define frailty or its varying prevalence, this is true. Examples of frailty and post-operative complications from a variety of surgical populations are outlined in Table 4.

Table 4. Frailty Assessment and Post-Operative Outcomes

Author/Year	Population	Patients	Frailty Observed	Key Study Findings
Fried Frailty Score				
Makary (2010)[51]	Elective surgery	594	Frail: 10.4% Intermediate: 31.3%	Increased risk of complications - OR intermediate 2.1 (95% CI 1.2-3.6); frail 2.5 (95% CI 1.1-5.8) Increased LOS - IRR intermediate 1.5 (95% CI 1.2-1.8), frail 1.7 (95% CI 1.3-2.2) Higher DC other than home - OR intermediate 3.2 (95% CI 1.0-10.0), frail 20.5 (95% CI 5.5-75.7) Frailty improved predicted power of other risk indices including ASA.
Revenig (2013)[52] Li (2016)[53]	Major intra-abdominal surgery	189	Intermediate or frail: 26.5%	Increased 30-day complications - Intermediate/frail OR 2.07 (95% CI 1.05-4.08) Higher 1-year mortality in intermediate/frail - 3.6% vs 20.0%
Revenig (2014)[54]	Major MIS procedures (endoscopic, laparoscopic, robotic)	80	Intermediate or frail: 16%	Increased complications (intermediate/frail OR 5.9 95% CI 1.3-28).
Makhani (2017)[55]	Major operations	330	Frail: 1% Intermediate: 19%	Frail + cognitive impairment higher risk of death compared with robust patients (non-frail, no cognitive impairment) - OR 3.9 (95% CI 1.7-9.3)
Modified Frailty Index (mFI)				
Obeid (2011)[40]	Laparoscopic and open colectomies, elective and emergent—NSQIP data	58448	Ratio of # deficits/total number	Increasingly frailty index associated with Clavien class IV and V complications (OR 14.4, p = 0.001).
Tsiouris (2013)[56]	Lobectomy—NSQIP data	1940	mFI ≥0.27: 14.6%	30-day morbidity and mortality increased with increasing mFI. Rate of at least one complication: 14.9% mFI 0 vs 32% mFI ≥0.27 (p < 0.001).
Velanovich (2013)[41]	All NSQIP cases 2005-2009	971434	Ratio of # deficits/total number	Increase in 30-day mortality and morbidity for each incremental increase in mFI.
Vermillion (2017)[57]	GI cancer, NSQIP data	41455	Frail: 10.1%	Increased LOS (11.7 vs 9.0 days), major complications (29.1% vs 17.9%), and 30-day mortality (5.6% vs 2.5%), all p<0.001. Multivariate analysis identified mFI as an independent predictor of 30-day

Author/Year	Population	Patients	Frailty Observed	Key Study Findings
				- major complications (OR 1.5, 95%CI 1.4-1.6) - mortality (OR 1.5, 95%CI 1.2-1.7).
Wahl (2017)[58]	Orthopedic, General, Vascular—VASQIP data	236957	0 traits: 19.9% 1 trait:32.4% 2 traits: 25.8% ≥3 traits: 21.9%	mFI predictive of 30-day readmission (c-statistic 0.71).
Seib (2018)[59]	Hernia, breast, thyroid, parathyroid ambulatory and 23-hour stay operations, age > 40—NSQIP data	140828	Intermediate mFI: 14.9% High mFI: 0.7%	Intermediate mFI (2-3 frailty traits) - Any complication OR 1.7 (95% CI 1.5-1.9) - Serious complication OR 2.0 (95% CI 1.7-2.3) High mFI (≥ 4 traits) - Any complication OR 3.3 (95% CI 2.5-4.5) Serious complication OR 3.9 (95% CI 2.7-5.9)
		Risk Analysis Index-Clinical (RAI-C)		
Hall (2017)[42]	All elective surgery patients—VA hospital	6803	0-15: 77.2% 16-25: 17.3% 26-35: 4.3% >/= 36: 1.2%	RAI-C predicts 180-mortality (c-statistic 0.772).
		Edmonton Frail Scale		
Dasgupta (2009)[45]	Elective non-cardiac surgery including orthopedic procedures—	125	EFS > 7:13%	Increasing frailty was associated with complications (p = 0.02), increased length of hospitalization (p = 0.004) and inability to be discharged home (p = 0.01), independent of age. Increased complications in EFS > 7 - OR 5.01 (95% CI 1.5-16.3); EFS ≤ 3 ref
		Multidimensional Frailty Score		
Kim (2014)[46]	Elective surgeries	275	Score > 5: 35.6%	High-risk (score >5) increased mortality risk (HR 9.0, 95% CI, 2.1-37.8) and increased LOS (median 9 vs 6 days, p <0.001).
Choi (2015)[47]	Elective curative cancer operations, including low risk breast and thyroid	281	High risk: 19.2%	High-risk (≥7) increased risk, after adjusting for confounders (ref < 7). - complications OR 8.5 (95% CI 2.2-32.8) - prolonged LOS OR 2.3 (95% CI 1.5.0)
		Robinson Assessment		

Author/Year	Population	Patients	Frailty Observed	Key Study Findings
Robinson (2011)[48]	Major elective operations requiring postoperative ICU admission—VA hospital	223	--	Increased number of frailty characteristics related to increased rate of discharge to location other than home.
Robinson (2011)[49]	Elective colorectal operations—VA hospital	60	Frail: 38% Prefrail: 22%	Frailty associated with increased hospital cost, 6-month cost following discharge, discharge location other than home and 30-day readmission.
Robinson (2013)[50]	Elective colorectal and cardiac—VA hospital	201	Frail: 28% Prefrail: 20%	Increased 30-day complications, independent of increased age. - Colorectal cases: nonfrail 21%, prefrail 40%, frail 58% (p=0.016) - Cardiac cases: nonfrail 17%, prefrail 28%, frail 56% (p<0.001). Increase in LOS and readmission rates with higher frailty.
Modified Hopkins				
Revenig (2015)[60]	major surgical intervention—urology, general surgery, surgical oncology (endoscopy excluded)	351	Frail: 2.8% Intermediate: 24.5%	Increase in 30-day complications risk with increasing frailty Low (ref), intermediate (OR 2.0 95% CI 1.0 to 3.9), high (OR 4.9 95% CI 2.2 to 10.8.
OR, odds ratio; LOS, length of stay				

Unless otherwise stated as using VASQIP/NSQIP data, which represents national, de-identified data from a variety of clinical settings, studies represent single institution experience from academic medical centers (VA or civilian). While the majority of these studies represents patients age 18 or greater, male and female, work from Kim et al.,[46] Makary et al.,[51] and Robinson et al.[48-50] focuses on patients 65 year or older while Dasgupta et al.[45] includes patients 70 or older and Choi et al.[47] focuses on seemingly low-risk female patients 65 or older. Seib et al.[59] study focuses on patients older than 40. The prevalence of frailty differs across studies, ranging from single percentage points to nearly 40%. Despite this, the varying metrics to assess and cutoffs for analysis used in differing populations, it is clear from this cumulative data that frailty impacts outcomes.

1.4.5. Barriers to Widespread Application

The number and heterogeneity across frailty assessments is confusing and likely a barrier to utilization. With different variables and scoring systems, the lack of generalizability is a concern. Even a single score, the mFI, has a variety of definitions of reported formats (ratio versus number of components) and cutoffs across studies.[40, 56-59] For other metrics, the sheer number of components and time required make the likelihood of widespread application low. This is true with the Multidimensional Frailty Score which requires the Charlson Comorbidity Index (19 components), ADL assessment using the Barthel Index (10 items), independent ADLs via the Lawson and Brody Index (8 items), a Mini-Mental State Examination, Geriatric Depression Scale, Mini Nutritional Assessment, and Nursing Delirium Screening Scale in addition to labs and physical exam components.[47] Unfamiliarity and need for education/exposure, as demonstrated by Eamer et al. in a survey of perception and importance of frailty of over 100 health care professionals,[61] is likely another factor impacting usefulness in clinical practice. Finally, even if frailty identifies patients at risk, we don't entirely know what to do with this information, which questions its clinical usefulness. The concept of prehabilitation, or rehab prior to surgery, will be addressed later.

2. ESTABLISHING A SYSTEM-WIDE ASSEMENT OF PRE-OPERTAIVE FRAILTY IN ELECTIVE SURGERY

2.1. Background

Frailty was hypothesized to correlate with increased post-operative risk across our institution's surgical population. Prior to exploring the relationship between frailty and post-operative morbidity or designing interventions to minimize impact, standardized frailty assessment within the clinical setting was necessary. Frailty was incorporated into all pre-operative evaluation of patients undergoing elective surgery in the BSW-Central system. Reasoning for the selected metric is provided. The implementation process, data collection and data generation are each described below.

2.2. Clinical Setting

Baylor Scott & White (BSW) Health is the largest not-for-profit healthcare system in the state of Texas. There are currently over 50 hospitals and 800 patient care sites across the state. The Central Texas Region (BSW-CTX) represents the care sites across the Central Texas geographic region. There are 4 main hospitals with over 900 beds in BSW-CTX. Scott & White Medical Center (SWMC) is a 640-bed tertiary center with over 2 million outpatient visits and 50,000 surgical procedures annually. SWMC functions as a BSW Health system referral center, Level 1 Trauma Center, and the primary location for the BSW-Central Department of Surgery and the Texas A&M Health Science Center College of Medicine – Scott & White General Surgery Residency. Led by the Chairman

Dr. Harry Papaconstantinou, the Department of Surgery focuses on QI and patient safety efforts along with surgical outcomes research. A research fellowship is offered in Healthcare Quality Improvement and Patient Safety, with a focus on frailty & outcomes research. The processes and data discussed represent IRB-approved work from the BSW-CTX Department of Surgery.

2.3. Frailty Tool Decision

Introducing frailty assessment into clinical work-flow required additional effort and time, both which are limited and important resources in healthcare delivery. The selected metric needed to be simple, objective, efficient, economical and prospective. Many of the frailty metrics discussed above were not appropriate given the time requirement, number of components or their retrospective nature. Additionally, given the geographic distribution and variety of surgical subspecialties represented in BSW-Central, the metric needed to be scalable and feasible across clinic locations and surgical subspecialties.

The Fried Frailty Index, also known as the Hopkins Frailty Score, is associated with morbidity and mortality in the surgical literature.[51-54] Within BSW-CTX, it was successfully implemented and is incorporated into the pre-transplant candidate selection process by the Abdominal Transplant Surgery Program. Logistical and subjectivity concerns constrained widespread implementation. The exhaustion component and low activity are self-reported and thus subjective and more prone to variability. Likewise, the slow walking requires a 15-foot time walk test, arguably difficult to implement within busy surgical clinics evaluating patients with various ambulation capabilities.

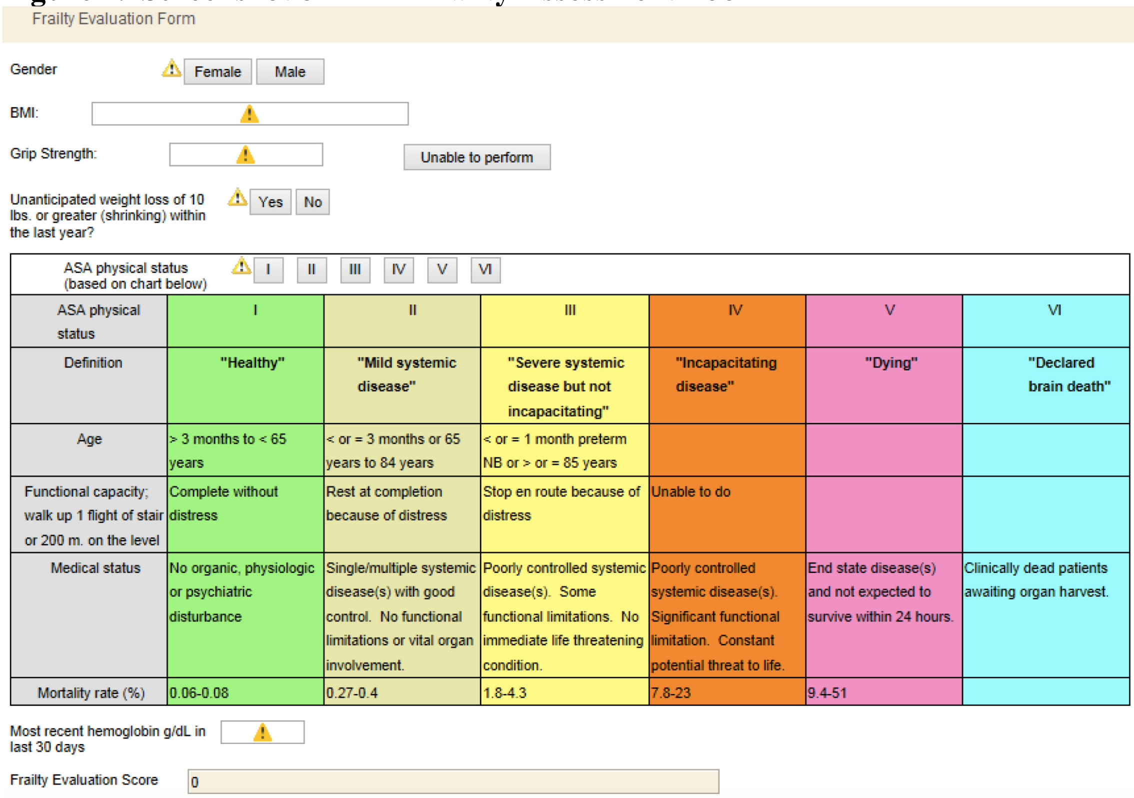
The limiting factors for implementing the Fried Frailty Index across BSW-CTX are similar to the critiques prompting the development of the Modified Fried or Modified Hopkins score.[60] By evaluating each component of the Fried Frailty Criteria, individually, in combination and with additional clinical data, Revenig et al. presented a new composite score with similar prognostic information for 30-day morbidity and mortality.

The Modified Hopkins Score uses 2 of the original Fried Criteria: weak grip strength and shrinking (unintentional weight loss of 10 pounds in the last year) in combination with a serum hemoglobin level and ASA score. A point is assigned for each of the following values: weak grip strength, presence of shrinking, ASA 3 or greater, low hemoglobin. Weak grip strength and hemoglobin are gender and age adjusted. An additional point is assigned if shrinking and weak grip strength are both present. A composite score from 0-5 results, with the following categories: low risk (0), intermediate risk (1-2) and high risk (3-5). In its design, traditional assessments (CCI and ECOG PS) along with routine pre-operative laboratory values (albumin, C-reactive protein, serum creatinine and platelets) were evaluated but did not strengthen predictive ability. The Modified Hopkins Score was selected to assess frailty within the BSW-Central Department of Surgery as it prospective, objective, economical and scalable across our surgical clinics.

2.4. Implementation Process

Frailty assessment using the Modified Hopkins Score was proposed as a method to identify high risk patients who could benefit from targeted interventions. Although the role of frailty was a clinical research question, the actual introduction of frailty into clinical practice was a departmental quality improvement initiative. Pre-implementation education was provided regarding frailty, hypothesis regarding risk-assessment and workflow logistics. To facilitate both calculation and documentation, a frailty calculator was built into our electronic medical record (EMR) with the score easily imported into clinic notes (Figure 1). Progress with implementation was measured over time. Compliance with frailty assessment was a component of QI-based physician incentives.

Figure 1. Screenshot of EMR Frailty Assessment Tool


Frailty Evaluation Form

Gender — Female | Male

BMI:

Grip Strength: — Unable to perform

Unanticipated weight loss of 10 lbs. or greater (shrinking) within the last year? — Yes | No

ASA physical status (based on chart below) — I | II | III | IV | V | VI

ASA physical status	I	II	III	IV	V	VI
Definition	"Healthy"	"Mild systemic disease"	"Severe systemic disease but not incapacitating"	"Incapacitating disease"	"Dying"	"Declared brain death"
Age	> 3 months to < 65 years	< or = 3 months or 65 years to 84 years	< or = 1 month preterm NB or > or = 85 years			
Functional capacity; walk up 1 flight of stair or 200 m. on the level	Complete without distress	Rest at completion because of distress	Stop en route because of distress	Unable to do		
Medical status	No organic, physiologic or psychiatric disturbance	Single/multiple systemic disease(s) with good control. No functional limitations or vital organ involvement.	Poorly controlled systemic disease(s). Some functional limitations. No immediate life threatening condition.	Poorly controlled systemic disease(s). Significant functional limitation. Constant potential threat to life.	End state disease(s) and not expected to survive within 24 hours.	Clinically dead patients awaiting organ harvest.
Mortality rate (%)	0.06-0.08	0.27-0.4	1.8-4.3	7.8-23	9.4-51	

Most recent hemoglobin g/dL in last 30 days

Frailty Evaluation Score — 0

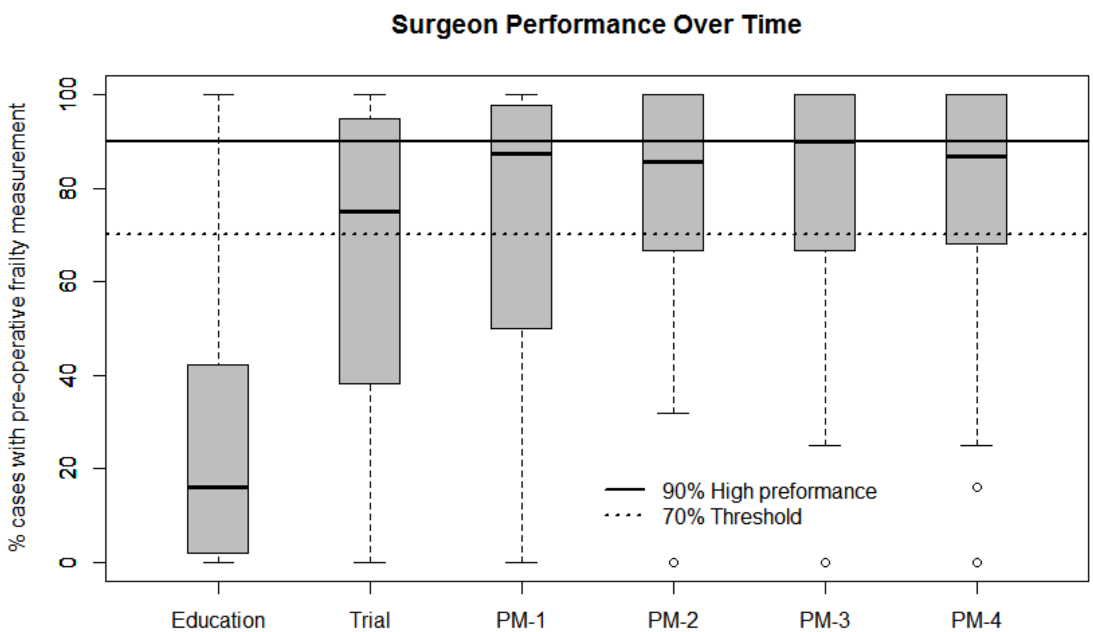
2.4.1. Progress Assessment

A 3-month education period permitted instruction and workflow optimization. Feedback was provided during the trial period, without impact on compensation. Performance compliance was linked to compensation starting in the following month, defined as performance month 1 (PM-1). Compliance measurement, reporting and performance-based compensation continued in subsequent months (PM-2, PM-3 and PM-4). Threshold and high-performance targets were set at 70% and >90% compliance, respectively. Data for the implementation pilot was analyzed using Wilcoxon signed rank and Kruskal-Wallis tests with significance at $p < 0.05$.

2.4.2. Results

Preoperative frailty assessment performance was evaluated for 92 surgeons, with median surgeon performance evaluated over time and compared with threshold and high-performance targets (Figure 2). Median surgeon compliance for the system was 16% in the education period and 75% in the trial period. Compliance during PM-1 was 88%, with subsequent months showing similar or improved results (PM-2 86%, p=0.055; PM-3 90%, p=0.019; PM-4 87%, p=0.077). Surgical subspecialty and regional hospital-specific analysis revealed no difference from the overall performance trend (p=0.082 and 0.66, respectively). As of PM-4, 73% of surgeons met threshold performance when considering all 4 performance months (>70%), of which over ½ achieved the high level goal (>90%).

Figure 2. Median Surgeon Performance Over Time



2.4.3. Conclusion

Pre-operative frailty measurement at a system level was successfully implemented after an education and trial period. Sustainability was demonstrated over the measured time frame, with similar percentage of cases measured at subsequent time periods (data not shown). Ensuring successful implementation across all surgical services was necessary prior to defining the presence of frailty and its potential impact on surgical morbidity.

2.5. Frailty Data Generation

As shown above in Figure 1, a frailty calculator was built into the EMR within the health system. From this, the frailty assessment could be imported into clinical notes. Given the volume of surgical cases, manual chart review for frailty score was not feasible. Additionally, individual chart review provided an increased risk of accessing unnecessary components of sensitive-health data. Institutional approval was received, and a data query performed for frailty data for all electives cases within the study time period. In addition to the frailty score (composite and individual components) the data acquisition included type of surgical procedure, Current Procedural Terminology (CPT) code, demographics, associated and new diagnoses, length of stay, and 30-day hospital code activation, emergency room visits and readmission. Cost data was also included.

2.6. Remarks

The above processes outlined above represent an approximately 18-month process required to support subsequently presented analyses.

3. FRAILTY DATA*

3.1. Approach to Data Analysis

In approaching the analysis of our dataset, there was not a uniform approach in the literature. The data supporting the Modified Hopkins Score was in a cohort of 351 consecutive patients, and no published data regarding the external validity of the Modified Hopkins Score was available[60]. Given the strength of the NSQIP program, we decided to first use NSQIP-targeted procedures and outcomes to explore frailty within our surgical population. After an association was demonstrated, frailty across all cases was investigated with respect to morbidity, mortality and cost. Finally, a disease specific focused analysis was performed for breast cancer patients given investigator clinical interest.

3.2. Prospective Frailty Correlates with NSQIP Outcomes in Elective Major Abdominal and Non-Cardiac Thoracic Surgery

3.2.1. Methods

3.2.1.1. NSQIP Participation

SWMC participates in the American College of Surgeon's NSQIP. NSQIP incorporates data from multiple surgical specialties from over 700 voluntarily participating institutions into a blinded, risk-adjusted database of 30-day postoperative outcomes, facilitating national benchmarking of complication rates and surgical outcomes.[10,11] SWMC participates in essential and procedure-targeted data collection. Essential data

* This article was published in Journal of the American College of Surgeons, Vol 228, Mary M. Mrdutt, Harry T. Papaconstantinou, Bobby D. Robinson, Erin T. Bird, Claire L. Isbell, Preoperative Frailty and Surgical Outcomes Across Diverse Surgical Subspecialties in a Large Health Care System, 482-493, Copyright Elsevier (2019).

collection results in a set number of randomly selected cases reviewed on an alternating schedule and represents a true random sampling in terms of both type of cases performed and individual surgeon performance. Procedure-targeted data collection provides review of all cases with pre-identified CPT codes, allowing investigation into all patient morbidity for certain procedures. Procedures of interest for this data collection method are determined by the ACS.

3.2.1.2. Data Collection

An IRB-approved retrospective review of patients 18 or older undergoing elective surgery January 2016-June 2017 was performed. Major abdominal and non-cardiac thoracic cases defined by NSQIP as procedure-targeted cases[62] at SWMC were evaluated. The procedures groups included: esophagectomy, hepatectomy, pancreatectomy, nephrectomy, cystectomy, colectomy, proctectomy and pulmonary resections. CPT codes for each procedure targeted case are listed (

Table 5). Procedures within six months of a prior operation were excluded. Although considered procedure-targeted cases at SWMC, predominately outpatient (thyroidectomy), acute care (appendectomy) and sub-specialty (brain tumor resection, total hip arthroplasty, spine, breast reconstruction, free flaps, hysterectomy) procedures were excluded from our study. Non-elective cases were excluded as pre-operative frailty is not assessed.

Table 5. CPT Codes for Procedure-Targeted Abdominal and Non-Cardiac Thoracic Cases Based on 2016 NSQIP Guidelines

Procedure	CPT Codes
Esophagectomy	101, 43107, 43108, 43112, 43113, 43116, 43117, 43118, 43121, 43122, 43123, 43124
Hepatectomy	47120, 47122, 47125, 47130
Pancreatectomy	48120, 48140, 48145, 48146, 48148, 48150, 48152, 48153, 48154, 48155, 48999
Nephrectomy	50220, 50225, 50230, 50234, 50236, 50240, 50543, 50545, 50546, 50548
Cystectomy	51550, 51555, 51565, 51570, 51575, 51580, 51585, 51590, 51595, 51596, 51597
Colectomy	44140, 44141, 44143, 44144, 44145, 44146, 44147, 44150, 44151, 44160, 44204, 44205, 44206, 44207, 44208, 44210
Proctectomy	44155, 44156, 44157, 44158, 44211, 44212, 45110, 45111, 45112, 45113, 45114, 45116, 45119, 45120, 45121, 45123, 45126, 45130, 45135, 45160, 45395, 45397, 45402, 45550
Pulmonary Resection	32440, 32442, 32445, 32480, 32482, 32484, 32486, 32488, 32491, 32503, 32504, 32505, 32506, 32507, 32663, 32666, 32667, 32668, 32669, 32670, 32671, 32672

Demographics, comorbidities and 30-day post-operative outcomes were obtained from institutional NSQIP data. Demographic variables included gender, age, body mass index (BMI), independent functional status, and American Society for Anesthesiologists (ASA) classification. Patients were stratified based on the World Health Organization BMI categories of normal weight, overweight and obesity classes I, II, and III, (BMI: 20 to 25; 25 to 30; 30 to 35, 35 to 40, and >40 kg/m^2, respectively). Comorbidities included diabetes, tobacco use within one year, dyspnea, severe COPD, ventilator dependence, CHF within 30 days prior to surgery, hypertension requiring outpatient medication, renal failure, ascites within 30 days prior to surgery, disseminated cancer, open wound present at time of surgery (PATOS), steroid/immunosuppressant use for chronic condition, recent weight loss of >10% in 6 months prior, bleeding disorder, preoperative transfusion requirement within 72 hours prior to surgery, severe inflammatory response syndrome (SIRS), and sepsis. A malignancy variable was assigned using International Classification of Diseases, Tenth Revision (ICD-10) codes.

3.2.1.3. Outcomes

30-day post-operative complications as defined by NSQIP included: surgical site infection (SSIs; including superficial, deep and organ space/intra-abdominal), wound dehiscence, prolonged ventilation, progressive renal failure, acute renal failure (ARF), urinary tract infection (UTI), stroke (CVA), cardiac arrest requiring cardiopulmonary resuscitation (CPR), myocardial infarction (MI), transfusion requirement, deep vein thrombosis (DVT), *Clostridioides difficile* infection (C Diff), sepsis, septic shock, unplanned readmission, unplanned reoperation, discharge to setting other than home and death. A composite variable of "any NSQIP complication" (listed above) was created. For each CPT code, patient length of stay (LOS) was compared with the national interquartile range (calculated from 2015 NSQIP data),[62] and was categorized as prolonged if greater than the 75th percentile. Prolonged LOS was not included in the composite outcome "any NSQIP complication."

3.2.1.4. Prospective Frailty Assessment

Frailty was prospectively assessed in elective surgery patients at BSW-CTX using the Modified Hopkins Frailty score.[60] Components included: shrinking (unintentional recent weight loss 10 pounds or greater in the last year), handgrip strength, hemoglobin, and the American Society of Anesthesiologists Physical Status Classification System (ASA). Possible frailty score ranged from 0-5. ASA from the frailty calculations was compared to NSQIP ASA, which was obtained from the anesthesia record. If discordance existed, frailty score was adjusted using the NSQIP ASA as the standard. Risk stratification was based on frailty score: low (0), intermediate (1-2; int), high (≥3).

3.2.1.5. Statistical Analysis

Categorical variables were reported as counts (percentages), and continuous variables as mean (standard deviation) if normally distributed or as median (minimum – maximum). A Kruskall-Wallis test was used to test for associations in bivariate comparisons for continuous variables and a chi-square test for categorical variables. A logistic regression model was used for estimating the odds ratio for frailty for each outcome, adjusting for demographics and comorbidities. Age and gender were not included in the model as 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., Cary, NC).

3.2.2. Results

3.2.2.1. Demographics

548 patients met study inclusion criteria; 426 (77.8%) had a frailty evaluation and were included in the analysis. Figure 3 depicts total number of cases by procedure type; 80.1% of cases were abdominal procedures and 19.9% pulmonary resections. Overall frailty distribution was 13.2% low, 76.5% intermediate and 10.3% high. Demographics by frailty classification are listed in

Table 6. All groups were >50% male. Median age increased with increased frailty (56.0 low, 64.2 intermediate, 68.4 high) while BMI was lower in the high frailty cohort than low and intermediate (median 26.7 high vs 29.1 low and 29.6 intermediate). Distribution of frailty by age group is shown in Figure 4. High frailty was present in patients as young as the 30 or older cohort, while low frailty was present in patients older than 80.

Overall, 68.3% of cases were for malignancy. Malignant diagnoses increased with frailty (low 50.0%, intermediate 70.9%, 72.7%, $p = 0.007$). Low, intermediate and high frailty patients were present in all procedure type groups expect for hepatectomy, where there were no low frailty patients. Intermediate frailty was the predominate classification (>50%) in all procedure type subgroups. Frailty distribution differed by procedure type ($p = 0.003$,

Figure 5). Cystectomy and esophagectomy had the highest proportions of high frailty patients, 35.3 and 25.0%, respectively. Pancreatectomy followed by nephrectomy, 2.8 and 7.4%, had the lowest.

Figure 3. NSQIP Procedure-Targeted Analysis: Total Number of Cases by Procedure Type

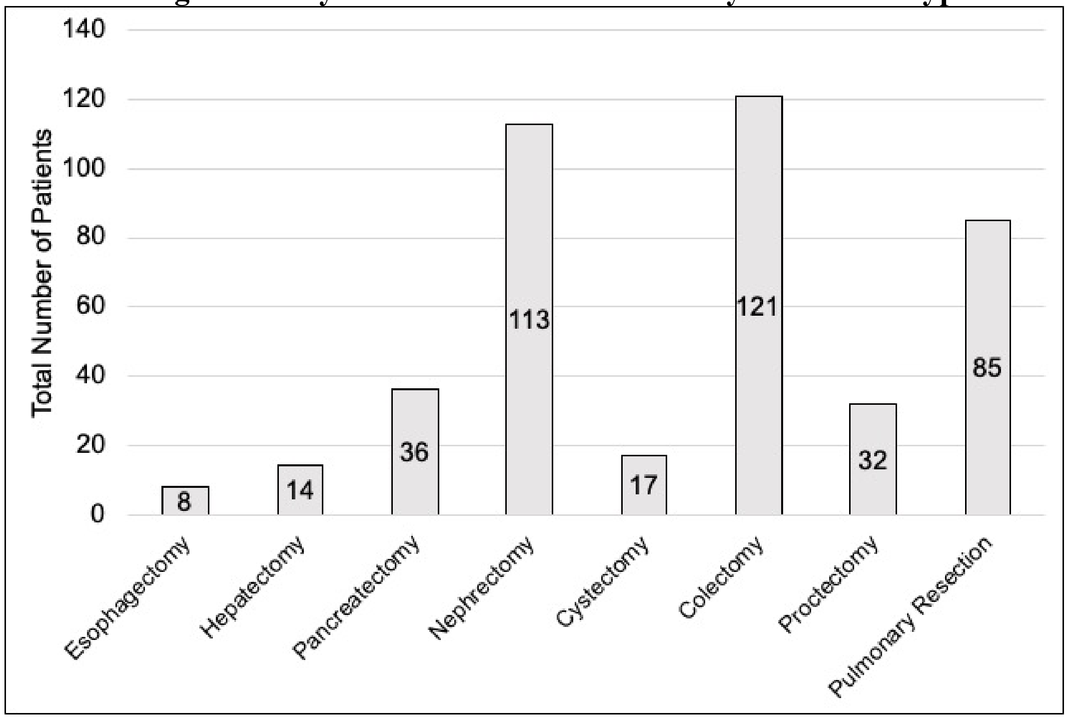


Figure 4. NSQIP Procedure-Targeted Analysis: Frailty and Age

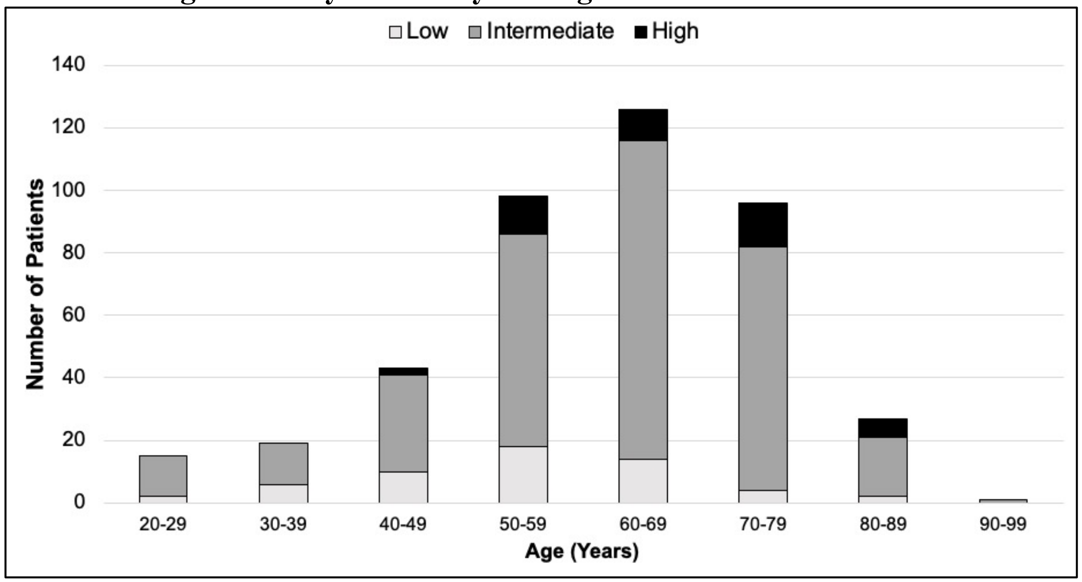
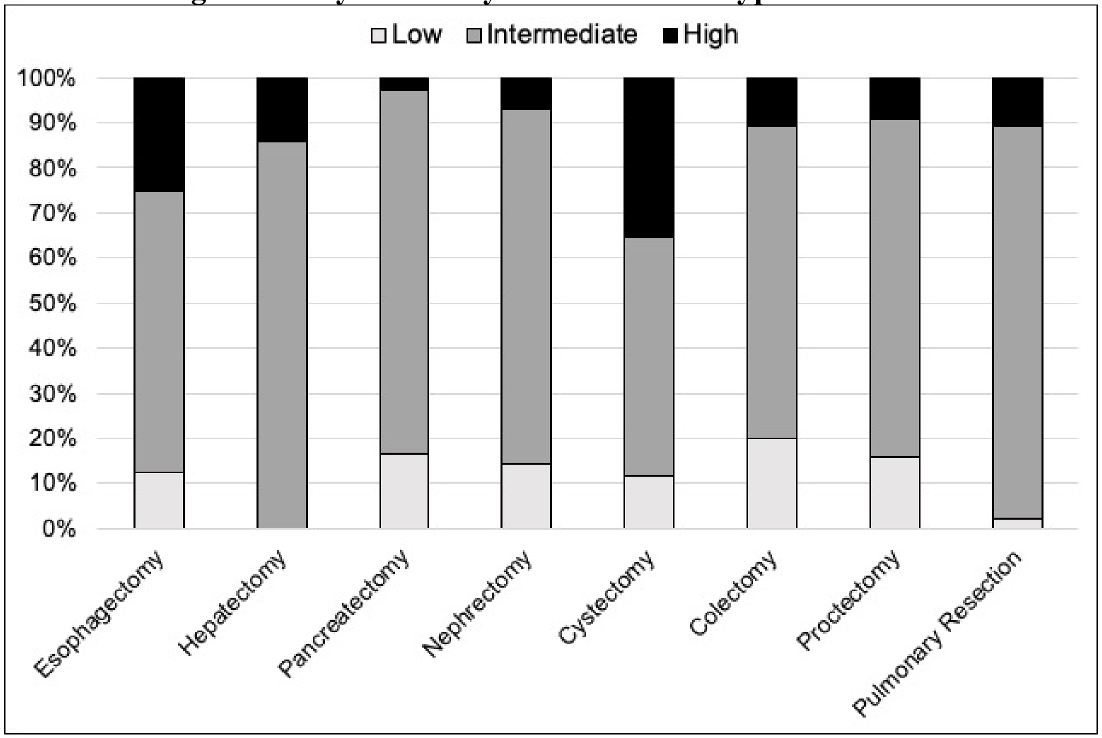


Figure 5. NSQIP Procedure-Targeted Analysis: Frailty and Procedure Type



3.2.2.2. Outcomes

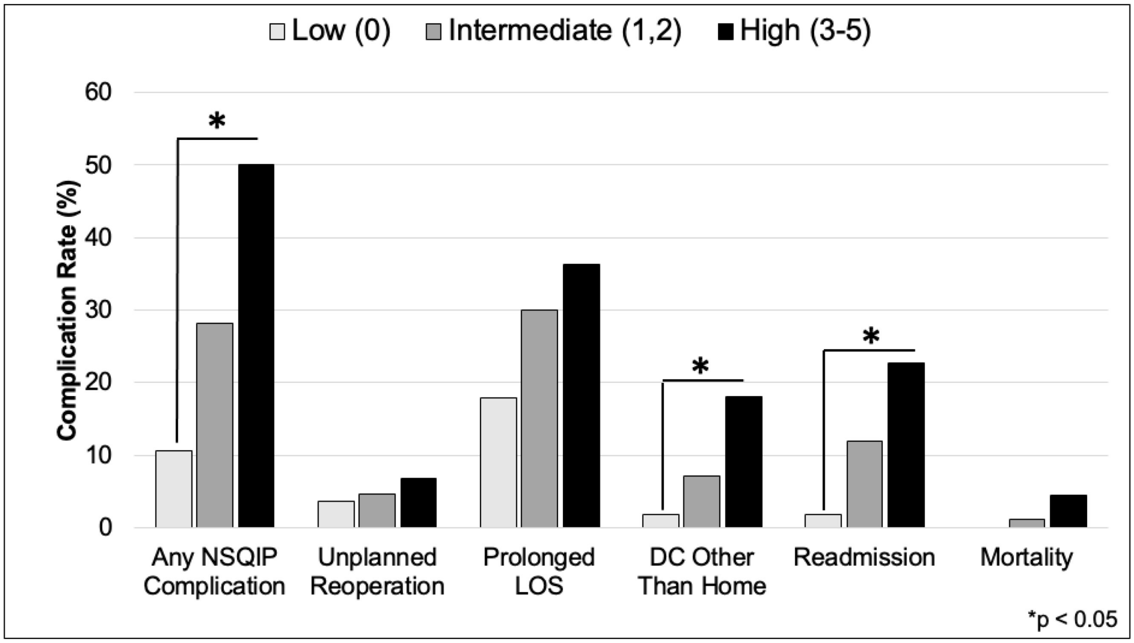
Observed rates for 30-day outcome are listed by frailty group in

Table 7, with univariate analysis for predetermined complications of interest (readmission, reoperation, DC other than home, death, any complication, prolonged LOS) by frailty group in

Table 8. Of the individual NSQIP complications, transfusion requirement (low 3.6%, intermediate 8.9%, high 27.3%) and organ space infections (low 0%, int 5.2%, high 9.1%) occurred most frequently. Otherwise, individual NSQIP complications occurred in less than 5% in all frailty groups. Rate of the composite of any NSQIP variable increased with frailty classification (low 10.7%, int 7.1%, high 50.0% $p < 0.05$). Discharge to setting other than home (low 1.8%, int 7.1%, high 18.2%) and readmission rates (low 1.8%, int 12.0%, high 22.8%) also had statistically significant increases with frailty (all $p < 0.05$). Rates of reoperation and prolonged LOS increased with frailty but did not meet statistical significance (

Figure 6). Most readmissions and reoperations were related to the index operation (readmission low 100%, int 84.6%, high 90%; reoperations low 100%, int 86.7%, high 100%). 30-day mortality was 1.2% for intermediate frailty group and 4.5% in high frailty. No deaths occurred within 30 days in the low frailty group.

Figure 6. NSQIP Procedure-Targeted Analysis: 30-Day Complications



3.2.2.3. Logistic Regression Model

A logistic regression model for each of the following 30-day complications was performed: readmission, reoperation, DC other than home, any NSQIP complication and prolonged LOS. BMI groups, diabetes, current smoker, dyspnea, functional health status, COPD, hypertension, steroid use, malignancy and frailty were covariates. Adjusted odds ratios for each complicated based on frailty classification are listed in

Table 9 along with the c-statistic. Odds of having readmission and any NSQIP complication both show significant increase in intermediate and high frailty patients, while odds of DC setting other than home show a significant increase with high frailty patients

3.2.3. Tables for NSQIP Procedure-Targeted Data

Table 6. NSQIP Procedure-Targeted Analysis: Patient Demographics

Variable	Low (n = 56)	Intermediate (n = 326)	High (n = 44)
Male sex, n (%)	30 (53.6)	169 (51.8)	24 (54.5)
Age in years, median (IQR)	56.0 (46.8-65.4)	64.2 (54.5-72.6)	68.4 (58.7-77.3)
BMI, median (IQR)	29.1 (25.8-32.9)	29.6 (25.0-34.3)	26.7 (24.0-33.5)
Diabetes, n (%)			
No	55 (98.2)	264 (81.0)	30 (68.2)
Oral Agents	1 (1.8)	38 (11.7)	7 (15.9)
Insulin	0 (0.0)	24 (7.3)	7 (15.9)
Tobacco Use Within 1 year, n (%)	12 (21.4)	82 (25.1)	11 (25.0)
Dyspnea, n (%)			
No	55 (98.2)	282 (86.5)	35 (79.5)
Moderate Exertion	1 (1.8)	39 (12.0)	8 (18.2)
At Rest	0 (0.0)	5 (1.5)	1 (2.3)
Severe COPD, n (%)	1 (1.8)	35 (10.7)	8 (18.2)
Independent Functional Status, n (%)	56 (100.0)	319 (97.9)	41 (93.2)
CHF within 30 days prior to surgery, n (%)	1 (1.8)	3 (0.9)	0 (0.0)
Hypertension Requiring Outpatient Medication, n (%)	23 (41.1)	185 (56.7)	32 (72.7)
Renal Failure, n (%)			
Acute	0 (0.0)	0 (0.0)	1 (2.3)
Requiring or on Dialysis	0 (0.0)	0 (0.0)	2. (4.5)
Disseminated Cancer, n (%)	0 (0.0)	12 (3.7)	8 (18.2)
Open Wound PATOS, n (%)	0 (0.0)	2 (0.6)	0
Steroid or Immunosuppressant Use for Chronic Condition, n (%)	1 (1.8)	19 (5.8)	4 (9.1)
>10% Loss of Body Weight in 6 Months Prior, n (%)	1 (1.8)	10 (3.1)	5 (11.4)
Bleeding Disorder	0 (0.0)	4 (1.2)	1 (2.3)
Requiring Preoperative Transfusion of RBC < 72 hours form surgery, n (%)	0 (0.0)	1 (0.3)	1 (2.3)
SIRS, n (%)	0 (0.0)	2 (0.6)	0 (0.0)

IQR, interquartile range; PATOS, present at time of surgery; RBC, red blood cells; SIRS, severe inflammatory response syndrome

No patients were ventilator dependent, had ascites present or met sepsis criteria at time of surgery.

Table 7. NSQIP Procedure-Targeted Analysis: 30 Day Morbidity and Mortality

Outcome	Low (n = 56)	Intermediate (n = 326)	High (n = 44)
SSI—superficial	1 (1.8)	14 (4.3)	1 (2.3)
SSI—deep	0 (0.0)	2 (0.6)	0 (0.0)
SSI—organ space	0 (0.0)	17 (5.2)	4 (9.1)
Wound Dehiscence	1 (1.8)	0 (0.0)	1 (2.3)
Prolonged Ventilation	1 (1.8)	9 (2.8)	1 (2.3)
Progressive Renal Failure	1 (1.8)	3 (0.9)	1 (2.3)
Acute Renal Failure	0 (0.0)	1 (0.3)	0 (0.0)
UTI	1 (1.8)	11 (3.4)	1 (2.3)
CVA	0 (0.0)	1 (0.3)	1 (2.3)
CPR	0 (0.0)	1 (0.3)	0 (0.0)
MI	0 (0.0)	2 (0.6)	0 (0.0)
Transfusion Requirement	2 (3.6)	29 (8.9)	12 (27.3)
DVT	0 (0.0)	3 (0.9)	0 (0.0)
C Diff	0 (0.0)	4 (1.2)	1 (2.3)
Sepsis	0 (0.0)	8 (2.5)	1 (2.3)
Septic Shock	0 (0.0)	6 (1.8)	1 (2.3)

Table 8. NSQIP Procedure-Targeted Analysis: Univariate Analysis of 30-Day Outcomes

Outcome	Low (n = 56)	Intermediate (n = 326)	High (n = 44)	p-value
Readmission*	1 (1.8)	39 (12.0)	10 (22.8)	<0.05
Reoperation**	2 (3.6)	15 (4.6)	3 (6.8)	NS
DC Other Than Home	1 (1.8)	23 (7.1)	8 (18.2)	<0.05
Death	0 (0.0)	4 (1.2)	2 (4.5)	NS
Any Complication	6 (10.7)	92 (28.2)	22 (50.0)	<0.05
Prolonged LOS	10 (17.9)	98 (30.1)	16 (36.4)	NS

DC, discharge; LOS, length of stay
*Readmission related to primary operation in majority of patients (100% low, 84.6% int, 90% high)
**Reoperation related to primary operation in majority of patients (100% low, 86.7% int, 100% high)

Table 9. NSQIP Procedure-Targeted Analysis: Multivariable Analysis of Association Between Preoperative Frailty and 30-Day Complications

Outcome	Frailty	OR (95% CI)	C-statistic
Readmission	Intermediate High	7.5 (1.5-134.9) 15.2 (2.6-293.5)	0.69
Reoperation	Intermediate High	1.0 (0.2-6.7) 1.1 (0.1-9.8)	0.69
DC Other Than Home	Intermediate High	3.3 (0.6-50.0) 10.0 (1.4-166.7)	0.74
Any NSQIP Complication	Intermediate High	3.5 (1.5-9.8) 8.8 (3.1-28.5)	0.68
Prolong LOS	Intermediate High	1.6 (0.8-3.6) 1.8 (0.7-5.1)	0.64

DC, discharge; OR, odds ratio
Ref = Low frailty

3.2.4. Summary

We describe the presence of frailty in 426 patients undergoing elective intra-abdominal and thoracic non-cardiac procedures. Outpatient and low risk procedure-targeted cases were excluded from the procedure given the low rate of morbidity in the immediate post-operative period. We focused on procedures traditionally considered “higher risk” due to the hypothesis that such patients may have detectable frailty. We wanted to determine the presence and the possible association of frailty in post-operative complications in a small pilot experience, prior to analyzing the much larger number of cases likely needed with procedures traditionally considered lower risk.

Frailty was present in over 85% of patients, with approximately 10% of patients having high frailty. High frailty was present in each age decade group except those adults very young (age 20-29). Patients with high frailty were present in each of the procedure types. This finding is not surprising given diagnoses prompting such surgical management (such as esophageal, pancreatic and lung cancer) often present with malnutrition and require a component of neoadjuvant systemic therapy. Over two-thirds of our pilot cohort had a primary malignant diagnosis. What is more interesting however is the presence of low frailty patients across these high-risk procedure types, who may suffer from benign but complex diagnoses (pancreatic cysts, chronic diverticulitis) or had significant physiologic reserve prior to developing a malignancy. Our data suggests not all patients undergoing a pancreatectomy or esophagectomy, for example, are frail, which differs from our initial hypothesis of high frailty across these high-risk procedures in predominately malignant patients. What we cannot determine from this data is the presence of frailty in non-operative candidates with similar disease processes. This cohort likely represents a higher rate and level of frailty, both from advanced disease and comorbidities disqualifying a surgical candidate from a high-risk operation. Put another way, high frailty may be increased in patients unable to tolerate neoadjuvant systemic therapy and those progressing to metastatic disease.

The overall rate of post-operative complications was low and such a composite variable of any complication was predetermined and included in the analysis. The rate of any complication significantly differed across frailty groups: low 10.7%, int 7.1%, high 50.0% ($p < 0.05$). When considered in multivariable model, the odds of having any NSQIP complication increased with intermediate and high frailty (OR intermediate 3.5, high 8.8). Health utilization metrics, specifically readmission and discharge to a setting other than home were also associated with increased frailty.

This pilot analysis of NSQIP procedure-targeted cases demonstrated frailty was detectable in our patient population using the Modified Hopkins Frailty score and was associated with post-operative morbidity. These findings were encouraging and prompted analysis of a larger, more heterogenous population of inpatient and outpatient elective procedures.

3.3. Preoperative Frailty and Surgical Outcomes—Published Manuscript

This article was published in Journal of the American College of Surgeons, Vol 228, Mary M. Mrdutt, Harry T. Papaconstantinou, Bobby D. Robinson, Erin T. Bird, Claire L. Isbell, Preoperative Frailty and Surgical Outcomes Across Diverse Surgical Subspecialties in a Large Health Care System, 482-493, Copyright Elsevier (2019).[63] Article can be found in Appendix A Previously Published Work with permission for reproduction of this work in Appendix B.

3.4. Defining the Role of Frailty in Breast Oncology Patients Across a Regional Healthcare System

3.4.1. Background

Breast oncology procedures carry a relatively low morbidity and mortality profile relative to other surgical oncology fields, however the need to identify at-risk patients within this population should not be overlooked. Frailty has emerged as a promising approach to capture composite risk in pre-operative patients. We sought to define the predominance of frailty in breast oncology patients within a regional healthcare system and explore its relationship with post-operative complications.

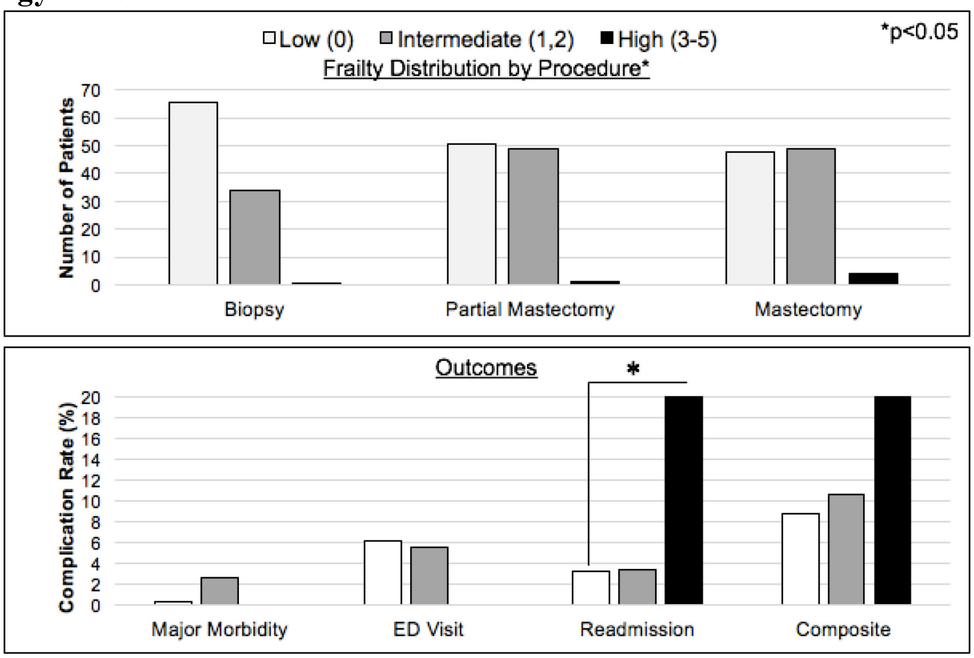
3.4.2. Methods

Frailty was prospectively measured in elective surgery patients (1/2016-6/2017) in a healthcare system (4 hospitals/901 beds). Frailty classifications—low (0), intermediate (1-2), high (3-5)—were assigned based on the modified Hopkins score.[60] Operations were classified as inpatient versus outpatient. Outcomes measured (30-day) included major morbidity, mortality, Emergency Department (ED) visit, readmission and length of stay. Inclusion criteria for our study included: greater than 18 years, elective surgery, and undergoing a breast oncology procedure. Breast oncology procedures were classified into the following cohorts: biopsy (with/without radiographic marker; CPT 19120, 19125), partial mastectomy (19301, 19302), mastectomy (19180, 19240, 19303, 19307).

3.4.3. Results

14,530 patients (68.1% outpatient, 31.9% inpatient) were preoperatively assessed in elective surgical cases. High frailty was found in 3.4% of all patients (5.3% inpatient, 2.5% outpatient). 623 patients met our inclusion criteria with the following distribution: 226 (36.6%) biopsy, 218 (35.0%) partial mastectomy, 179 (28.7%) complete mastectomy. All biopsy patients were outpatient procedures; partial and mastectomy patients were admitted for overnight observation or longer as required. High frailty was present in 10 (1.6%) of study patients. Frailty distribution differed by procedure types: biopsy 0.4%, partial mastectomy 0.9%, mastectomy 3.9% ($p < 0.05$; Fig). Median age of high frailty patients was 69.5 years (range 23-88), although 2 high frailty patients were less than 50 years. BMI extremes, < 20 and >40) were present in the high frailty cohort (range 17.1-63.1). The incidence of major morbidity, ED visits and a composite outcome did not differ with frailty, however high frailty patients had a higher incidence of readmission ($p<0.05$; Fig). Median LOS after mastectomy did not differ based on frailty (median LOS in days: low 1.3, intermediate 1.2, high 1.2).

Figure 7. Frailty Distribution by Procedure and Complications by Frailty in Breast Oncology Patients



3.4.4. Conclusion

Frailty is feasible to assess pre-operatively in breast oncology patients. High frailty combined with extremes in age and BMI are represented in outpatient and inpatient populations. Given the increased utilization of breast conservation following neoadjuvant chemotherapy,[64] the elevated frailty burden observed in mastectomy patients is not fully explained by higher stage disease requiring chemotherapy prior to surgery. High frailty patients experience increased readmission rates. Additional work is required to explore this relationship in a larger population and determine how to mitigate this risk.

4. A PROGRAM PLAN FOR WALKING TO BETTER OUTCOMES

4.1. Contemporary Preoperative Efforts

Much of the interest regarding frailty is identifying patients we can intervene on prior to complications occurring. To date, the most mature and robust approach for preoperative intervention is the Strong for Surgery program, a public health initiative designed and piloted in the state of Washington by Varghese et al.[65] The program addresses four domains—nutrition, glycemic control, smoking cessation and medical management—in a standardized approached applying guideline recommendations. Early experience demonstrated improved compliance with and adoption of evidence-based practices such as peri-operative beta blocker use, glucose testing and immunonutrition.

Strong for Surgery was subsequently adopted by the ACS with a clinical toolkit available for use, and additional domains regarding pain management, delirium, patient directives and prehabilitation added. The ACS defines prehabilitation as "a process of improving functional capacity of a patient prior to a surgical procedure so the patient can withstand any postoperative inactivity and associated decline".[66] Similar to components seen in frailty assessments, the Strong for Surgery prehabilitation checklist screens for falls, cardiac disease, unstable pulmonary disease and poor mobility. Recommendations for each domain include referral to geriatrician, cardiologist, pulmonologist and physical therapy, respectively. A daily walking program is an alternative suggestion for those with ambulation and/or endurance concerns.

Interventions for frailty in surgical patients are in their infancy. Compelling evidence exists of improved mortality at 30, 180 and 365 days in 9153 patients undergoing major, elective non-cardiac surgery.[67] All patients were screened for preoperative frailty as an institutional quality improvement initiative. Rather than a unifactorial cause, the authors hypothesize that the reduction in mortality was due to awareness of frailty with changes in decision making, anesthesia-plans and post-operative rescue treatments. The protocol for systematic review of preadmission interventions by Perry et al. highlights the interest and need to synthesize pilot institutional experiences into more universal approaches.[68]

Below is a program independently designed during master's coursework. It provides a simple pre-operative intervention to improve ambulation and physical activity. Although designed for a thoracic surgery clinic, implementation would be equally feasible in other settings, such as a high frailty clinic.

4.2. A Program Plan: Walking to Better Outcomes

4.2.1. Community Description, Statement of Need and Program Rationale

Obesity and low physical activity are known to contribute to multiple chronic conditions including cancer and heart disease, disease processes with the two highest mortality rates within the state of Texas and more locally within Bell County.[69] According to 2013 CDC data, nearly ¼ of US adults engage in no leisure physical activity; in Texas this is nearly 30%.[70] CDC data also shows that only 20% of US adults meet weekly aerobic and muscle strengthening recommendations; in Texas less than 1 in 5 adults meet minimum recommendations. Obesity and poor physical activity are arguably two of the largest health issues faced by Texas.[71] Unfortunately, current projections suggest by 2040 up to 20 million people within Texas alone will be overweight or obese.[72] From a fiscal standpoint, obesity cost Texas businesses $11.1 billion in 2012, with projections of greater than $30 billion by 2030 at the current rate of change.[73]

The lack of physiologic reserve, also known as frailty, correlates with poor surgical outcomes both short and long term, 30 days and 1 year respectively.[52-54, 60] Poor functional activity, obesity and malnutrition all contribute to the concept of frailty. Obesity is also an independent risk factor for numerous surgical outcomes.[74] Increased interest from the surgical community on patient outcomes has catalyzed significant interest in appropriate risk stratification and documentation of surgical outcomes.

An example of a successful pre-operative program is Strong for Surgery, a national initiative to ensure medications, glucose control, nutritional status and smoking cessation are optimized prior to surgery.[65] The surgical community accepts these as important risk factors for surgical outcomes. Early ambulation following surgery is also very important for recovery and optimizing outcomes. Low activity levels are associated with increased infections, thrombotic events such as blood clots in legs and lungs, delayed return of bowel function (known as ileus), poor wound healing, and pressure ulcers among other conditions.[75] Early ambulation is an important goal.

Obesity and poor physical activity are a known problem in Texas, as outlined above. Surgical patients would benefit from increased physical activity both prior to and after their surgery. While increased activity could help cause weight loss, it may also improve pre-operative functional status and promote early ambulation after surgery. These changes would benefit all surgical patients—those having day surgery and those recovering in the hospital.

Obesity and poor physical activity are daily challenges in primary care and surgical clinics. Deconditioned and/or obese patients have worse surgical outcomes. Even within our surgical sub-population, the health needs of our local community impact people's survival and quality of life after surgery. "Walking To Better Outcomes: A Health Education Program to Increase Activity Prior to and After Surgery" would target the elective surgery patient population at Scott & White Medical Center (SWMC) in Temple, TX. SWMC preforms over 750 elective cases per month, and serves as a tertiary referral center, is a Trauma I center and the county hospital/Safety Network Hospital for Bell County and surrounding areas. At least half of all surgical patients have a BMI 30 or greater.

"Walking to Better Outcomes" would be a self-directed program aimed at increasing physical activity prior to surgery and maintaining increased activity during recovery. The program would consist of a website, a patient class, individual logs, a pedometer, support meetings, program blog and you-tube videos. There would be a nursing-coordinator to facilitate data collection and outcomes tracking. Patients would record daily physical activity (walking) and then increase by 5% every day prior to surgery. After surgery, the patient would work on an accelerated program to return to their pre-operative baseline. A pedometer and logbook would allow nursing providers and family/support to understand and support the patient's daily ambulation goals.

There is significant interest in pre-habilitation for high-risk patients.[76,77] Walking to Better Outcomes would be a form of pre-habilitation that every patient, regardless of baseline health or surgery date, could participate in as benefits from physical activity and early ambulation following surgery are universal. Objective measures of success would include the patient's daily ambulation logs, length of stay in the hospital, and already tracked surgical outcomes (such as infections, ileus, thrombotic events, myocardial infarction, etc.). Patient satisfaction and subjective surveys could also provide useful information, as would long-term activity logs, maintained during and after recovery from surgery.

As surgeons, we can promote Walking to Better Outcomes with our patients. Likewise, a pre-surgery physical activity health promotion program would be successful because most individuals undergoing surgery want some say and control over their care. Major events such as a cancer diagnosis and/or major surgery are scary; people often feel like they have lost all control. This proposed program would give them the tools to help improve their outcomes and recovery and, in the process, lay a foundation for a sustained behavior change.

"Walking to Better Outcomes" is a health promotion program that would benefit surgical patients by 1) increasing physical activity prior to surgery, 2) supporting early ambulation after surgery, 3) encouraging long-term behavior modification, 4) empowering surgical patients regarding their care and recovery and 5) potentially provide cost savings to patients and the health care system.

4.2.2. Program Description

The proposed program is called Walking to Better Outcomes. The mission statement: To improve surgical outcomes by increasing awareness, understanding and compliance with physical activity in surgical patients through education, support and health promotion. Goals and objectives supporting this mission are listed in Table 10.

Table 10. Walking to Better Outcomes: Program Goals and Objectives

Goal #1: Improve knowledge on importance of physical activity, both pre-operatively and long-term	
Outcome Objective	75% of program participants will maintain increased physical activity and activity, logging 6 months following surgery.
Impact Objective	After completion of the physical activity class, 75% of patients will demonstrate improved knowledge and attitude on a post-class survey (when compared to pre-class survey).
Process Objectives	After 1 month of program rollout, 50% of elective surgery patients will complete the physical activity class prior to surgery. After 2 months of program rollout, 75% of elective surgery patients will complete the physical activity class prior to surgery. After 3 months of program rollout, 90% of elective surgery patients will complete the physical activity class prior to surgery.
Goal #2: Minimize surgical morbidity by increasing peri-operative physical activity in elective surgery patients	
Outcome Objectives	Within 1 year, surgical morbidity—including falls, blood clots, hyperglycemia, pneumonia—will decrease by 25% in elective surgery patients participating in Walking to Better Outcomes. Post-operative quality of life following surgery will be 50% improved compared with pre-program control population. Time to return to work/ADLs will be 25% lower in patients participating in Walking to Better Outcomes when compared with pre-program/historic mean.
Impact Objectives	75% of patients in the program will bring pre-operative walking logs (created using their take-home pedometer) to be reviewed on the day of surgery. 75% of patients participating in Walking to Better Outcomes program will have post-operative daily steps that are equal to or greater than pre-operative values.
Process Objectives	After 1 month of program rollout, 50% of elective surgery patients will receive a take-home pedometer from the program staff. After 2 months of program rollout, 75% of elective surgery patients will receive a take-home pedometer from the program staff. After 3 months of program rollout, 100% of elective surgery patients will receive a take-home pedometer from the program staff.
Goal #3: Healthy People 2020 Objectives[78] relating to the program's mission, goals and objectives	
- PA-1 Reduce the proportion of adults who engage in no leisure-time physical activity - PA-2 Increase the proportion of adults who meet current federal physical activity guidelines for aerobic physical activity and for muscle-strengthening activity - PA-11 Increase the proportion of physician office visits that include counseling or education related to physical activity - PA-13 Increase the proportion of trips made by walking	

4.2.3. Theoretical Foundation

Improved physical activity is an important goal for not only Bell County citizens, but Texans and Americans as a whole. CDC data suggests nearly ¼ of US adults and 30% of Texans engage in no leisure physical activity; meanwhile only 20% of US adults meet weekly aerobic and muscle strengthening recommendations and in Texas this is even lower.[70] With surgery, the lack of physiologic reserve, also known as frailty, correlates with poor surgical outcomes both short and long term, 30 days and 1 year respectively, and with poor functional activity, an important component of frailty.[53, 60]

The goal for the proposed "Walking to Better Outcomes" is to improve physical activity in surgical patients prior to surgery and during their recovery. The priority population for the health intervention includes all surgical patients undergoing elective surgery at Scott & White Medical Center (SWMC). SWMC serves Bell County along with other surrounding areas in Central Texas. Emergency surgery patients and pediatric surgery patients are excluded from the pilot effort.

Theories and models are critical to program planning,[79] allowing for "better utilization of resources and improved effectiveness".[80] When considering a theory to address physical activity in surgical patients, the Social Cognitive Theory (SCT) is best-suited.[79-81] SCT is an interpersonal level theory that is rooted in the influence and strength peer interactions possess and the dynamic interaction between an individual and his or her environment. Opinions, beliefs and social norms are also important. On a basic level, SCT is similar to Stimulus Response Theory with the concept of reinforcement (see below), but SCT builds on learning with reciprocal interaction.

Reinforcement is present via direct reinforcement (provided by program facilitators and medical team), vicarious reinforcement (via peer support groups) and self-reinforcement (via self-logs). Additionally, SCT stresses the importance of behavioral capability, which is provided by the educational component of the proposed program. The expected outcomes with "Walking to Better Outcomes" are improved surgical outcomes and recovery secondary to increased physical activity. Another important component of SCT is the self-efficacy; individuals develop competence to meets goals and overcome barriers. Ultimately individuals become empowered and gain confidence that they can increase physical activity; "Walking to Better Outcomes" provides them with reinforcement, personal success and support to do so!

Ideally, the Health Belief Model (HBM) is well-designed to support improving physical activity based on perceived threat and severity of poor health and chronic disease; however, the time constraints of "Walking to Better Outcomes" is problematic. In order for HBM to be successful, motivation and perceived benefits must also exist[81]. While the threat and severity of surgery, and surgical diseases such as cancer, are very much present, the individual likely does not have the time needed to process, prioritize and decide on the benefits of physical activity.

As mentioned above, the Stimulus Response Theory (SRT) seems like a suitable choice for program planning, with positive reinforcement for increasing physical activity. The concern exists though that SRT lacks the development of self-efficacy and coping skills needed to deal with temptation and relapse.[81] Cognitive skills and strategies for problem solving are critical to cope with "demands of everyday life."

Elaboration Likelihood Model of Persuasion is not a good fit, because the emotional aspect of having surgery will likely prevent individuals from central route, or even peripheral route, processing. Likewise, the time required for stages of change in the Transtheoretical Model is not conducive with the time frame of surgery; we need someone to quickly go from whatever stage they are currently in (precontemplation, contemplation, etc.) to action in a matter of days not months! Similar time constraints are true regarding the stages of the Precaution Adoption Process Model; patients facing surgery don't have the luxury of time to decide not to act.

Ultimately the SCT capitalizes on interactions between the individual and the environment to build self-efficacy. This compliments the supportive nature of Walking to Better Outcomes" which is designed to support the individual's process to empowered behavior change for their own health.

4.2.4. Budget

A pilot experience would include 6 months, with approximately 30 cases per month. The budget includes supplies for 200 patients, assuming a portion enrolled will not go on to surgery (Figure 8).

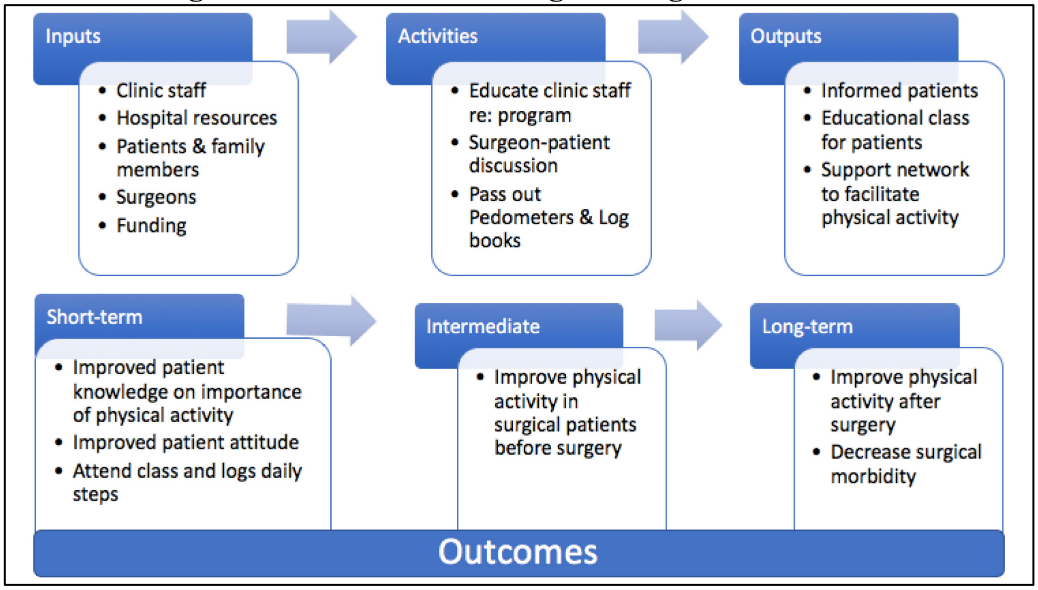
Figure 8. Walking to Better Outcomes: Pilot Budget

Revenue	**$13,500**	
Grants	$5000 BSW Young Investigator	
Grant		
	$1500 BSW Research Travel Fund	
Donations	$5000 Industry	
	$2000 BSW Media	
Participation Fee	$0	
Expenditures		**$10,150**
Curriculum Materials (booklets w daily log, $5 each)		$1000
Equipment (pedometers with BSW logo, $5 each)		$1000
Incentives		
Tshirts ($8 each, 2/participant)		$3200
Marketing		
Print (fliers, posters, pamphlet)		$1000
Video production		$500
DVD player for thoracic clinic		$250
Personnel		
Salary—included in thoracic clinic overhead		
Incentives—weekly breakfast for staff ($50/week)		$1200
Space (provided within thoracic clinic & BSW)		$0
Supplies (digital camera & printer, wall supplies)		$500
Travel (to conference to present pilot experience)	$1500	
Balance		**$3350**

4.2.5. Program Logic Model

A program logic model is provided in Figure 9.

Figure 9. Walking to Better Outcomes: Program Logic Model



4.2.6. Program Strategies

Strategies and activities included in the program, the objectives they relate to, and justification for inclusion are outlined in Table 11.

Table 11. Walking to Better Outcomes: Program Strategies

Program Objective	**Strategy**	**Strategy Justification**
Objective #1 After completion of the physical activity class, 75% of patients will demonstrate improved knowledge and attitude on a post-class survey.	Health Education	Health education activities allow priority populations an "opportunity…to gain in-depth knowledge"[81]. The physical activity class would re-iterate conversations with the surgeon regarding the importance of physical activity especially around surgery.
	Incentive	In addition to knowledge, participation in the physical activity class has an intangible incentive of friendship and encouragement. The class enables participants to meet with other individuals in similar situations and to bond over a common goal. Incentives, tangible or intangible, encourage compliance with health programs[81].
Objective #2 75% of patients in the program will bring pre-operative walking logs (created using their take-home pedometer) to be reviewed on the day of surgery.	Incentive	Patients bringing a completed walking log on the day of surgery will receive a t-shirt and, if they opt, their name on the "we walk" wall in clinic. Similar incentives are provided if they complete and bring their 30-day walking log for 1 month following surgery. Social reinforcement (such as recognition) and material reinforces (such as the t-shirts) have been shown to facilitate compliance with health promotion programs[81].
	Behavior Modification	Walking to Better Outcomes is a health promotion program targeting surgical patients. Although individualized attempts to increase physical activity are not the desired approach for public health programs and can be less successful that community and policy-based interventions[82], individuals facing a surgical operation have increased incentive and motivation to invest and follow a health intervention program. The CDC Guide addressing increasing physical activity sites the importance of developing behavioral skills as an important intervention in any attempt to increase physical activity. Log keeping is a precursor to behavior modification and also enables accountability[81]. For this objective, the behavior modification would be via log keeping of daily activity and daily steps. A benefit of behavioral skill development is that it transcends different cultures, ages and backgrounds. The downside, however, is that it requires patient investment for sustainability.
Objective #3 75% of patients participating in Walking to Better Outcomes program will have post-operative daily steps for 30 days after surgery that are equal to or greater than pre-operative values.	Health Communication	Health communication is noted to have the "highest penetration rate" of intervention strategies[81]. The intra-personal relationship between surgeon and patient is an opportune place to start a dialogue about physical activity and surgical outcomes. The surgeon typically has a level of credibility to the patient/program participant at baseline given the nature of the appointment, and this can strengthen the impact of health communication.
	Behavior Modification	Like justification for behavior modification strategy listed above in objective 2, behavior modification would facilitate increased physical activity, which would include establishing each patient's baseline activity and then incrementally increasing it. This was shown successful in a study looking at pre-operative activity in bariatric surgery patients[83]. The pro of incremental increases is that patients can improve their physical activity rather than just maintain it, approaching the CDC and Healthy People 2020 best practice guidelines. The con is that is requires increasing effort from patients despite the emotional and physical stress of surgery which can be difficult.

4.2.7. Marketing Plan

Walking to Better Outcomes is committed to helping patients achieve better outcomes through physical activity before and after surgery.

4.2.7.1. What benefit does it provide to a participant?

Our program provides patients with education and tools to be physically active prior to and after surgery. Physical activity decreases the risk of complications following surgery.

4.2.7.2. Who is your segmented audience?

Our audience is surgical patients at SWMC, >18 years. The pilot audience includes thoracic surgery patients. The full-implementation audience would include all elective surgery patients.

4.2.7.3. What will it cost the intended population to obtain the product?

The cost to the intended population is time and commitment. Time is required to travel to and attend the educational class. Additionally, it takes time to record daily steps and increase physical activity/daily steps each day. It also requires commitment and dedication to reaching your daily goal.

4.2.7.4. Where and when will the program be offered? What is the rationale for placing it this way?

The program will be piloted to the thoracic surgery clinic due to the high risk of pulmonary complications following thoracic surgery. Physical activity post-operatively helps with lung-recruitment and decreasing pneumonia. After the pilot phase, the program would be offered to all elective surgery patients at SWMC on a continuous enrollment basis.

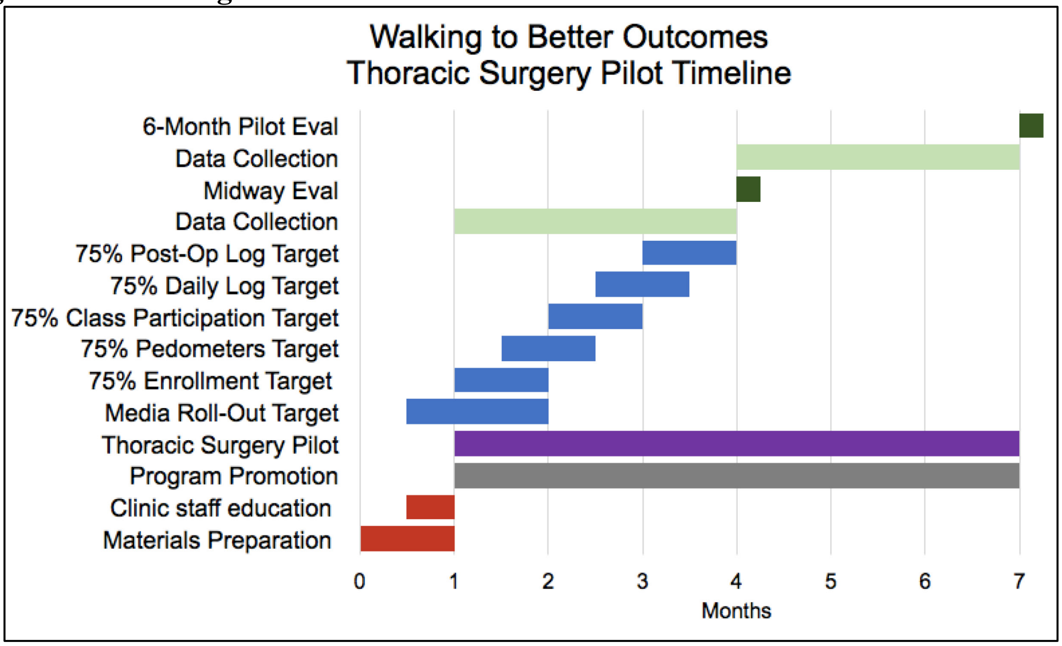
4.2.7.5. Marketing Activities and Associated Costs

The main marketing techniques would include posters in surgery clinics and around the hospital (day surgery, lab, radiology, cafeteria), an incentive/accomplishment wall in clinic, fliers given to all surgery consults, and an educational video that would be available online as well as playing in the clinic waiting areas. Budget for marketing would include paper media ($1000), video production ($500), DVD player and screen for the clinic ($250).

4.2.8. Timeline

A timeline for a 6-month pilot including 1 month education and preparation time is provided in Figure 10. Compliance targets used for progress assessment are also reflected.

Figure 10. Walking to Better Outcomes: Pilot Timeline



4.2.9. Evaluation Plan

Evaluation for the Walking to Better Outcomes: Thoracic Surgery Pilot will occur midway and then at 6 months. Evaluation will be on each of the monthly timeline targets (i.e., compliance with post-op log, class participation, media rollout) as well as with standardized quality metrics such as LOS, mortality, readmission, return to ED and post-operative complications tracked nationally (SSIs, reoperation, pneumonia, ventilator requirement >48 hours, UTI, acute renal failure, myocardial infarction, pulmonary embolism, etc.).

5. CONCLUSIONS

5.1. Summary and Implications for Clinical Practice

Pre-operative frailty assessment was successfully implemented in a regional health care system. An association between frailty and 30-day surgical morbidity was demonstrated in pilot analysis of common major surgical procedures, as designated by the ACS NSQIP. A system-wide analysis determined frailty was associated with peri-operative morbidity for all elective surgery procedures—inpatient and outpatient—along with cost for inpatient procedures. This work of nearly 10,000 patients represents an external validation of the Modified Hopkins score and the largest prospective single-institution series of frailty and outcomes in surgical patients to our knowledge. Finally, a disease-specific evaluation of breast cancer patients demonstrated an association between high frailty and readmission, without an increase in post-operative morbidity.

5.2. Future Interventions

Peri-operative risk mitigation is an area of ongoing research for surgical patients. At BSW-Central, frailty assessment is a standard component of the pre-operative evaluation within the Department of Surgery. There is growing interest with possible application to other surgical specialties, such as gynecology, orthopedic surgery and neurosurgery. Additionally, a high risk prehabilitation clinic has been proposed.

5.2.1. Identification of High-Risk Procedures

There is no universal metric to categorize the severity of risk associated with various procedures. Often, this is based on expert opinion within surgical subspecialties. The NSQIP risk calculator provides procedure-based risk for an individual patient, but a generalized risk based on procedure is unclear.

Current efforts within the BSW-CTX Department of Surgery are directed at developing and creating a CPT-based risk profile. This would enable stratification of patients with low-, medium- and high-risk procedures based on their frailty. The idea would be to pilot a pre-habilitation clinic and/or post-operative interventions for high frailty patients undergoing high risk procedures. This process remains underway but is critical for targeting patients with the highest theoretical benefit from interventions given limited resources and personnel.

5.2.2. High Frailty Clinic and Pathway

Strong for Surgery is an ideal framework for a high frailty clinic. In addition, a focused prehabilitation effort, such as an ambulation or physical therapy plan, would be necessary. Ideally, a high frailty clinic would incorporate an internist or geriatrician (as age appropriate), nutritionist, physical therapist and anesthesiologist. Additional specialists could include cardiologists, pulmonologists and PM&R to aid in referral to the appropriate discharge facility. A social worker would be important to address financial/logistical aspects of care.

Ideally a patient seen in the high frailty clinic would move forward with surgery after optimization. A post-operative recovery pathway for frail patients could incorporate techniques successful in Enhanced Recovery Pathways popularized with colorectal surgery.[84] Pre-surgery education would include nutrition, incentive spirometer teaching and early ambulation. Post-operative order sets would include non-narcotic analgesia, sleep hygiene protocols, ambulation metrics along with increased visits from physical therapists. Following discharge, patients would have intensified follow-up with phone-calls and/or telehealth visits.

5.2.3. Palliative Care and Goal Setting

A concern we encountered presenting our data at surgical meetings is pre-operative risk assessment could result in limited access to surgical care. We suggest frailty not as a binary stop-point for surgical approval but rather a piece of information to factor into patient-centered decision making. For example, identifying patients at increased risk for complications after surgery may help frame a discussion about non-operative alternatives and timing of systemic therapy (neoadjuvant versus adjuvant). Additionally, increased risk of ED visits and readmission could identify patients benefiting from acute care rehab or earlier post-operative calls or clinic visits. As quality of life is increasingly prioritized with health and healthcare goals, reliable frailty assessment with meaningful post-operative data could help frame decision making and advanced directives.

5.2.4. Breast Cancer and Frailty

Breast cancer is one of the most common diseases encountered by healthcare systems and surgeons. Identifying frail patients and the impact frailty carries for seemingly "lower-risk" patients is important as we individualize surgical and systemic approaches to disease management. Further studies aim to investigate the role of frailty in locally advanced disease, explore how frailty may impact provider and patient bias towards treatment choices and determine if degree of frailty impacts delivery of guideline concordant care.

5.3. Final Comments

The future of medicine is individualized care. Frailty is a promising metric to assess therapeutic risk-to-benefit ratio and to identify where peri-operative resources and optimization efforts are best focused. By tailoring therapy to the patient, health care can shift to a high value product focused on quality of life.

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APPENDIX A

PREVIOUSLY PUBLISHED WORK

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

Check for updates

Mary M Mrdutt, MD, Harry T Papaconstantinou, MD, FACS, Bobby D Robinson, MD, Erin T Bird, MD, MBA, FACS, Claire L Isbell, MD, MSCI, FACS

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

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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/m^2), 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 ($\geq$3), as previously reported.[10]

Statistical analysis

Categorical variables were reported as counts (percentages), and continuous variables as mean (standard deviation), if

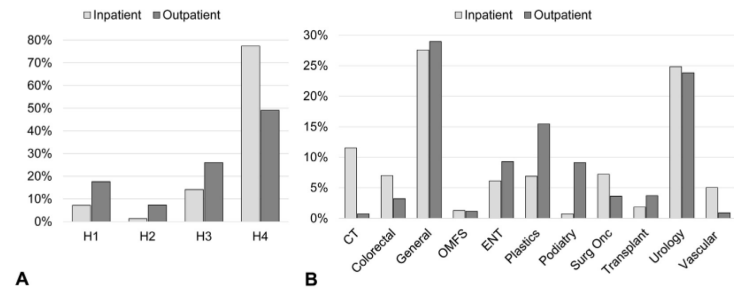

Figure 1. Distribution of cases based on hospital location (A) and subspecialty (B) for the inpatient and outpatient cohorts. Bed sizes of hospitals H1 to H4 are: 143, 46, 101, and 640 beds, respectively. Preoperative frailty measurements were collected for both inpatient and outpatient cases from all 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.

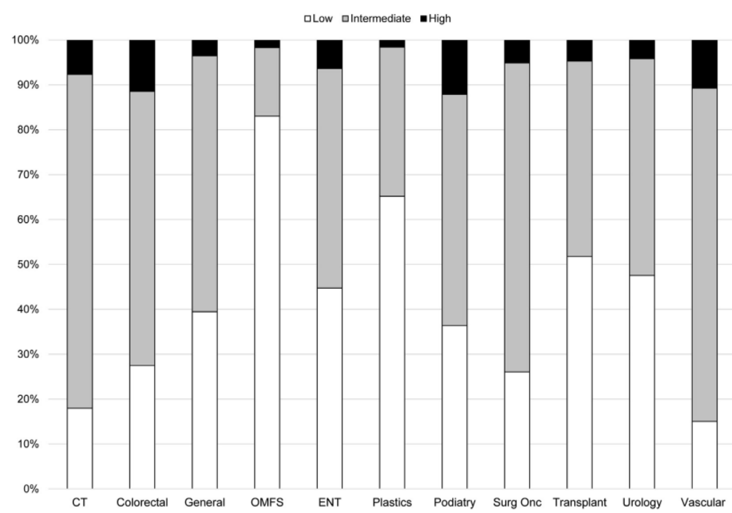

Figure 2. Distribution of frailty classification by subspecialty for inpatient cohort. Low, intermediate, and high frailty was represented in both inpatient and outpatient procedures within 11 surgical subspecialties. CT, cardiothoracic; ENT, otolaryngology; OMFS, oral and maxillofacial; Surg Onc, surgical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

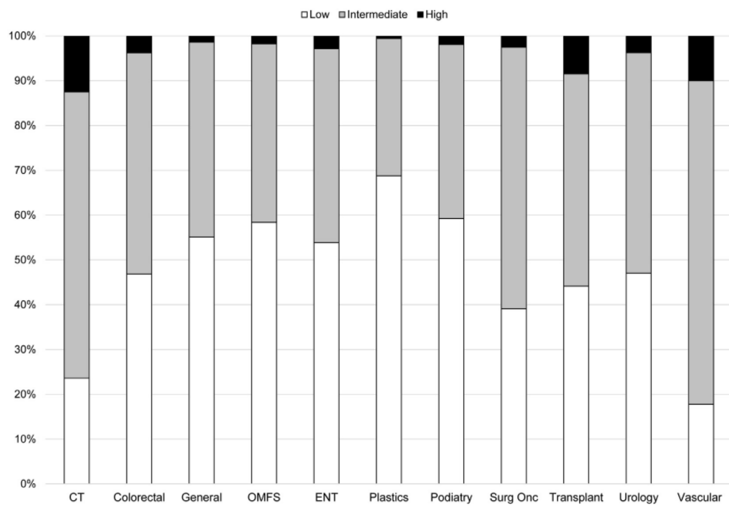

Figure 3. Distribution of frailty classification by subspecialty for outpatient cohort. Low, intermediate, and high frailty was represented in both inpatient and outpatient procedures within 11 surgical subspecialties. CT, cardiothoracic; ENT, otolaryngology; OMFS, oral and maxillofacial; Surg Onc, surgical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

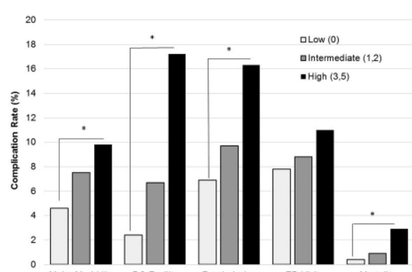

Figure 4. Inpatient (n = 4,632) 30-day morbidity and mortality stratified by frailty. A stepwise increase in complications was seen with increasing frailty. The risk of major morbidity, discharge to location other than home (DC facility), readmission, and mortality were significantly increased with increasing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

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

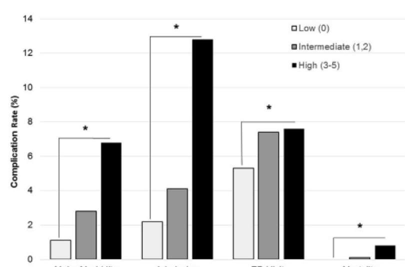

Figure 5. Outpatient (n = 9,898) 30-day morbidity and mortality stratified by frailty. A stepwise increase in complications was seen with increasing frailty. The risk of major morbidity, unplanned admission, emergency department (ED) visit, and mortality were significantly increased with increasing frailty.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

APPENDIX B

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