A preliminary study on assessing optimization of surgically frail patients comparing multiple variables effecting prognosis, outcome, mortality, and future considerations

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Statement of Intent

This study serves as part of successful completion of the thesis for the course, Scholarly Pursuit and Thesis, for the curriculum at the Anne Burnett School of Medicine at Texas Christian University as the degree granting entity for the fulfilment of the requirements of Doctor of Medicine.

Furthermore, this study serves as a preliminary adjunct to a sibling project and continued research on the matter to be completed in the following years by Lauren Hui[1] and Dr. Richard Miller[1,2], entitled: *A Prospective Study to Improve Frail Patient Prognosis and Outcomes through the JPS Surgical Optimization Clinical with Home Health Physical Therapy and Cognitive Exercise Interventions*.

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Mentor Approval

This study has been verified and approved by the research mentors and co-authors listed below as part of the requirements for successful completion of the Scholarly Pursuit and Thesis.

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ABSTRACT

Research Question: Which components of the Edmonton Frailty Scale are most associated with surgical optimization and clinical outcome? Background and Significance: Surgical optimization is an underused, but highly effective method for preparing patients to undergo procedures in the operating room, which inevitably bear significant stressors upon the body. In addition to the actual time in the operative room, post-operative management of a patient presents an additive variable on the prognosis, recovery, and outcome of patients. There have been scales and calculators that have been implemented in an effort to grasp some objectivity in the management and optimization of patients prior to surgery, one of which is the Edmonton Frailty Scale (EFS). There are several variables that could be potentially correlated, and as a result, controlled and measured using the EFS. The problem facing surgical optimization is determining which factors have measurable differences in the overall outcomes and improvement of patients. Materials and Methods: We, therefore, hope to address a foundational question that can be built-on by future studies asking, within the realm of cognitive, therapeutic, functional, risk factor assessment, neurological, and psychiatric, which, if any, can be feasibly implemented into surgical optimization with a high enough patient adherence that there can be a measurable difference on prognosis, outcomes, and mortality and morbidity. Several Optimization Components (OC) were implemented with available data including (1) home health physical therapy, (2) cognitive exercises, (3) neuropsychiatric evaluation, and (4) medical management. Individuals who were referred to the optimization clinic for surgery were given a neuropsychiatric evaluation, cognitive exercises, and home health physical therapy, based on their needs and requirements as established by their past medical history, upcoming surgery, and EFS score. With these points of control, the selected population was compared with outcome surrogates for effectiveness and overall outcomes for the implemented OC's. The overarching themes for comparison were (1) rate of proceeding to surgery, (2) number of post-operative infections, (3) number of same-day cancellations, and (3) mortality rate. The statistical analysis was separated into several components: (1) EFS compared to length of stay, (2) time between optimization and surgery, (3) proceeding to surgery vs. cancellation of surgery, (4) age and sex, (5) intensive care unit admission, and (6) prior health history and risk factor stratification. By isolating these aspects of the study, the authors hope to lay a foundation for deeper investigation into the implementation and use of the Edmonton Frailty Scale for surgical optimization for patients in a surgical setting. Results: A total of 167 patients were enrolled in this study and selected as the sample from patients referred to the optimization clinic by surgical subspecialties, including general surgery, orthopedic surgery, vascular surgery, orthopedic surgery, surgical oncology, gynecologic surgery, urology, ophthalmology, and oral maxillofacial surgery. Each patient was evaluated and assessed with standardized lab work, EFS scoring, and committee meeting to determine if patients were eligible and safe to proceed to surgery. Conclusion: The results and analysis of this data hope to serve as foundation for continued research on the matter.

RESEARCH QUESTION

Which components of the Edmonton Frailty Scale are most associated with surgical optimization and clinical outcome? Furthermore, of these components, which of these have controllable and feasible implementation strategies to impact frailty, and therefore, improve surgical outcome?

Recognizing that the Edmonton Frailty Scale is a reliable form of objectively analyzing surgical optimization for patients in a surgical setting, the authors hypothesize that there are, in fact, specific controllable components of optimization that can be readily implemented by the patient population which will ultimately have a significant bearing on the outcomes of patients and can be correlated to the established outline within the Edmonton Frailty Scale.

INTRODUCTION & SIGNIFICANCE

Surgical optimization prior to entering the operating room has been an understood and recognized part of surgical management. Some components of it are part of every aspect of determining is patients, in a non-acute setting, are prepared to undergo the bodily stressors of surgery, from body mass index to history of smoking, to history of prior surgery, and so on[1]. Currently, there is growing literature on the avenue of optimizing patients that have been deemed frail, but the concept continues to be new and has many avenues that are still being explored.

In order to determine which patients are considered frail, we are able to look at the Frailty Phenotype, described by Fried et al. where if three or more components were met, the patient was deemed to be a frail patient in a surgical setting. The components are as follows: (1) unintentional weight loss of greater than ten pounds in the last year, (2) self-reported exhaustion, (3) weakness in grip strength, (4) slow walking speed, (5) and/or low physical activity. In this study, Fried et al. found that approximately seven percent of community-dwelling population met the criteria for being frail, was more prevalent in females than males, and correlated with an increase in age. This phenotype was statistically significant in correlating the relationship between a patient meeting the criteria of being frail and predictability of falls, worsening activities of daily living (ADL), hospitalization, and death. More recent studies project that the population of patients meeting these criteria will continue to increase as the population at-large continues to shift toward an older population[2].

At the same time, Cheung et al. found that there are approximately four million surgical operations that are performed on patients who are over the age of sixty-five, and even more so, Castillo-Angeles et al. found that patients who are deemed frail have a higher incidence of mortality in even low-risk surgical cases, suggesting the importance of pre-operative optimization in surgically frail patients[3,4].

Recognizing the prevalence of frailty in a surgical population, we build on the conclusions made by Castillo-Angeles et al. and others regarding the importance of finding a way to optimize patients in this demographic knowing how measurably at-risk they are undergoing even the smallest operation. Santa Mina et al. introduces the idea of 'pre-habilitation' as a strategy for enhancing functional and mental capacity of patients aimed at improving the pre-, peri-, and post-operative experience by looking at components such as exercise, nutrition, education, and psychosocial approaches specifically targeted at increasing their physical, physiological, metabolic, and psychological reserve in preparation for surgery. This concept serves as a foundational idea and highlights the importance of considering optimization options for patients in a surgical setting. With that being said, the authors in this study hope to elaborate on this concept in the following paragraphs and the outline of methods and analysis done here.

If we begin to delve into the existing literature on frailty and the impact on surgical outcomes, there is an abundance of complications, measurable, and statistically significant outcomes that are affected by frailty. A systematic review and meta-analysis done by Fehlmann et al. found that after looking at nearly 1,300 patients, frail patients had a nearly three-times higher likelihood of dying within thirty days post-operatively, and higher complication risks ninety days and one year post-operatively, as well as longer hospital stays[5]. Another systematic review and meta-analysis by Chan et al. concluded that within approximately 60,000 patients, just under forty percent of them were frail, and that coincided with an increased mortality risk, hospital length of stay, specifically in the Intensive Care Unit, the need for mechanical ventilation, and being discharged to places other than home, such as a Skilled Nursing Facility or Long-Term Acute Care Hospital[6].

As described earlier, age does play one role in the overall assessment of frailty, but Panyani et al. elaborated on other factors affecting frailty using the Modified Frailty Index (history of diabetes mellitus, congestive heart failure, hypertension with the requirement of medication, trans-ischemic attack or cerebrovascular accident, myocardial infarction, peripheral vascular disease, congestive obstructive pulmonary disease, angina of multiple entities, and/or impaired sensorium). After analyzing 680,000 cases in multiple surgical settings, including vascular, gastrointestinal, and orthopedic, found that there was a one to two times increased risk of complications, major complications, wound complications, readmission, and discharge to places other than home, and there was a four times higher likelihood of these patients dying after surgery[7]. The importance of this study illustrates, not only the obvious impact of frailty on surgical outcome, but that defining frailty is a multi-faceted continuum that accounts, not only for age, but for overall measurable components of health.

The abundance of literature finding significance in the detrimental impact of frail patients in surgery has opened an avenue aimed at addressing such issues. The question then becomes, knowing that there is such a significant and poor outcome in patients who are frail, what can be done to address these variables that have time and time again been associated with these poor outcomes. We previously introduced the concept of 'pre-habilitation' previously. This is proactive approach to initiate a scaffolding which patients and providers can implement with specific and actionable protocols directed specifically at addressing the components of frailty scales by isolating certain surrogates for each scored component of said frailty scales.

One frailty index often used is the Edmonton Frailty Scale. This scale uses cognition, general health status noting any admissions to the hospital in the past year, functional independence, social support, nutrition and/or weight loss, psychiatric mood, urinary continence, and functional performance. Each component is graded on a scale of zero to two, with a total of seventeen possible points. Zero to five is considered not frail, six to seven is considered vulnerable, eight to nine is considered mildly frail, ten to eleven is considered moderately frail, and anything over twelve is considered severely frail, as explained by Rolfson et al. By looking at this scale, there are several areas that may have potential for improvement through pre-habilitation protocols that can be simple and easily implemented. If these components can be improved upon, the overall frailty score will decrease, thus correlating with an improved surgical outcome. The question then becomes, of the scored components of the Edmonton Frailty Scale, which ones can be improved upon in an efficient and cost-effective way, and furthermore, how adherent will patients be to these protocols, and finally, if these patients are adherent, which components are actually resulting in a measurable difference in outcomes.

In order to determine the areas of in which pre-habilitation can play an impactful role and be measurable with the use of the Edmonton Frailty Scale, we seek to illustrate the previous literature available on the matter. Baimas-George et al. studied the components of pre-habilitation in surgical patients, including exercise, nutrition, and psychiatric counseling, finding that there was promise in pre-habilitation for surgically frail patients. Interestingly, they recognized the there were, in fact, components of feasibility and ability to implement such protocols, such as cost-effectiveness. This challenge needed to be balanced with the potential for cost-benefit and savings in long-term projections for patients who were able to be optimized.

Illustrated in Koh et al., the PEERS program (Program for Enhanced Elderly Recovery at Sengkang General Hospital) was an implemented optimization program for patients greater than seventy years old preparing to undergo elective colectomies. The PEERS program consisted of several weeks of nutrition management, resistance training, polypharmacy consultation, and cardiovascular consultation, with measured outcomes, such as grip strength, gait speed, and functional reach. Although there were no significant findings in the measurable outcomes projected, there were statistically significant outcomes seen in overall quality of life, reduced hospital stays, and surprisingly, in overall cost-benefit, noting a saving of nearly $12,000 per hospital stay. We found this study to be significant in two principles for this study: (1) there were measurables that could be built on, and (2) we recognize the need to be aware of the feasibility of implementing protocols.

Determining which variables could be controlled, which variables could be measured, and which variables have historically been seen to be significant, this study had to determine the set of variables that could be analyzed from a massive pool of available data points. There were three sections of variables that needed to be grouped: (1) what are controllable and feasible pre-habilitation protocols that can be compared to (a) optimization, and (b) surgical outcomes, (2) what data is already collected that can be used as surrogates for (a) effectiveness, and (b) surgical outcomes, and finally, (3) with feasible pre-habilitation protocols and available data, can these be compared to a standardized and valid frailty score, such as the Edmonton Frailty Score; that is, do the surrogates accurately translate to the components established within the Edmonton Frailty Scale, and ultimately, will they have any effect on the improvement of the frailty score, and thereafter, prognosis and clinical outcomes.

The variables were chosen as follows. The baseline variables collected from each patient will include neurocognitive assessment, and an initial scoring with the Edmonton Frailty Scale. The neurocognition assessment will be graded using the Mini-Cog test, which Borson et al. found to have 76% sensitivity and 89% specificity in determining neurocognition deficits such as dementia, while being shorter and with easily applicability when compared to longer and fuller neurophysiological exams, such as the Mini-Mental State Examination (MMSE). Having a baseline for cognition and a baseline Edmonton Frailty Scale score allows for measurable comparison once the OC's were implemented. The OC's were selected based on ability to implement and feasibility that was seen in prior literature. The OC's will include (1) neuropsychology and memory training, (2) physical and resistance training using MedBridge, an available online platform with video demonstrations of exercises, (3) medical management, and (4) nutrition optimization to increase protein status. The implementation of each of these OC's will be based on the initial optimization clinic assessment, in a standardized fashion. All assessments will be completed the same way, with the same electronic medical record note template, in order to ensure all encounters are the collected in the same way. The note template will include a general history of present illness, baseline labs (complete blood count and complete metabolic panel), auto-populated relevant radiological imaging, complete physical exam with vitals, and assessment.

The assessment will include the EFS score, the associated risks of surgery for this individual ranking from high, intermediate, and low, the identified risk factor components (i.e. cognitive, functional, past medical history), and finally, the recommendations for optimization and proceeding to surgery. The recommendations will be based on each individual and will correlate with their specific medical problems that need to be optimized prior to surgery. For example, .individuals identified as having hypoalbuminemia will be recommended to undergo physical and resistance training using MedBridge, individuals identified to be hypoalbuminemia will be recommended to increase protein status and nutrition, and so on.

Now that the overarching variables for future studies has been outlined, we can now establish the data that will be collected in this study, the importance of the selected variables to be studied, and the stratification and association we will be making with parallel studies' analysis, as well as the correlations within the dataset. The parallel study will be analyzing a more stratified dataset, looking at specific components contributing to proceeding to or cancellation of surgery, as well as complications of completed surgeries, such as wound infection rate, urinary tract infection rate, pneumonia rate, respiratory or cardiac issues, and 30-emergency room return and readmission.

This study will aim to use the standardized evaluation, as described above, with the scored EFS components to analyze the associations between: (1) length of stay, (2) time between initial optimization clinic visit and proceeding to surgery, (3) proceeding to surgery or cancellation, (4) age and sex, (5) intensive care unit (ICU) admission, and (6) risk factors and prior medical history. The risk factors and prior medical history will be further stratified into several quantifiable components with two sub-stratification groups. The groups will be: (1) cognitive, (2) functional, (3) nutrition, (4) smoking, (5) alcohol, (6) body mass index (BMI), (7) neurological issues, (8) cardiac issues, (9) pulmonary issues, (10) gastrointestinal issues, (11) renal issues, and (12) endocrinological issues. The two sub-stratifications will be within the cardiac issues subset, and the endocrinological issues subset, as there are a myriad of risk factors and past medical issues in these two areas ranging from hypertension, heart failure, and coronary artery disease, to diabetes, hypothyroidism, and hyperlipidemia. These variables were selected by looking at the components that compose the scoring of the EFS. The above 17 variables will all be compared to the EFS score given at the initial optimization clinic visit and assessment. Through this, we hope to not only substantiate the EFS scoring system, but isolate particular components of the EFS that have the greatest effect on outcome, as well as begin to specify optimization techniques to improve the overall EFS score.

Specifically, the components of the Edmonton Frailty Scale that this study hopes to impact are (1) cognition, (2) functional independence, (3) nutrition, (4) mood, and (5) functional performance. We will analyze the relationship between the OC's and the components of the Edmonton Frailty Score, and furthermore, we will analyze the relationship between the dependent variables and the Edmonton Frailty Score. By isolating out these several pillars of the study, we hope to lay a solid foundation for future studies to build on this. Specifically, we aim to isolate overall impact on outcomes with the comparison to the dependent variables. Secondly, we aim to isolate whether these OC's have any direct relation to bearing significant effects on the Edmonton Frailty Score. Finally, we hope to identify specific risk factors impacting the EFS score to continue to refine optimization techniques specifically targeting these identified risk factors.

This determinization and selection of the variables was filtered down from prior studies. These variables were chosen by looking at prior studies implementing pre-habilitation and the protocols that were used before, but also considering the available data points at the institution that this study was being done at. For instance, McIsaac et al. found that home-based exercises less than four times per week leading up to surgery with strength training, aerobic training, and flexibility in a structure format had greater than fifty percent adherence, noting that adherence is a major aspect that needs to be addressed in pre-habilitation protocols. As a result, we determined that continuing with this home-based approach offered a higher probability of adherence when compared to in-house pre-habilitation. Assessing the available data collected within the electronic medical record at our institution and within the optimization clinic, we concluded that the independent and dependent variables were actionable, measurable, and feasible.

In that regard, the authors recognize the limitations within the study, which have been accounted for and detailed in the methods section of this study. Once such limitation that must be accounted for and stratified appropriately is the inclusion data of participants in the study. The institution this study is conducted at serves a wide population and demographic of people, being a county funded hospital. As such, accessibility and socioeconomic status may play hindrance in implementation i.e. transportation, internet accessibility, and medical literacy as barriers to healthcare prominent in this population. Additionally, as this is prospective data, some patients were excluded as their surgeries are scheduled for future dates at the time of this writing.

In summary, this study has apparent and applicable purpose as evidently illustrated by the literature available on frailty in a surgical setting. Frailty has a significant and negative impact on surgical outcomes, prognosis, mortality, and morbidity. The definition of frailty has been elaborated on in multiple papers, but the overall sentiment of certain aspects, such as age, functional ability, cognition, nutrition status, and overall health seem to be relatively unanimous across the platforms. Studies have validated a handful of scoring systems to objectively assess frailty, one so being the Edmonton Frailty Scale. The Edmonton Frailty Scale has an outlined list of measurable components that comprise a grading scale of the severity of frailty. Higher scores have been linked to worse outcomes in the surgical setting. Within the scoring system, there appears to be certain components that can be improved upon with implementation of protocols, such as cognition, functional ability, and nutrition.

By taking a baseline score of the patient demographic, implementing evidence-based protocols aimed at improving those scored components, we hope to see an improvement in the frailty score, and thus, an improvement in the overall surgical outcomes. Furthermore, noting certain trends in risk factors contributing to increased EFS scores, we hope to continue to refine the optimization management and implementation for future patients. As a result, we hope to determine if optimization management with specific and implementable components impacts surgical outcomes and clinical prognosis, and if there are specific risk factors across the board in this patient population that can be addressed or improved upon in future optimization management protocols.

RESEARCH MATERIALS & METHODS

Selection of Sample

The population that will be analyzed will be patients who are planning or have elective surgeries scheduled at John Peter Smith Hospital, a county hospital in Fort Worth, Texas. ICD-10 codes will be used to stratify and isolate a patient population that is within 30-100 years of age, has had their surgery and follow-up at John Peter Smith Hospital, and that patients have been referred to the optimization clinic located in the hospital prior to surgery. The entire dataset and study will be prospective. Individuals selected to undergo optimization must be willing, meet the criteria of being frail by Edmonton Frailty Scale scoring, planning to have their surgery at John Peter Smith Hospital, and have been recommended the surgical team performing the surgery to be evaluated at the optimization clinic. Individuals who will not undergo optimization are any individuals who do not meet all the previously stated criteria.

For this part of the study, patients who are listed multiple times, due to multiple visits to the optimization clinic will only have the first encounter recorded and analyzed. The selection of the sample size will reside within the years of 2021 to 2023. All patients enrolled in this data collection must undergo optimization clinic assessment and exam, with listen age, sex, referring surgical team, and expected surgery. The encounter note must include a full assessment and plan, with an accurate EFS score, risk factors and medical issues, and recommendations for optimization and proceeding to surgery. The recommendations will be based on the EFS components and the risk factors unique to each patient, as illustrated in Table 1. Finally, each of the patients will be evaluated based on the expected surgical procedure they will undergo, and be graded as a high, intermediate, or low risk patient.

Table 1: Risk Factor and Edmonton Frailty Scale components and the associated optimization component and recommendation.

Risk Factor/EFS Component	OC's/Recommendation
Cognitive	Cognitive Exercises; Crossword Puzzles, Memory Games, Reading
Functional	Physical Therapy and Occupational Therapy
Nutrition	Counseling and Protein Intake Recommendations
Smoking	Counseling
Alcohol	Counseling
Body Mass Index	Counseling, Daily Exercise Recommendations
Neurological Issues	Neurological Evaluation, Pathology-Specific Rehabilitation
Cardiac Issues	Cardiology Evaluation, Electrocardiogram, Diet Counseling
Pulmonary Issues	Chest Radiographs, Inspiratory Spirometer, Pathology-Specific Medication
Gastrointestinal Issues	Abdominal Ultrasound, Pathology-Specific Medication and Procedures
Renal Issues	Complete Metabolic Panel, Electrolyte Optimization, Pathology-Specific Management
Endocrinological Issues	Pathology-Specific Medication

Data Collection

Once the population has been identified, any replicate patients and any patients who do not meet the complete outlined criteria above will be eliminated from the dataset. Data collection will comprise several standard components, several patient specific components, and several recordable components for statistical comparison.

The standard components will be the patients name, the initial encounter date to serve as the time of initial optimization clinic visit, the patient's sex, and the patient's age. These will be standardized across all the patients and will be used in statistical comparison, detailed later.

The patient specific components will include a formal Edmonton Frailty Scale score (Figure 1), the referring surgical service, and the expected surgery. These components will be unique to each patient, and will aid in proper stratification, analysis, and bias elimination.

The recordable components will be determining if the surgery was cancelled, if the surgery proceeded, what the deemed risk of the surgery was, what the risk factors and medical history relevant to each patient, the length of time from initial optimization clinic encounter to time of surgery, length of stay in the hospital after surgery, post-operative infections within initial stay, mortality, and intensive care unit (ICU) admission.

Each of these points of collectable data will be manually extracted, itemized, recorded, and encrypted until statistical analysis can proceed. The electronic medical records at the institution's hospital will only be accessed while on-campus on a secured server. An outline of all the data to be collected can be seen in Table 2.

Table 2: Outline of all data to be collected from each patient enrolled in the dataset.

A. Standard Components		
Patient Name	Initial Encounter Date	Sex
Age		
B. Patient Specific Components		
Edmonton Frailty Scale Score	Referring Surgical Service	Expected Surgery
C. Recordable Components		
Cancellation	Proceeding to Surgery	Deemed Risk
Length of Stay	Time to Surgery	Post-Operative Infection
Mortality	ICU Admission	

Frailty domain	Item	0 point	1 point	2 points
Cognition	Please imagine that this pre-drawn circle is a clock. I would like you to place the numbers in the correct positions then place the hands to indicate a time of 'ten after eleven'	No errors	Minor spacing errors	Other errors
General health status	In the past year, how many times have you been admitted to a hospital?	0	1–2	≥2
	In general, how would you describe your health?	'Excellent', 'Very good', 'Good'	'Fair'	'Poor'
Functional independence	With how many of the following activities do you require help? (meal preparation, shopping, transportation, telephone, housekeeping, laundry, managing money, taking medications)	0–1	2–4	5–8
Social support	When you need help, can you count on someone who is willing and able to meet your needs?	Always	Sometimes	Never
Medication use	Do you use five or more different prescription medications on a regular basis?	No	Yes	
	At times, do you forget to take your prescription medications?	No	Yes	
Nutrition	Have you recently lost weight such that your clothing has become looser?	No	Yes	
Mood	Do you often feel sad or depressed?	No	Yes	
Continence	Do you have a problem with losing control of urine when you don't want to?	No	Yes	
Functional performance	I would like you to sit in this chair with your back and arms resting. Then, when I say 'GO', please stand up and walk at a safe and comfortable pace to the mark on the floor (approximately 3 m away), return to the chair and sit down'	0–10 s	11–20 s	One of : >20 s , or patient unwilling , or requires assistance
Totals	Final score is the sum of column totals			

Scoring :
0 - 5 = Not Frail
6 - 7 = Vulnerable
8 - 9 = Mild Frailty
10-11 = Moderate Frailty
12-17 = Severe Frailty

TOTAL **/17**

Administered by : ______________________________

Figure 1: Components and scoring system of the Edmonton Frailty Scale.

Statistical Analysis

Once all data collection has been completed, secured, and encrypted, statistical analysis will begin with determining the appropriate ranges, means, and outliers based on two standard deviations from the mean for the (1) EFS scores, (2) ages, (3) lengths of stay, (4) time to surgery, and (5) risk factors. By doing this, any significant outliers impacting the data can be accounted for within a 95% confidence interval. We expect there to be outliers within the lengths of stay and time to surgery which will inaccurately portray most of the dataset. Once this data has been standardized, we will analyze several relationships explained below.

Several possible correlations will be assessed using a linear regression model ($r = 1$; $y = mx + b$). The r^2 will be rooted to give a strength of association, while the slope, m, of each of the models will represent a positive or negative correlation. Seen in Table 3, the linear regression models will be analyzed as the following pairs: (1) Edmonton Frailty Scale score to length of stay, and (2) Edmonton Frailty Scale score to time to surgery. We expect to see a negative sloped correlation between the Edmonton Frailty Scale score and the length of stay, as we expect there to be a positive impact of patients being seen in the optimization clinic; that is, patients being seen in the optimization clinic, we presume, will have been adequately optimized, thus leading to shorter length of stays in the hospital post-operatively. We expect to see a positive sloped correlation between the Edmonton Frailty Scale score and the time to surgery, as we expect that higher EFS scores will require more time to optimize, thus increasing the time to surgery before being cleared and deemed optimized.

Table 3: Linear regression model relationships to be analyzed from dataset ($r = 1$).

1	Edmonton Frailty Scale Score	Length of Post-Operative Hospitalization Stay
2	Edmonton Frailty Scale Score	Time to Surgery from Initial Optimization Encounter

Next, the components seen in Table 2 will be analyzed for any statistical significance. This will fall into two groups: (1) Edmonton Frailty Scale score to proceeding to surgery, (2) Edmonton Frailty Scale score to cancellation of surgery, and (3) Edmonton Frailty Scale score to intensive care unit (ICU) admission. It should be noted that there must be a distinct and deliberate difference between a cancellation of a surgery and surgery that was never scheduled; to meet the criteria of a cancellation, the surgery must have been posted in the electronic medical record and then cancelled. Patients who are seen in the optimization clinic for future surgeries that have not been posted do not meet the criteria for cancellation. Additionally, if surgeries are scheduled for future dates than the time of this study, they too must be excluded, as there is no data available for those patients yet. The statistical analysis of these three groups will be completed using a two-tailed t-test assuming equal variance ($p < 0.05$), as outlined in Table 4. We do not expect any statistically significant results for any of the three groups, as we believe that optimization of each of the patients will decrease cancellations of surgery and ICU admissions, while allowing for patients to safely proceed to surgery.

Table 4: Two-tailed t-test assuming equal variance groups ($p < 0.05$).

1	Edmonton Frailty Scale Score	Proceeding to Surgery
2	Edmonton Frailty Scale Score	Cancellation of Surgery
3	Edmonton Frailty Scale Score	ICU Admission

Finally, the associated risk factors and medical history will be converted from qualitative data to quantitative data to be placed in the following bins: (1) cognitive, (2) functional, (3) nutrition (as represented by albumin status), (4) smoking, (5) alcohol, (6) body mass index, (7) neurological issue, (8) cardiac issue, (9) pulmonary issue, (10) gastrointestinal issue, (11) renal issue, and (12) endocrinological issue (Table 5). The average and standard deviation of the totals of this data will be calculated, and any bins that are greater than two standard deviations from the mean will be re-analyzed and stratified to decrease any possible bias. We expect there to be several bins that will require stratification as some of the systems-based bins may have multiple pathologies or risks associated with them, for example, the (8) cardiac issues bin may include heart failure, arrythmias, and hypertension. If such issues should arise, the data will require further isolation.

As we do expect further stratification of the data, the bins that undergo stratification will be separated out and the individual risk/medical history contributing components will be compared to the (1) EFS, (2) the length of stay, (3) the time to surgery, and (4) ICU admission (Table 6). Any outliers that are greater than two standard deviations from the mean will be eliminated from this stratification. By doing this, we hope to further isolate any specific risk factors or medical history that is contributing to measurable outcomes. This can then serve as a target for future studies to address and continue quality improvement of the optimization techniques for these isolated components.

Table 5: Quantitative conversion points using components of EFS and medical history.

Edmonton Frailty Scale Associated Risk Factors					
Cognitive	Functional	Nutrition	Smoking	Alcohol	BMI
Systems-Based Risk Factors & Medical History					
Neurological	Cardiac	Pulmonary	Gastrointestinal	Renal	Endocrine

Table 6: Outline for possible stratified variables and comparison groups.

Possible Stratified Variables	Edmonton Frailty Scale
	Length of Stay
	Time to Surgery
	ICU Admission

Comparison of Results

Recognizing the preliminary aspect of this study, it is working in congruence with a sibling study, Hui et al., occurring in parallel. This study will be continued in the future after our study is completed and we will utilize a set of data points and statistical analysis aggregated from the Hui study for statistical comparison with this study.

Hui et al. collected data unique from this study stratifying complications post-operatively that occurred outside of the operating room. Namely, the study analyzed: (1) wound infection rate, (2) urinary tract infection rate, (3) pneumonia rate, (4) respiratory or cardiac related issues, and (5) 30-day return to Emergency Department and readmission rate status-post surgery. Although this analysis will not be directly compared to the analysis completed in this study, we do wish to note this in our methods as it will serve of vital importance in the discussion, and in order to allow for proper replication of this study, the authors felt it necessary to allocate a section deliberately recognizing the sibling study.

Of note, there are several components that overlap between the sibling study and this study, and they will be statistically compared to each other. (1) Patient age, (2) sex, (3) average Edmonton Frailty Scale score, (4) proceeding to surgery, (5) cancellation of surgery were all collected by the sibling study at an earlier date. The data for this study was independently collected, with a greater sample size due to elapsed time for enrollment. We aim to compare these two datasets to ensure no radical or unaccounted changes have occurred in the same patient population. We do not expect any significant changes.

Summary and Main Points

With the nature of this study being somewhat complex, in addition to running in parallel with a sibling study, a summary with the main points can be illustrated in this section (Figure 2), beginning with revisiting the research question of this project: Which components of the Edmonton Frailty Scale are most associated with surgical optimization and clinical outcome? Furthermore, of these components, which of these have controllable and feasible implementation strategies to impact frailty, and therefore, improve surgical outcome?

By setting up a standard operating procedure in the recruitment and initial optimization clinic encounter, with the implementation of an accurate EFS score and associated OC implementation, we hope to eliminate any selection bias. Once the initial encounter has taken place, the data collection can proceed as described above. The statistical analysis will then address the main research question by determining if any correlations, associations, and/or significance is present regarding EFS scores, surgical optimization, and clinical outcome. By converting the qualitative data of risk factors and medical history, we hope to be able to determine any controllable and feasible implementation strategies to improve frailty, and thereafter, clinical outcome.

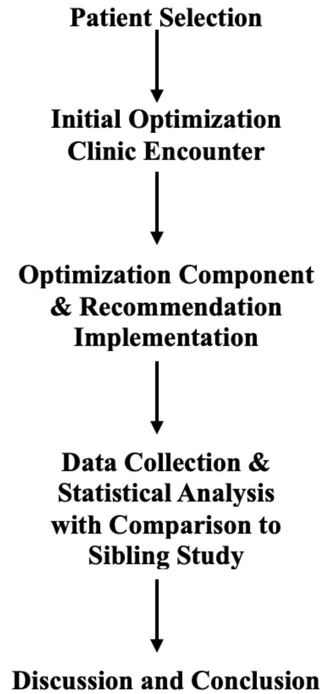

Figure 2: Summary outline flow of the projected study.

RESULTS

Data Overview

A total of 167 patients were enrolled at the start of this study. After elimination of patients who did not meet the criteria of the study or were duplicated patients, the final total for the dataset was n = 144. The raw data points that were collected for every patient approved for the dataset were as follows: (1) the patient's name, (2) the patient's sex, (3) the patient's age, (4) the referring surgical service, (5) the expected surgical procedure, (6) the EFS score from the initial optimization clinic encounter, (7) if the surgery was cancelled after posting, (8) if the surgery proceeded, (9) the determined risk of the procedure, (10) the listed medical history and related frailty components from the initial optimization clinic encounter, (11) the time from initial visit to surgery, (12) the length of stay post-operatively, (13) post-operative infections during initial stay post-operatively, (14) mortality, and (15) if the patient was admitted to the ICU post-operatively. All data was systematically and independently extracted from the electronic medical records at the institution. Additionally, the initial optimization clinic encounter was documented in the electronic medical record using a standardized note template.

Standardized Data Collection

Of the sample size, 64 patients were male, and 80 patients were female, with an average age of 71.06, ranging from 38 to 96 years of age, and a standard deviation of 9.84. The average Edmonton Frailty Scale score for each patient was 8.05, with a range of 2 to 16, and a standard deviation of 3.50. The average length of stay post-operatively was 2.40 days, with a range of 1 to 21 days, and a standard deviation of 4.41 days. The average length of time from initial encounter to proceeding to surgery was 50.48 days, with a range of 1 to 592 days, and standard deviation of 39.3. Of note, entries that were greater than 129.11 (2 standard deviations from the mean) were eliminated, as they accounted for several anomalous outliers. The summary of all the data points collected in this section can be reviewed in Table 7.

Table 7: Summary of standardized data collection points.

Data Point	Average	Range	Standard Deviation
Age	71.06	38-96	± 9.84
Edmonton Frailty Scale Score	8.05	2-16	± 3.50
Time to Surgery (Days)	50.48	1-592	± 39.3
Length of Stay (Days)	2.40	1-21	± 4.41

Correlation and Regression Analysis

Several linear regression models were completed to analyze relational data within the study. All the comparisons were to the standardized and accurate EFS score taken at the initial optimization clinic assessment. The models were completed as follows: (1) EFS to length of stay, (2) EFS to time to surgery, and (3) age to EFS. Each of these three models assumed r = 0, with a linear relationship of y = mx +b, with a slope of "m," to represent the relationship.

EFS score to length of stay was found to have an r^2 of 0.0063, representing an r of 0.070. The slope for this relationship was found to be -0.10, intercepting at 4.88 days (Figure 3).

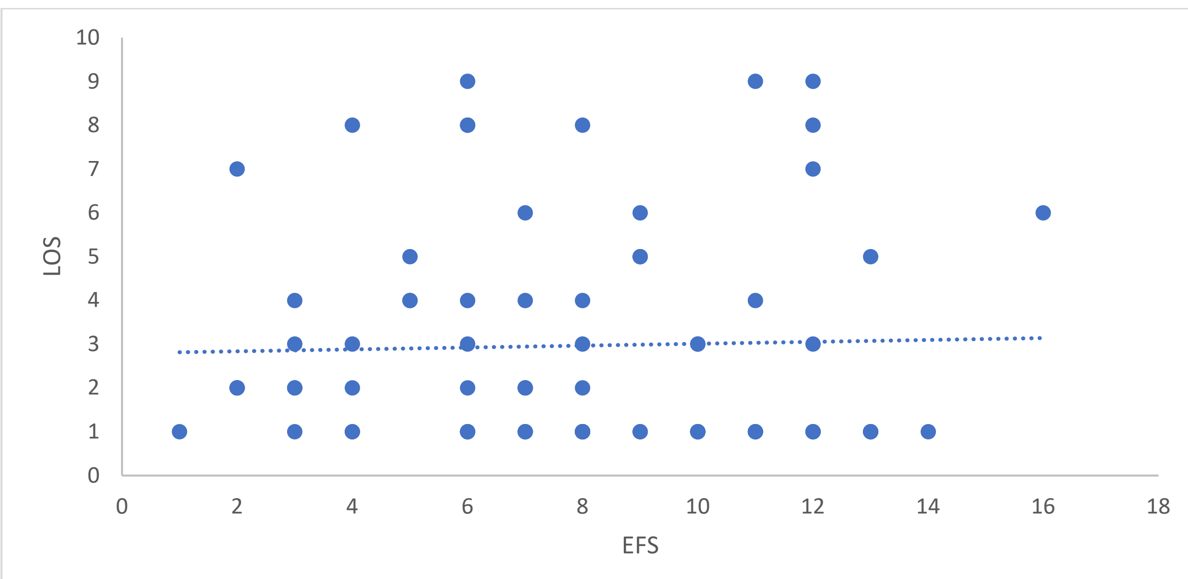

Figure 3: Edmonton Frailty Scale score to length of stay post-operatively (r = 0.070).

EFS score to time to surgery, once proceeding to surgery or cancellation were accounted for, was found to have an r^2 of 0.0075, representing an r of 0.087. The slope for this relationship was found to be 1.02, intercepting at 42.72 days (Figure 4). There were several outliers that fell more than 2 standard deviations away from the mean, which were eliminated, leaving a new r^2 of 0.99, and a new r of 0.99, intercepting at 35.60 days.

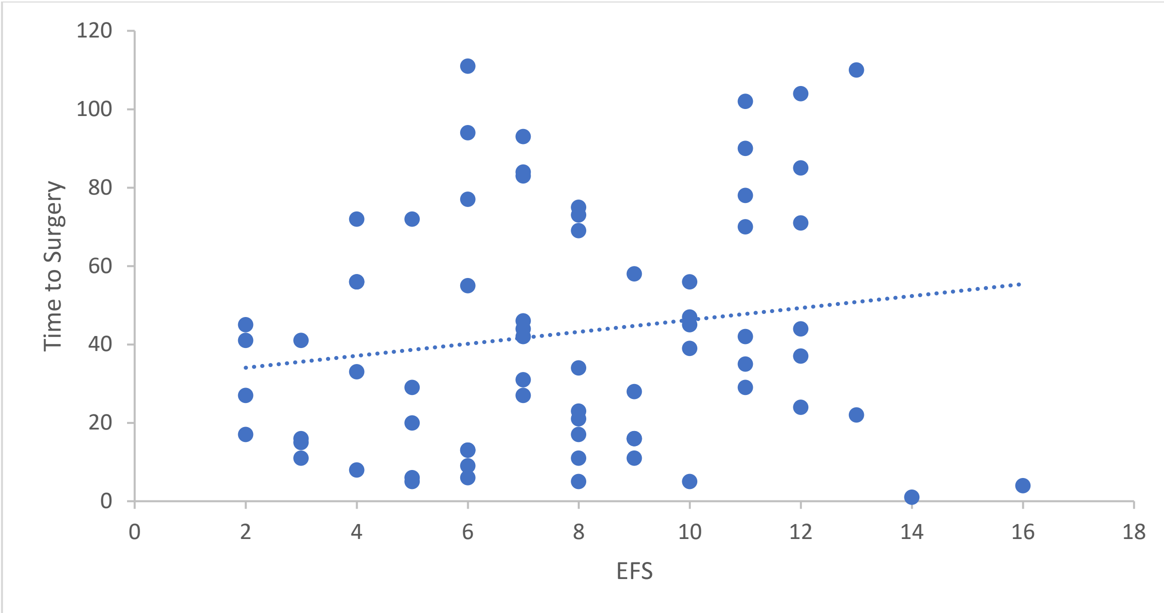

Figure 4: Edmonton Frailty Scale score to time to surgery without cancellation (r = 0.087).

Age to EFS was found to have n r^2 of 0.0068, representing an r of 0.082. The slope of the relationship was found to be 0.028, intercepting at an EFS score of 6.07 (Figure 5). Once adjusted for several outliers, the new r^2 value was 0.020, and an r of 0.14, intercepting at an EFS of 4.72.

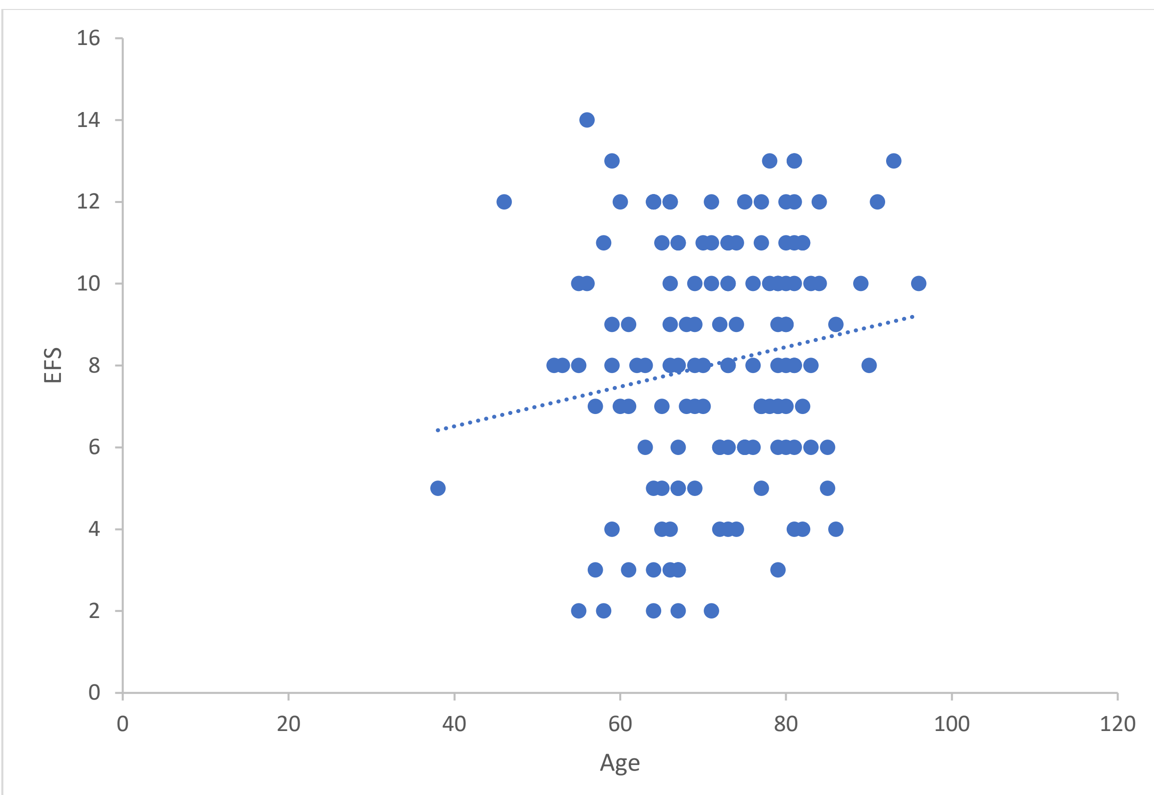

Figure 5: Age to Edmonton Frailty Scale score (r = 0.14).

Variance Analysis

Several relationships were analyzed to look at possible statistical significance within the Edmonton Frailty Scale score, (1) proceeding to vs. cancellation of surgery, (2) sex of the patient, and (3) intensive care unit (ICU) admission post-operatively. Totals for each group were taken and divided into sub-groups, detailed below, for accurate analysis. Relationships were analyzed using a two-sample t-test assuming equal variance with normal variance (significance set at alpha = 0.05).

The first group, proceeding to vs. cancellation of surgery in comparison to the EFS score, found a total of 86 patients proceeded to surgery, 57 patients did not proceed to surgery, and of those patients that did not proceed to surgery, 19 surgeries that were initially posted were cancelled, accounting for 59.72% of patients proceeding to surgery, 39.60% of patients not proceeding to surgery, and 13.20% of patients who had posted surgeries that were cancelled (Table 8). There was a significant difference between the EFS score and proceeding to surgery with a p-value of 0.002.

Table 8: Raw data entry for group one analysis (p = 0.002).

Proceeded to Surgery	86 (59.72%)
Did Not Proceed to Surgery	57 (39.60%)
Cancellation of Surgery	19 (13.20%)

In the second group, sex of the patient in comparison to the EFS score, there were 64 males and 80 females. The average EFS score for the males was found to be 7.98, and the average EFS score for the females was found to be 8.10. There was no significant difference found between the EFS score in males and the EFS score in females, with a p-value of 0.42 (Table 9).

Table 9: Male to female EFS score relationship comparison (p = 0.42).

Sex	Sample Size	EFS Score Average	p < 0.05
Male	64	7.98	p = 0.42
Female	80	8.10	

The third group, ICU admission post-operatively to EFS score, found an average EFS score of 7.77 in individuals who required ICU admission post-operatively, and an average EFS score of 7.11 in individuals who did not require ICU admission post-operatively, with a p-value of 0.29 when comparing this relationship (Table 10).

Table 10: Average EFS scores based on ICU admission post-operatively.

	ICU Admission	No ICU Admission
Average EFS Score	7.77	7.11

Quantitative Data Comparison

We converted the following data from quantitative to qualitative data: (1) cognitive, (2) functional, (3) nutrition, (4) smoking, (5) alcohol, (6) body mass index, (7) neurological issue, (8) cardiac issue, (9) pulmonary issue, (10) gastrointestinal issue, (11) renal issue, and (12) endocrinological issue seen in Table 5. Cardiac issues and endocrinological issues were sub-divided into smaller groups, due to multiple possible combinations that led to increased sorting to those bins. Cardiac issues were separated out into all possibilities, including the following: hypertension, arrythmias, heart failure, coronary artery disease, peripheral arterial disease, and other. The endocrinological issues were separated out into the following: diabetes, hyperlipidemia, hyperthyroidism, hypothyroidism, and other. These sub-divisions accounted for all the reported risk factors in these two bins.

The two most prominent risk factors in the two bins were found to be diabetes for the endocrine bin, totaling 60 accounted patients (41.67%), and hypertension for the cardiac bin, totaling 80 accounted patients (55.56%). Of these patients, 23.08% had both diabetes and hypertension, and 64.01% had at least one of the two. A majority of the patients who only had one of the two risk factors was more likely to have diabetes (52.94%) compared to hypertension (46.06%) (Table 11 & Table 12).

Table 11: Patients having one or both of the top two risk factors.

Risk Factor	Total Patients	Percent of Patients
Hypertension	80	55.56%
Diabetes	60	41.67%
Both	32	23.08%

Table 12: Patients having one vs. the other of the top two risk factors.

Hypertension	Diabetes
46.06%	52.94%

Several factors were compared within the quantitative data. The first being length of time from initial optimization to surgery if surgery proceeded without cancellation. For patient who had either diabetes or hypertension, there was an average time of 72.98 days before proceeding to surgery compared to 55.93 days of patient who did not have either risk factor ($p = 0.43$) (Table 13).

Table 13: Patients proceeding to surgery based on the top two risk factors.

Risk Factor	Time to Surgery
Diabetes/Hypertension/Both	72.98 Days
Neither	55.93 Days

Regarding post-operative infection during admission found that 75% of patients in this category had at least one of the two top risk factors of diabetes or hypertension. The remaining 25% did not have either risk factors but did develop a post-operative infection during their admission.

Regarding length of stay post-operatively, patients who had at least one of the top two risk factors had an average length of stay of 3.17 days, when compared to patients who did not have either diabetes or hypertension with an average length of stay of 3.83 days ($p = 0.38$) (Table 14).

Table 14: Length of stay of patients with the top two risk factors, with no significant difference in the two risk factors.

Risk Factor	Length of Stay
Diabetes/Hypertension/Both	3.17 Days
Neither	3.83 Days

Regarding ICU admission post-operatively within the initial stay found that all patients who had at least one of the two top risk factors had an ICU admission during their stay post-operatively.

Table 15: Edmonton Frailty Scale scores compare to the top two risk factors, with no significant difference found between the risk factors and EFS score.

Risk Factor	EFS Score
Hypertension	8.04
Diabetes	8.21
Both	8.07
Neither	7.41

Summary and Main Points

The results, data collection, and analysis were categorized into several groups using various statistical tests to determine any relationships between the groups. The groups were sub-divided into (1) data collection phase, (2) correlation analysis, (3) variance analysis, and (4) quantitative analysis. The data collection phase outlines the exact piece of information that were independently and directly recorded from the selected sample size's electronic medical record. The correlation analysis used linear regression analysis to determine any association between EFS score, age, time to surgery, and length of stay. The variance analysis studied the associations between EFS score, sex, time to surgery, and ICU admission. Finally, the quantitative analysis converted the qualitative data, determined which of the risk factors and medical history were most prominently found in the sample size, identifying two risk factors (hypertension and diabetes), and analyzed the relationships between EFS scores, ICU admissions, length of stay, and time to surgery. Throughout the analysis of all the variables, there were no significant relationships determined within these data. This bears importance in the overall understanding of which, if any, risk factors directly influence established components of optimization.

DISCUSSION & INNOVATION

Recognizing the significant impact that frailty has on patient outcomes, the impact of this project could be significant in the overall management and optimization of frail patients. Although the data is preliminary and the sample size is still mounting, we hope to join the already existing pool of literature that has been published regarding the implementation and use of pre-habilitation protocols to directly impact frailty indexes and scores. Though the idea of having pre-habilitation protocols is not necessarily novel, continued research in determining which controllable components bear significant impacts on frailty is an ongoing question that will continue to be addressed over the course of many years. Nevertheless, we hope that this study continues to lay groundwork for more refined and detailed studies looking at the effectivity and availability of specific controllable factors that can have measurable and statistically significant improvements in validated frailty scores, such as the Edmonton Frailty Score.

Beginning with the data collection phase, we see that the average age of the sample size was 71.06, with an average EFS score of 8.05. This falls within our understanding of age being a major predicating factor in frailty. Additionally, we saw an average time to surgery of 50.48 days and an average length of stay post-operatively of 2.40 days. There may be several factors affecting these averages. Within the dataset, we found many instances in which surgery was delayed due to multiple factors, some of which we can only speculate about, taking into consideration the demographic of the population that this institution serves. Some of these included other medical problems the patients were facing that fell outside of the surgical optimization management, leading to Emergency Department visits and admissions after initial optimization assessment and before surgery. Other factors included time for optimization recommendations to be implemented, such as visits to primary care providers or other specialty services. Finally, we do see fit to comment on the patient demographic, recognizing that the county hospital serves patients who have certain barriers to healthcare, such as transportation, finances, and literacy that were not specifically analyzed in this study, but are nevertheless apparent and plentiful in this population.

Upon a deeper look at the correlation and regression analysis of EFS scores to length of stay times post-operatively, we did find a positive significant correlation. This aligns with our understanding of increased frailty being associated with increased time in the hospital. We did expect to see a positive correlation in this set, and this data further supports the principle and necessity of frailty optimization in surgical candidates.

Furthermore, we found a positive correlation as an experimental finding, though without ascertaining any significance, between EFS scores and time to surgery without cancellation. Again, this does align with our expectations for the study, as a higher index of frailty would require more optimization time prior to being deemed clear and safe to proceed to surgery. With that being said, there may be other factors that influenced that time to surgery in patients with higher EFS scores. Patients with higher EFS scores, by the sheer nature of being frailer, most likely had other medical factors influencing their scores, and as a result, may have been delayed in proceeding to surgery due to addressing those other factors that fell outside of the optimization assessment and recommendations. For example, patients who had Emergency Department visits independent of the optimization assessment and recommendations would inevitably elongate the time to surgery. On the other hand, a patient with a higher EFS score was most likely to have more recommendations from the initial assessment that needed to be met with other sub-specialties which would require time and would then require more follow-up with the optimization clinic, thus elongating the time to surgery. For example, a patient who was recommended cardiac clearance would need to schedule a time to meet with their cardiologist, have the work-up done there, optimize the aspects that could be optimized, and then return to the optimization clinic to re-assess the frailty and preparedness to proceed to surgery. Although these specific factors were not directly analyzed in this study, it does serve as a baseline for continued research on the matter.

When looking at the EFS score to age, we found a positive correlation as an experimental finding, though without ascertaining any significance. This aligns with our understanding of age and its influence on frailty. As mentioned earlier in the introduction, although age is a factor that cannot be optimized or controlled, it does bear significance in determining which patients are frail, but again, we emphasize that this is not the only factor influencing frailty, as previously thought. The components of frailty are abundant, and although we do see a correlation between the EFS score and age, we also recognize there are many other factors that influence one's frailty.

Determining if patients with higher EFS scores proceeded to surgery or not found that patients with a high EFS score were significantly more likely either not to proceed to surgery or have their posted surgeries be cancelled when compared to patients who ultimately did end up proceeding to surgery. Although this does align with the understanding of poor surgical outcomes in frailer patients, we do recognize that there may be other factors influencing these results. Again, we bring to light that those patients with higher EFS scores most likely had other influencing factors on their health, and as a result, may have never scheduled their surgery, decided for themselves that they did not want to proceed with surgery for personal reasons, or may have had hospital admissions outside of the optimization assessment that led to cancellation of the surgery. Many other factors may have influenced these results, but these were the most common findings in the data collection.

Upon analysis of sex when compared to the EFS score, there was no significant difference between the two, with females having a slightly higher average EFS score. Based on our literature review, we expected no significant difference between the two. There are many other factors that influence frailty, but we did not expect sex to play an influential role on frailty.

There was a difference when comparing EFS scores to ICU admissions, which, per literature review, we expected to find. Patients with higher EFS scores were found to be more likely admitted to the ICU within their initial stay post-operatively. Although frailty was a component as one of the factors influencing ICU admission, we recognize that other factors that were unaccounted for in this study may have also influenced the rate of ICU admissions, one of which being the overall risk of the surgery, regardless of frailty. We did not find a particular surgery or specialty that led to more ICU admissions, but it was apparent from the data, that surgeries that carried a higher inherent risk, such an invasive vascular surgical procedure led to a higher likelihood of being admitted to the ICU. As a result, we extrapolate that there are multiple factors influencing ICU admission aside from frailty. Additionally, some of the patients who were admitted to the ICU were only admitted for 1-2 days, leading us to believe these patients were there for ICU level observation following surgery, which may or may not have been influenced by frailty, or other factors such as the course of surgery.

Among the qualitative data that was collected, in part from components of the EFS score and in part of risk factors and medical history identified in the initial optimization assessment, two risk factors stood out as present in almost the entire dataset, being cardiac risk factors and endocrinological risk factors. As a result, these two bins were stratified and individually assessed. We found that the two most prominent pathologies in these bins were hypertension and diabetes, respectively, with many patients having at least one, if not both, of these two risk factors. Of these patients, more were likely to have diabetes. The protocols for optimization for patients for hypertension and diabetes, as shown in Table 1, were to undergo medical management. Recognizing the prominence of these two risk factors and the impact on the EFS score, we believe that continued improvement of the optimization components and protocols regarding these risk factors is essential in minimizing frailty and maximizing optimization pre-operatively. With that being said, there are many other factors that influence hypertension and diabetes, many of which overlap one another. Future directions may hope to look at relationships between these two risk factors and the specific components of the EFS score or other systems based medical history, such as BMI, renal function, general health, nutrition, neurological issues, and cognition.

Patients who had at least one or both of the top risk factors had a 23.36% longer time to proceeding to surgery than those that had neither hypertension nor diabetes (Table 13). Aligning with our understanding of the impact on frailty and surgical outcomes, this was expected. Patients who required optimization of these two risk factors would require more time to surgery, requiring follow-up and management of other sub-specialties outside of the surgical services. This opens the question of balance between patients who urgently need surgery versus patients who have the luxury of time. As it is well known, some patients do not have the luxury of time to proceed to surgery. Thus, clinically balancing the safety of optimizing patients prior to surgery must be struck between those requiring more urgent surgery. Patients who have either diabetes or hypertension should be identified early and managed appropriately if time allows.

We found that patients without hypertension or diabetes had a longer length of stay post-operatively when compared to patients who had at least one of the two risk factors, experimentally, though not significantly. Initially, this appeared counter-intuitive, but upon further analysis, we believe this coincides with patients who either did not proceed to surgery or had their surgery cancelled (Table 8). Recognizing that there is overlay between hypertension and diabetes, and the impact on frailty and the EFS score, we can extrapolate that patients with one or both risk factors may not have proceeded to surgery, which would ultimately drive the length of stay days for patients who did proceed to surgery up. In fact, we found that patients with higher EFS scores was associated with patients who had either hypertension, diabetes, or both, as will be discussed later. We do infer that should those patients with higher EFS scores have proceeded to surgery, this would most likely be associated with higher lengths of stay and even ICU admission.

Finally, patients who had diabetes had a higher EFS score when compared to patients who had neither, and patients who had at least one or both hypertension and/or diabetes had a higher EFS score than those patients who had neither. As a result, we conclude that hypertension and diabetes are factors that do impact the EFS score in some capacity, and as a result, are factors that can be optimized, controlled, and improved in order to drive the frailty down and improve surgical outcomes.

Among the other qualitative data that was collected, nutrition, as represented by hypoalbuminemia, also played a significant factor in optimization. This may be related to the endocrinological findings and has other implications within the reset of the systems-based qualitative data. As a result, we believe that nutrition optimization and diet modification bear an important factor in optimization of patients. This has already been implemented into the OC criteria at the initial optimization assessment and recommendation but could perhaps be elaborated on for the future in the entire patient population. The challenge will be in finding efficacious and feasible ways to improve protein intake, especially when considering certain barriers to healthcare that were not addressed in this study.

Revisiting the research question of this project: Which components of the Edmonton Frailty Scale are most associated with surgical optimization and clinical outcome? Furthermore, of these components, which of these have controllable and feasible implementation strategies to impact frailty, and therefore, improve surgical outcome? we feel that we were able to answer this question and lay a concrete foundation for future studies to build upon, as we have identified many areas of uncertainty, while finding relationships within the dataset. Hypertension and diabetes seem to have an impact on surgical optimization and clinical outcome, are directly related to the EFS score, and have some association with length of stay and time to surgery.

Table 16: Summary of the analyzed data and discussion, without statistical significance, but with experimental interpretation of clinical outcomes, which serves as potential preliminary data for future research.

Comparison	Outcome	Experimental Interpretation
EFS to Length of Stay	Negative Correlation	Lower EFS Proceeds to Surgery
EFS to Time to Surgery	Positive Correlation	Allowing More Time for Optimization is Beneficial
EFS to Proceeding to Surgery	Negative Correlation	Decreasing EFS Leads to Proceeding to Surgery
EFS to ICU Admission	Positive Correlation	Higher EFS Leads to ICU Admission
EFS to Hypertension	Positive Correlation	Hypertension is Associated with Higher EFS
EFS to Diabetes	Positive Correlation	Diabetes is Associated with Higher EFS
EFS to Hypertension & Diabetes	Positive Correlation	Hypertension and Diabetes are Associated with Higher EFS

FUTURE DIRECTIONS

This study identified certain areas for continued research and analysis. Additionally, this study is serving as a preliminary study for a sister project, and, in addition to narrowing the spectrum with the research question, served to lay groundwork analysis for the sister project to use in its completion. The sister project has already completed a collection of data using the same sample size, and has analyzed specific aspects of post-operative infection, including wound infection, urinary tract infection, pneumonia rate, respiratory/cardiac issues, and 30-day return to the Emergency Department or readmission, as well as the relationship between the EFS score and whether those patients proceeded to surgery, which found similar findings to this study, in that regard.

In that light, we recognize that there were many underlying variables in this study that influenced the result and would hope these continue to be studied in future directions. The components influencing frailty and surgical outcomes is well-known, but the ways upon which direct implementation can influence surgical outcomes still has areas of nuance and factors outside of optimization that play significant roles in clinical outcomes.

We have identified several areas for future directions in this matter: (1) patient demographic, (2) outside hospital admissions, (3) sub-category stratification, (4) surgical risk assessment, (5) overlapping risk factors influencing frailty, (6) time to surgery variables, and (7) OC implementation of hypertension and diabetes (Table 17).

Patient demographic was not analyzed in this study, but we do recognize that there are multiple factors that influence, not only frailty, but compliance and feasibility of OC implementation. Barriers to healthcare, socioeconomic status, healthcare literacy, transportation, and job position would be areas of continued research in their role in frailty. The institution that this study was done at was a county hospital which serves a specific demographic of patients, as a result, there is a lot of room for stratification and data collection which we believe could be relevant in managing patients who are requiring optimization prior to surgery.

Patients who had a higher EFS score most likely would have other comorbidities that were not assessed in the initial optimization encounter or may have precipitated between the time of initial encounter to re-assessment. We noted that there were several patients who did not have surgery scheduled due to being admitted to the hospital for unrelated issues. As we cannot account for all patients that were lost to follow-up, perhaps stratifying the exact reasons that surgery was not scheduled or cancelled may give insight into other factors that could be controlled and improved upon in the future.

The qualitative data that was collected had multiple components that comprised one bin. Although we stratified two of the bins with the most inputs, we believe that further stratification of this data would ultimately lead to more influential findings that could have potential relationships to EFS scores and frailty management.

Inherent surgical risk, regardless of patient frailty, were noted in the initial optimization assessment. This study did not analyze the factors that influenced surgical risks independently. This could serve as an area of continued research that could be compared to the data collected in this study. If the inherent risk of types of surgery could be quantified, it would serve to stratify possible influences on length of stay or ICU admission.

There were multiple overlapping factors that were present within the collected data. For example, BMI, nutrition, diabetes, and renal issues may all have a similar presentation within one single patient, but we did not stratify all those variables within this study. Breaking down those aspects could serve to find significance in specific aspects influencing frailty and/or outcomes.

Although we analyzed time to surgery for this dataset, as mentioned in the discussion, there were multiple variables that were unaccounted for that influenced the time to surgery. We find it would be beneficial to isolate the possible causes of elongated time to surgery, be it from being lost to follow-up or other potential reasons.

Finally, we emphasize the most important aspect of continued research in this matter which is determining the possible areas of improvement on the optimization component implementation for hypertension and diabetes. These two risk factors, if managed appropriately, could serve to significantly drive down the EFS score, which would ultimately lead to improved clinical outcomes in these frail patients.

Table 17: Areas of identified future and continued research.

Area of Future Research	Research Components
Patient Demographic	Healthcare literacy, socioeconomic status, transportation availability, & job title
Independent Hospital Admission	Reasons for hospitalizations outside of optimization encounters
Qualitative Stratification	Analyzing each component within the systems-based bins
Overlapping Risk Factors	Stratifying the multiple components that fall within multiple bins
Time to Surgery Variables	Filtering and identifying multiple components influencing time to surgery
Optimization Components for Diabetes/Hypertension	Continued improvement on management of diabetes and hypertension

CONCLUSIONS

Frailty in surgical patients can be defined using a myriad of methods, but many studies have addressed several components being linked to frailty. Namely, age, and overall health status, which can be further broken down into past medical history, cognition, and overall ability to function independently on a day-to-day basis. There have been many frailty indexes, scales, and scores that have been aimed at finding an objective measuring stick to determine the overall frailty of patients, one of which is the Edmonton Frailty Scale. The reason for such emphasis on quantifying frailty is due to the plethora of literature in the clinical setting that has time and time again shown the negative effects and poor outcomes of frail patients in a surgical setting. By giving an objective score to select for frail patients, clinical management can cater to finding ways of concretely and actionably addressing poor frailty scores and thus, improve the surgical outcomes and prognoses of these patients.

Major Findings

The major findings of this study revolved around the conversion of qualitative to quantitative data, finding the most prominent risk factors being diabetes and hypertension. Additionally, we were able to expand on some of the previous literature, finding that age was associated with increased EFS score, and increased EFS score was associated with increased time to surgery, as well as associated with risk factors, including diabetes and hypertension. We were also able to identify relationships between EFS scores, time to surgery, and ICU admission. We found a decreased length of stay with increased EFS scores, most likely associated with patients who did not proceed to surgery or had surgery cancelled.

Clinically, we found an increased EFS score was more likely associated with increased ICU admission and time to surgery, and although there was no significant statistical data supporting this, we do feel that the trend, especially in a preliminary report, to be beneficial in future studies. Finally, we found that increased EFS scores were associated with diabetes and hypertension, and furthermore, that hypertension and diabetes were associated with an increased time to surgery and increased length of stay. Most patients were most likely to have diabetes, if they only had one of the two major risk factors, and diabetes was associated with a higher EFS.

Impact

These findings have direct impact on, not only the sister study, but on the confirmation of previously reviewed literature, such as age and sex, with age still playing a factor in the overall frailty assessment. Additionally, we were able to assess the relationship between EFS, length of stay, ICU admission, and time to surgery. This aids in our understanding of frailty as it impacts measurable clinical components, thus giving insight into pre- and post-operative effects of frailty on surgical outcomes.

Most prominently, the finding of hypertension and diabetes as the two risk factors with the most inputs having association with length of stay, time to surgery, and EFS scores lays a significant impact on the existing literature and future studies as continued optimization in these matters will ultimately have significant impacts on frailty scores, and thereafter, surgical outcomes.

Implications of Work

The implications of this study can most significantly be seen in its groundwork and preliminary data for the sister study being completed on the same dataset. By isolating the myriad of variables done in this study, we have emphasized certain aspects of frailty management, but have also eliminated certain other aspects for frailty management. This point is equally important in the foundational analysis of future research, as we hope to have begun to ask the appropriate questions, answered the basic questions of the study, and opened possibilities and new variables that could be impacting surgical optimization and outcome from a frailty perspective.

Surgical optimization through the lens of frailty management is ongoing and continually changing. There are multiple factors and unaccounted variables that influence substantiated frailty scales, and although we were able to isolate a handful of variables and possible issues, this does not serve as an exhaustive review and analysis of frailty management and optimization protocols. The conclusions drawn in this study should be noted as preliminary data, and associations require further analysis in future studies. Nevertheless, we do hope that the data and analysis provided in this study help in the groundwork for continued research on the matter.

COMPLIANCE

Through the Executive Director of Research, Innovation, and Sponsored Programs at John Peter Smith, it has been determined that your project is not subject to human research regulations, and thus can continue without Institutional Review Board certification. Verification for this project has been completed via the authors, and proof of clearance can be provided upon request.

FUNDING

No external funding was required for the completion of this study.

CONFLICT OF INTEREST & DISCLOSURES

The authors have no conflicts of interest or disclosures to reveal regarding this study.

CERTIFICATION & PRIVACY

All authors were certified to complete human research and data collection through CITI certification. Datasets, patient information, and analysis were taken from a secured and encrypted network. All information was deidentified upon statistical analysis, and no records of the information were saved or kept on any personal software that was not approved by the institution or associated departments.

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JOURNAL IDENTIFICATION

This study has not been submitted to any journals for publication at this time, as a result, there is no available journal identification number, status, or editor contact information.

PLAGIARISM CHECK

Completed on 1/23/2024 on www.turnitin.com with 96% uniqueness and 4% match, without concern for plagiarism. The authors certify that all aspects of this study are independently collected, analyzed, and written by the authors, and all cited information accounts for prior studies used to guide the formulation of this study.

SIGN-OFF & APPROVAL

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Thesis Submission: 1/23/2024
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REFERENCES & BIBLIOGRAPHY

American Medical Association

1. Ayuso SA, Robinson JN, Colavita PD, Heniford BT. Smoking, Obesity, and the Elective Operation. Surg Clin North Am. 2021 Dec;101(6):981-993. doi: 10.1016/j.suc.2021.05.025. PMID: 34774276.

2. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, Seeman T, Tracy R, Kop WJ, Burke G, McBurnie MA; Cardiovascular Health Study Collaborative Research Group. Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci. 2001 Mar;56(3):M146-56. doi: 10.1093/gerona/56.3.m146. PMID: 11253156.

3. Cheung C, Meissner MA, Garg T. Incorporating Outcomes that Matter to Older Adults into Surgical Research. J Am Geriatr Soc. 2021 Mar;69(3):618-620. doi: 10.1111/jgs.17028. Epub 2021 Jan 18. PMID: 33462830; PMCID: PMC8323990.

4. Castillo-Angeles M, Cooper Z, Jarman MP, Sturgeon D, Salim A, Havens JM. Association of Frailty With Morbidity and Mortality in Emergency General Surgery by Procedural Risk Level. *JAMA Surg*. 2021;156(1):68–74. doi:10.1001/jamasurg.2020.5397

5. Santa Mina D, Scheede-Bergdahl C, Gillis C, Carli F. Optimization of surgical outcomes with prehabilitation. Appl Physiol Nutr Metab. 2015 Sep;40(9):966-9. doi: 10.1139/apnm-2015-0084. Epub 2015 May 13. PMID: 26300015.

6. Fehlmann, C. A., et al. (2022). "Association between mortality and frailty in emergency general surgery: a systematic review and meta-analysis." Eur J Trauma Emerg Surg 48(1): 141-151

7. Chan, R., et al. (2022). "Association between frailty and clinical outcomes in surgical patients admitted to intensive care units: a systematic review and meta-analysis." Br J Anaesth 128(2): 258-271

8. Rolfson DB, Majumdar SR, Tsuyuki RT, Tahir A, Rockwood K. Validity and reliability of the Edmonton Frail Scale. Age Ageing. 2006 Sep;35(5):526-9. doi: 10.1093/ageing/afl041. Epub 2006 Jun 6. PMID: 16757522; PMCID: PMC5955195.

9. Baimas-George, M., et al. (2020). "Prehabilitation in Frail Surgical Patients: A Systematic Review." World J Surg 44(11): 3668-3678

10. Koh, F. H., et al. (2022). "Structured presurgery prehabilitation for aged patients undergoing elective surgery significantly improves surgical outcomes and reduces cost: A nonrandomized sequential comparative prospective cohort study." Nutr Clin Pract 37(3): 645-653

11. Borson S, Scanlan JM, Chen P, Ganguli M. The Mini-Cog as a screen for dementia: validation in a population-based sample. J Am Geriatr Soc. 2003 Oct;51(10):1451-4. doi: 10.1046/j.1532-5415.2003.51465.x. PMID: 14511167.

12. McIsaac, D. I., et al. (2022). "Home-based prehabilitation with exercise to improve postoperative recovery for older adults with frailty having cancer surgery: the PREHAB randomised clinical trial." Br J Anaesth 129(1): 41-48

13. Beilstein, C. M., et al. (2023). "Multimodal prehabilitation for major surgery in elderly patients to lower complications: protocol of a randomised, prospective, multicentre, multidisciplinary trial (PREHABIL Trial)." BMJ Open 13(1): e070253

14. Guo, Y., et al. (2022). "Effects of prehabilitation on postoperative outcomes in frail cancer patients undergoing elective surgery: a systematic review and meta-analysis." Support Care Cancer 31(1): 57

15. Hunter, T. L., et al. (2023). "The Role of Surgical Prehabilitation During the COVID-19 Pandemic and Beyond." Phys Med Rehabil Clin N Am 34(3): 523-538

16. Janssen, T. L., et al. (2019). "Multimodal prehabilitation to reduce the incidence of delirium and other adverse events in elderly patients undergoing elective major abdominal surgery: An uncontrolled before-and-after study." PLoS One 14(6): e0218152

17. Leiner, T., et al. (2022). "Frailty and Emergency Surgery: Results of a Systematic Review and Meta-Analysis." Front Med (Lausanne) 9: 811524

18. Milder, D. A., et al. (2018). "The role of prehabilitation in frail surgical patients: A systematic review." Acta Anaesthesiol Scand 62(10): 1356-1366

19. Mohamed, B., et al. (2023). "Frailty Assessment and Prehabilitation Before Complex Spine Surgery in Patients With Degenerative Spine Disease: A Narrative Review." J Neurosurg Anesthesiol 35(1): 19-30

20. Ng, P., et al. (2022). "Finding value with prehabilitation in older persons receiving surgery." Curr Opin Support Palliat Care 16(1): 19-24

21. Norris, C. M. and J. C. T. Close (2020). "Prehabilitation for the Frailty Syndrome: Improving Outcomes for Our Most Vulnerable Patients." Anesth Analg 130(6): 1524-1533

22. Sadlonova, M., et al. (2023). "Surgical prehabilitation in older and frail individuals: a scoping review." Int Anesthesiol Clin 61(2): 34-46

23. Schaller, S. J., et al. (2022). "Prehabilitation of elderly frail or pre-frail patients prior to elective surgery (PRAEP-GO): study protocol for a randomized, controlled, outcome assessor-blinded trial." Trials 23(1): 468

24. Steinmetz, C., et al. (2023). "Prehabilitation in older patients prior to elective cardiac procedures (PRECOVERY): study protocol of a multicenter randomized controlled trial." Trials 24(1): 533

25. van der Hulst, H. C., et al. (2021). "Can physical prehabilitation prevent complications after colorectal cancer surgery in frail older patients?" Eur J Surg Oncol 47(11): 2830-2840

26. Zhao, F., et al. (2020). "The impact of frailty on posttraumatic outcomes in older trauma patients: A systematic review and meta-analysis." J Trauma Acute Care Surg 88(4): 546-554

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