Frailty And Health Related Outcomes In Acute Care

by

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AUTHOR’S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners. I understand that my thesis may be made electronically available to the public.

Abstract

Background: Current frailty screening tools have not been validated for day-to-day use in acute care (Binder, 2015). Many recommended tools include subjective questions and take too much time to complete in a fast-paced clinical environment (Morley et al., 2013). It is for this reason that hand grip strength and gait speed have been chosen as tools to be evaluated for their feasibility and potential utility as single indicators of frailty for use in acute care. A useful indicator should add value to a clinical assessment, such as predicting key outcomes to identify those patients who need more intensive treatment. The predictive validity of frailty measures has been studied extensively in the literature in connection to many different health related outcomes. However, their predictive validity in relation to length of hospital stay and quality of life during and post-discharge from acute care requires further investigation. The More-2-Eat study provides an ideal opportunity to address these knowledge gaps.

Purpose: **(1)** To determine the feasibility of two frailty indicators (5m and HGS) for acute care patients, **(2)** to determine the predictive validity of these tools with respect to LOS, and **(3)** to determine if these frailty indicators predict quality of life during and post-discharge from acute care.

Methods and findings: More-2-Eat was a multi-site participatory action research study with a before-after time series design. The primary objective of the study was to implement and evaluate the Integrated Nutrition Pathway for Acute Care (INPAC) in Canadian hospitals. Each site was led by an interdisciplinary team, which offered coaching and improvement strategies towards implementing nutrition care best practices. The study population were all patients on the chosen medical unit for implementation of INPAC at the: Royal Alexandra Hospital (Edmonton, AB), Regina General Hospital (Regina, SK), Concordia Hospital (Winnipeg, MB), Niagara

Health System, General Site (Niagara Falls, ON), and Ottawa Hospital (Ottawa, ON). There were two key aspects of data collection at the patient level; an 1) audit of nutrition care practices for all patients on the unit during monthly audit days, and 2) a detailed assessment of nutrition, frailty, disability, quality of life and food intake on a subset of patients recruited each month. This latter data collection was used for this study. There were 1250 detailed patient data collections over a 15-month period for analysis. Data included demographics, primary admission diagnosis, length of stay, nutritional risk (and diagnosis of malnutrition if relevant), an estimate of a single meal's food intake, barriers to food intake, self-reported quality of life, self-reported disability, frailty indicators, patient reported perceptions on adequacy of food intake and nutritional health, and nutrition care provided in the hospital at the time of the data collection. All data were typically collected over one to three days for each patient. Items used in this thesis include: handgrip strength (HGS) (n=1146, mean=20.82 kg), five meter timed walk (5m) (n=535, median=6.79 sec), subjective global assessment (SGA), perceived functional status (Nagi scale), length of stay (LOS), quality of life (QOL), demographics, and reasons for non-completion of assessments. **(1)** Descriptive statistics revealed that HGS is a more feasible indicator of frailty than the 5m in acute care medical patients, as the completion rate was over 90%; 5m walk could not be completed in more than 50% of patients. Further, HGS had high completion rates across all sites and for diverse populations (diagnoses, sex). HGS was associated with key patient characteristics such as nutritional status ($t=4.13$, $p<0.0001$) and perceived functional status ($t=10.69$, $p<0.0001$). **(2)** Multiple linear regression modeling revealed that the addition of HGS as an indicator of frailty significantly improved the predictive value for both male ($X^2=3.9$, $p<0.0001$) and females ($X^2=2.0$, $p<0.05$) for LOS, whereas 5m was not useful as a predictor across sex. Yet, standardized cut-points for both measures had low

sensitivity and specificity. **(3)** Multiple linear regression modeling also revealed that the addition of HGS as an indicator of frailty significantly improved the predictive value of both the male (X^2= 31.78, p<0.01) and female models (X^2= 21.02, p<0.01) with respect to the physical component of QOL in hospital (PCS1) and post-discharge (PCS2) (X^2=10.62, p<0.01; X^2= 10.75, p<0.01), whereas 5m added significant predictive value across sexes for the physical component of QOL in hospital (PCS1) (X^2=9.42, p<0.01; X^2=15.72, p<0.01), but not 30 days post-discharge (PCS2).

Conclusion: Overall, HGS appears to be a more appropriate single indicator of frailty for consideration in acute care. This tool is feasible for diverse patients and results are associated with nutritional status and perceived functional disability, indicating that it is likely measuring frailty (as defined by Fried, 2001). HGS also appears to be relevant for predicting important outcomes and clinical decision-making. Lower HGS values were correlated with longer LOS and poorer physical QOL. HGS also provided additional predictive value for LOS and physical QOL in hospital and 30 days post-discharge when adjusting for other covariates that would be collected in a clinical setting, including nutritional status. Consideration for use of this tool in acute care is appropriate once useful cut-points have been determined.

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Table of Contents

List of Tables & Figures

List of Abbreviations

5M: 5-meter timed walk

CNST: Canadian Nutrition Screening Tool

HGS: Handgrip strength

INPAC: Integrated Nutrition Pathway for Acute Care

LOS: Length of Stay

M2E: More-2-Eat

MAT: Mealtime Audit Tool

MMIT: My Meal Intake Tool

QOL: Quality of Life

SGA: Subjective Global Assessment

SF-12: 12 Item Short Form Survey

Chapter 1: Introduction

The following Master's thesis consists of three separate main research questions, pertaining to frailty and health-related outcomes in acute care. Each main research question and sub-questions will be addressed in an individual draft manuscript; analyses are based on secondary data from the More-2-Eat study (M2E).

More-2-Eat was a participatory action research study using a before-after time series design to study the implementation of improved nutrition care practices in five sites in Canada. The aim of this study was to "optimize nutrition care in hospitals, and thus performance of the healthcare system, by ensuring that malnutrition and poor food intake are prevented, detected and treated, hence promoting the recovery, function and quality of life of patients, with particular attention on the needs of frail elderly (>65)" (Keller, 2015, p. 8). Primary outcomes of this study included "fidelity to the INPAC (Integrated Nutrition Pathway for Acute Care) components (e.g. % screening, monitoring); patient reported outcomes of barriers to food intake and their self-rating on importance of nutrition to their recovery; and change in staff knowledge, attitudes, and practices" (Keller, 2015, p.8). Secondary outcomes were anticipated to occur if primary outcomes arose. Specifically, it was hypothesized that "patient length of stay, 30-day readmission, patient-reported food intake during hospitalization, frailty, and quality of life would all improve with full implementation of the INPAC" (Keller, 2015, p. 8).

This research used data collected in M2E from all five sites. There were approximately 1250 detailed patient data collections over an 18-month period for analysis, which included key measures used in this thesis. Specifically, data incorporated in Chapters 4 through 6 of this thesis include: handgrip strength (kg), 5m walk (seconds), patient length of stay (LOS; days), and quality of life (QOL). This research will begin by determining the feasibility of two potential frailty indicators for acute care patients. It will then determine the predictive validity of these tools with respect to LOS, and finally will examine which if these frailty indicators predict quality of life during and post-discharge from acute care.

This research will help to create a better understanding of how frailty can be identified in an acute care setting, and if these tools can be used to predict important health outcomes. One of the goals of this research is to gain a better understanding of the feasibility of potential frailty indicators to ultimately promote the use of the most appropriate tools in acute care. Another important goal of this research is to analyze and validate cut-points that can be used to make decisions with respect to improvement of important outcomes such as prolonged length of stay. Predictive cut-off points may help reduce length of stay for patients in acute care, by promoting earlier intervention as needed, and consequently, reduce costs to the Canadian health care system. This research will also contribute to a better understanding of factors influencing quality of life during and post-discharge from acute care. As health care shifts focus toward a more patient-centered philosophy of care, patient reported outcomes are becoming increasingly important for decision-making. Quality of life is a multi-dimensional outcome, which lends itself to a well-rounded understanding of physical, mental and social wellbeing (Fayers & Machin, 2013). Appreciating factors that might predict this outcome will allow health care providers to mediate or intervene to promote higher quality of life during and post-discharge from acute care.

Chapter 2: Background

The following review of the literature will begin by conceptualizing the notion of frailty, discuss how it is measured and identified and explore its prevalence and significance. This review will then focus on malnutrition, and its' conceptual overlap with frailty. This will lead to a discussion on handgrip strength and the 5-meter walk as potential indicators for frailty their connection to malnutrition, and their possible use in acute care settings. Focus will then shift to length of hospital stay, and its prevalence and significance in a Canadian context and why it is a relevant outcome variable. This review will aim to address why length of hospital stay is an issue, and why frailty is an important consideration within that issue. Finally, quality of life will be discussed. This review will aim to conceptualize quality of life, describe how it is measured, why it is an important patient-reported outcome, and explore some of its current predictors in the acute care context.

2.1 What is Frailty?

Conceptualizing frailty is of considerable interest in the research and practice communities, but consensus on what factors are necessary for defining frailty have appeared to be inconsistent for a long period of time (Conroy, 2009; Fried, Ferrucci, Darer, Williamson & Anderson, 2004; Fried et al., 2001; Rockwood & Mitnitski, 2007). Two main models for conceptualizing frailty have been consistently used in the literature: the phenotype model and the cumulative deficit model (Clegg, Young, Illiffe, Rikkert & Rockwood, 2013; Fried et al., 2001, Morley et al., 2013; Rockwood & Mitnitski, 2007). Fried established the phenotype model in 2001, based on a review of prior research and clinical consensus. This model posits that frailty is characterized by the presence of three or more of the following features: shrinking (e.g. weight loss), weakness, poor endurance and energy, slowness, and low physical activity level (Fried, 2001). Conversely, the cumulative deficit model defines frailty as an accumulation of deficits over time that reduces one's capacity to resist stressors (Rockwood, 2007). Despite the conceptual differences, research has demonstrated that both models have significant statistical convergence, helping to create a more consistent construct of frailty (Clegg et al., 2013).

More recently, work has been focused on coming to a consensus with regard to defining frailty, in an attempt to determine whether or not there is sufficient information available to promote screening for frailty by all physicians in all settings (Morley et al., 2013). In 2012, a consensus meeting was held, with six international, European and US societies represented (Morley et al., 2013). The group of experts defined frailty as "A medical syndrome with multiple causes and contributors that is characterized by diminished strength, endurance, and reduced physiologic function that increases an individual's vulnerability for developing increased dependency and/or death" (Morley et al., 2013 p. 393). This group also made four consensus-based statements and recommendations pertaining to frailty:

1. Frailty is an important medical syndrome
2. Simple screening tests are accessible to physicians to recognize frail persons and identify persons with physical frailty or at risk of frailty
3. Physical frailty is a manageable condition
4. All persons >70 years of age should be screened for frailty.

   (Morley et al., 2013, p. 393-395)

Of particular interest from this consensus was the identification of simple screening tests that already exist and can be used by physicians to identify frailty. This will be further discussed in a subsequent section on *Measuring and Screening for Frailty.* However, despite this effort to come to a consensus, recent reviews of relevant literature have shown that research on successful or healthy aging has failed to keep up with the focus on frailty (Friedman, Shah & Hall, 2015).

It is currently estimated that over 1 million Canadians are frail (Hoover, Roterman, Sanmartin & Bernier, 2013). Prevalence rates for frailty range from 10-20% of community dwelling older adults (>65 years), with higher rates among women than men (Collard, Boter, Schoevers & Oude Voshaar, 2012; Song, Mitnitski & Rockwood, 2010). With the presence of a chronic disease such as cancer, rates of frailty increase significantly; for example, over 50% of older cancer patients are considered pre-frail or frail (Handforth et al., 2015). Although frailty is not unique to older adults, frailty rates increase substantially with age (Fried et al., 2001; Song et al., 2010; Collard et al., 2012). Statistics Canada predicts that by the year 2036, nearly 1 in 4 Canadians will be over the age of 65 (Statistics Canada, 2015). With a large proportion of the Canadian population at risk of being frail, screening and measuring frailty in a reliable manner is essential to identify this condition as early as possible to provide potentially useful treatments and services.

2.2 Malnutrition and the overlap with Frailty

According to the Canadian Malnutrition Task Force, malnutrition involves any nutritional imbalance, including a deficiency or an excess of energy, protein and other nutrients that leads to body composition change and functional impairment. However, in an acute care setting, malnutrition (referring specifically to undernutrition and inadequate intake of energy, protein and other nutrients) is of primary concern (Canadian Malnutrition Task Force, 2014). Furthermore, roughly 45% of hospitalized patients who stay in hospital more than two days are malnourished (Allard et al., 2015). That being said, there is no universally accepted method or criteria to diagnose malnutrition, and current methods vary from simple assessments of appetite and weight loss (Ferguson M, Capra S, Bauer J, Banks M, 1999), to complex laboratory and anthropometric assessments (Ingenbleek & Carpentier, 1985). The European Society of Clinical Nutrition and Metabolism (ESPEN) defined malnutrition as a body mass index (BMI) <18.5, or the combination of unintentional weight loss along with a reduced BMI or a low fat free mass index (FFMI) (Cederholm et al., 2015). Conversely, Jensen and colleagues defined malnutrition as an overall "decline in lean body mass, with the potential for functional impairment" (as cited in White et al., 2012, p. 730). This definition contributed to the Academy of Nutrition and Dietetics and the American Society for Parenteral and Enteral Nutrition's (A.S.P.E.N) recommendation that a standardized set of diagnostic criteria be used to recognize and record malnutrition in clinical practice (White et al., 2012). This group recommended that at least 2 of the following 6 criteria need to be present in order to identify malnutrition: insufficient energy intake, weight loss, loss of muscle mass, loss of subcutaneous fat, localized or generalized fluid accumulation, and diminished functional status (White et al., 2012). The frailty indicators used in this study (handgrip strength and gait speed) are good indicators of the functional status aspect of this six-domain construct of malnutrition (Clegg et al., 2013; Chung et al., 2014; Jeejeebhoy, 2012; Savva et al., 2012; Studenski et al., 2003). A tool commonly used to assess malnutrition is the Subjective Global Assessment (SGA) (Detsky et al., 1987). This standardized tool meets the aforementioned criteria, and has been validated for use in acute care (Fontes, D., de Vasconcelos Generoso, S., & Correia, M. I. T. D., 2014). However, this tool requires clinical judgment and takes sufficient time to complete by a trained dietitian or other health professional.

The overlap in constructs of frailty and malnutrition are important to understand, especially when considering the phenotype concept of frailty, which includes weight loss and weakness as key components (Fried et al., 2001). Jeejeebhoy (2012) conducted a review, which highlighted the overlap between phenotypes of malnutrition and frailty. It was concluded that loss of body tissues, resulting in wasting is a common phenotype for several conditions, including frailty and malnutrition (Jeejeebhoy, 2012). A recent study on rural elderly Lebanese investigated the independent relationship between the construct of frailty and malnutrition (Boulos Salameh & Barberger-Gateau, 2016). Frailty was assessed using the Study of Osteoporotic Fractures (SOF) measure, which includes: involuntary weight loss of more than 5 kg during the past year, inability to rise from a chair five times without using arms and reduced energy level for at least 3 days during the past week (Boulos et al., 2016). Additionally, malnutrition was assessed using the Mini Nutritional Assessment (MNA), while adjusting for age and other covariates (Boulos et al., 2016). The results of this study revealed that malnutrition and risk of malnutrition were related to an almost four-fold increase in risk of frailty (Boulos et al., 2016). However, it should be noted that risk of malnutrition and malnutrition diagnoses are measured differently and risk tools are distinctive from diagnostic tools. Nonetheless, Boulos et al. (2016) determined that there is a significant association between malnutrition and frailty and that these constructs share common socio-demographic, physical and cognitive links. In 2002, Bales and Ritchie termed the concept of 'nutritional frailty', which refers to "rapid, unintentional loss of body weight and accompanying disability that often signals the beginning of a terminal decline in an elderly individual" (p. 310). This conceptual overlap is critical to recognize when considering identifying frailty in a hospital setting, as assessment tools for both frailty and malnutrition currently rely on lengthy, subjective tools, and feature similar diagnostic symptoms.

2.3 Measuring and Screening for Frailty

Methods for measuring and screening for frailty are also inconsistent and diverse within the literature. Fried et al., (2001) noted that a valid and standardized method for screening frailty is required to effectively target appropriate care. More recently, consensus regarding defining and screening for frailty has emerged with recommendations coming from an international body (Morley et al., 2013). One of the recommendations was that simple screening tests for frailty exist and should be used by physicians for older adults (Morley et al., 2013). The screening tests suggested by these experts included: FRAIL (Abellan et al., 2008), the Cardiovascular Health Study Frailty Screening Measure (Fried et al., 2001), the Clinical Frailty Scale (Rockwood et al., 2005), and the Gérontopôle Frailty Screening Tool (Subra, Gillette-Guyonnet, Cesari, Oustric & Vellas, 2012) (Morley et al., 2013). Although these tests have been recommended for physician use, three of the four aforementioned tools are subjective measures. The fourth tool, the Cardiovascular Health Study Frailty Screening Measure (Fried et al., 2001), involves a battery of objective measures, including gait speed and grip strength. That being said, in a clinical setting, it is essential that screening tools be simple, objective, and preferably single measures or indicators to ensure efficiency.

Cesari et al., (2016) recently noted that “the most appropriate frailty instrument should rely on the purpose of the evaluation, the outcome for which the definition was originally validated, the validity of the tool, the studied population and the setting in which the assessment will be conducted” (p.191). Cesari et al. (2016) suggested that objective; physical performance measures, which are more focused on the functioning of the individual, are preferable to subjective evaluations for measuring frailty, especially when conducting assessments in a clinical or hospital setting. A recent study was conducted in Taiwan to evaluate the predictive abilities of single items and their combinations in the instrumental activities of daily living and Nagi scales to predict care needs of older adults (Hsu, Chen & Wang, 2017). These results highlighted “doing heavy housework” and “walking 200 m” as having superior predictive ability for predicting care needs of older adults (Hsu et al., 2017). These single indicators are also consistent with Fried's phenotype model of frailty (Fried, 2001). In a Canadian context, the interRAI Assessment Urgency Algorithm (AUA) was implemented in primary care settings and an emergency department to trial a standardized approach to risk assessment (Elliott, Gregg, Reg & Stolee, 2016). However, this assessment needs to be validated against a criterion for frailty and its' association with other relevant constructs such as nutritional status requires further research to consider its' use for fast paced acute care.

Although specific frailty screening tools exist, none have demonstrated validity for acute care settings (Binder, 2015). Therefore, the use of these tools in clinical settings needs further study (Binder, 2015). Gait speed and handgrip strength have both been investigated in the literature as appropriate indicators of frailty (Clegg et al., 2013; Chung et al., 2014; Jeejeebhoy, 2012; Savva et al., 2012; Studenski et al., 2003). Additionally, studies have confirmed that decreased muscle strength (specifically grip strength) is a good indicator of frailty (Bohannon n.d, Jeejeebhoy, 2012; Morley et al., 2013; Roberts et al., 2011,). Although the use of these objective measures has been discussed in the literature (Morley et al., 2013; Studenski et al., 2003), a comparison in terms of the feasibility of these tools as single indicators of frailty in an acute care setting has yet to be established.

2.3.1 Gait Speed as an Indicator of Frailty

Slow gait speed has been reported to successfully characterize older adults who have experienced adverse outcomes, such as frailty (Clegg et al., 2013; Jeejeebhoy, 2012; Morley et al., 2013). Gait speed has also been shown to be associated with or predict a variety of health related outcomes, including: physical performance and incidence of falls (Scott et al., 2014), community ambulation (Elbers, Van Wegen, Verhoef & Kwakkel, 2013), survival among cardiovascular patients (Chiaranda et al., 2013), dyspnoea and health related quality of life (HRQOL) among COPD patients (Kon et al., 2013). Specifically, recent literature has provided a cut-point of > 6 seconds (determined by receiver-operator characteristic curves) as an indicator of frailty during the timed 5-metre walk test (Afilalo, 2010; Wilson, Kostsuca & Boura, 2015). Other literature suggests that a usual gait speed of <1m/s identifies a person at high risk of health related outcomes (Cesari et al., 2005). Decreased gait speed or 'slowness' is one of the components of the phenotype concept of frailty, as defined by Fried (2001), making it potentially a useful single indicator of frailty. Although cut-points have been suggested, they require evaluation in terms of sensitivity and specificity for use in acute care patients.

2.3.2 Handgrip strength as an indicator of frailty and malnutrition

Another important component of Fried's phenotype model is weakness, or decreased strength, highlighting the importance of considering handgrip strength (HGS) as a useful tool to indicate frailty (Fried, 2001). Kim, Higgins, Canaday, Burant & Hornick (2014) conducted assessments (Fried and Gill Frailty Instruments) on 162 male American veterans. Their results supported the contention that grip strength might be an important indicator of increasing frailty (Kim et al., 2014). Sydall, Cooper, Martin, Briggs and Sayer (2003) went as far as suggesting that HGS could be a single indicator of frailty. However, HGS has also become a popular tool to identify malnutrition (Norman et al., 2011). A systematic review was conducted, highlighting decreased muscle function in relation to nutritional deprivation, and found that HGS is being used often as an indicator for nutritional status (Norman et al., 2011). Flood et al. (2014) investigated whether or not HGS could be used as a single marker of nutritional status among hospital patients. Results of this study confirmed that PG-SGA scores (a valid measure of nutritional status) and categories were significantly correlated with HGS scores, suggesting that

HGS is potentially an appropriate single marker of nutritional status (Flood et al., 2014). However, a recent article provides a different perspective. Jeejeebhoy et al. (2015) identified that SGA was more useful than anthropometry and serum albumin for predicting length of stay and readmission, and thus is the most robust measure for assessing nutritional status that should be used in acute care to diagnose malnutrition. HGS added additional predictive value, implying that HGS is potentially measuring something in addition to SGA (Jeejeebhoy et al., 2015), and thus beyond malnutrition.

Handgrip strength values have been used in the past to determine or predict a number of different health related outcomes (Rijk, Roos, Deckx, van den Akker & Buntinx, 2016). Furthermore, handgrip strength cut-off points have been established in the current literature to determine and predict outcomes including: cognition, mortality, functional status and hospitalization (Rijk et al., 2016, Stessman et al., 2017). However, comparison to a key outcome in acute care, specifically length of stay, has been rare (Jeejeebhoy et al., 2015). Predictive validity relating to length of stay and use of sensitivity and specificity to determine potential cut-off points has yet to be established in the literature for this group.

2.4 Length of Stay

Length of hospital stay is defined as the day of admission to hospital to the moment of discharge or death (Isabel, Correia & Waitzberg, 2003). According to the Canadian Institute of Health Information (CIHI), in 2013-2014 there were more than 2.9 million acute care hospitalizations in Canada, and after adjusting for age (which is associated with length of stay), the average length of hospital stay (LOS) was 7.0 days (CIHI, 2014). Currently, 10% of the acute care population is experiencing LOS longer than 30 days (CIHI, 2015). The most common reason for hospitalization in acute care in Canada is giving birth, with an average LOS of 2.3

days (CIHI, 2014). However, LOS increases significantly for the next most common reasons for hospitalization (respiratory diseases and heart attacks) accounting for 7.7 days and 5.1 days respectively (CIHI, 2014). With regard to surgical procedures, after cesarean sections, the most common reasons for hospitalization include knee replacements (4.3 days) and fractures (9.3 days) (CIHI, 2014). However, research indicates that well-nourished patients have significantly decreased LOS as compared to malnourished patients (Isabel et al., 2003; Allard et al., 2015). LOS is also an important indicator of patient recovery. Shorter LOS benefits the patient in terms of decreasing their risk of deteriorating in terms of their physical condition. These trends highlight the need for efforts to continue to reduce length of stay, and the importance of considering nutritional status, and possibly, frailty in doing so.

In the 2012-2013 fiscal year, acute inpatient hospitalizations in Canada cost 24.4 billion dollars (CIHI, 2014). Of that cost, respiratory diseases along with hip and knee replacements incurred the highest costs (CIHI, 2014). It is also important to understand which users are incurring the bulk of these costs to attempt to reduce them. According to CIHI (2015), typical high users include: seniors, those with chronic conditions or mental health conditions, those receiving palliative care, and those with socio-economic factors such as poverty. Another important consideration impacting LOS is malnutrition. Allard et al. (2015) determined that HGS at admission, receiving nutrition support, and food intake ≤50% were all independently and significantly associated with length of stay. In addition, in 2012-2013, seniors (who are more likely to experience frailty and malnutrition) (Collard et al., 2012; Fried et al., 2001; Song et al., 2010) accounted for 78% of the three most expensive types of hospital stays (CIHI, 2014). Canadian estimates suggest that malnourished patients cost on average $2000 more than a well-nourished medical or surgical patient, amounting to an estimated $2 billion per year, as malnutrition occurs in approximately 45% of all medical and surgical patients who stay more than 2 days (Allard, 2015; Curtis et al., 2016).

Many components of health have been associated with LOS. For example, a multicenter observational study on predictors of LOS among older adults admitted to acute wards concluded that excessive polypharmacy was the strongest predictor of increased LOS among ER and elective surgery admissions (Vetrano et al., 2014). Cotts et al. (2014) noted that pre and perioperative factors were among significant predictors of LOS after implantation of a left ventricular assist device, while Suter-Widmer et al. (2012) identified that older age, respiratory rate, residing in a nursing home, and severity of disease state were important predictors of LOS. Many of these factors may result in or be correlated with the frailty status of patients.

Frailty is a multi-faceted syndrome that consists of several different characteristics that could be associated with LOS. For example, Pichard et al. (2004) found that a low fat-free body mass index (e.g. shrinkage as per the phenotype definition) was a predictor of length of hospital stay, even when adjusting for age. Allard et al. (2015) discovered that HGS at admission to hospital was significantly associated with LOS, however this was not the focus of this study, but rather malnutrition. Strength and weight loss are important components of frailty based on Fried's phenotype model (Fried et al., 2001), suggesting that some associations between components of frailty, malnutrition and length of stay exist.

Peel, Navanathan & Hubbard (2014) investigated the predictive validity of gait speed relating to length of stay in post-acute transitional care for older adults white adjusting for age and sex. Peel et al. (2014) determined that gait speed at admission was significantly and negatively correlated with length of stay. This research highlights that an association between gait speed and length of stay is plausible. However, this was a relatively small sample (n=351) and was conducted in transitional care, rather than acute care.

One study specifically addressed the independent associations between HGS and LOS. Kerr et al. (2006) conducted a small clinical study with men and women who were on average 83.7 years of age and found associations between HGS and LOS independent of sex; as well a higher admission grip strength was found to be associated with increased likelihood of an earlier discharge. However, no cut-off points were determined or tested in this small data set. Additionally, the demographic of the sample does not allow for associations to be assumed for all adult age groups, as this select group was elderly. The small data set and limited generalizability of this study warrants associations to be further explored between HGS and LOS in a larger sample, representative of a Canadian population, and adjusting for other covariates.

This overview indicates that LOS is an important health related outcome, and that a significant gap needs to be addressed. HGS and gait speed need to be evaluated in terms of their association with LOS to determine their usefulness as potential tools to identify frailty, and therefore mediate precursors for increased LOS in acute care.

2.5 Quality of Life

Much like frailty, a consensus on how to objectively define the concept of quality of life (QOL) has not been established (Fayers & Machin, 2013). However, there are facets of the definition that have growing consensus. The first is that QOL is subjective (Boissel & Chiflet 1992; Calman, 1987; Gerin, Dazord, Patrick & Erickson, 1993; Theofilou, 2013). Another agreed upon aspect of QOL is that it is multidimensional (Calman, 1987; O'Boyle, 1992; Schipper, 1990; Theofilou 2013); most instruments that assess this construct include physical, social and emotional wellbeing or functioning as sub-components (Fayers & Machin 2013). One of the earliest multidimensional definitions of QOL was provided by the World Health Organization. This definition stated that health was “a state of complete physical, mental and social well-being, and not merely the absence of disease” (WHO, 1997 page 1). Although quality of life takes on different meanings based on the area or discipline in which it is applied, definitions often emphasize components of happiness and satisfaction with life (Fayers & Machin, 2013; Theofilou, 2013). Health contributes significantly to quality of life, and its’ impact on QOL is referred to as health related quality of life (HRQOL) (Cunningham & Hunt, 2015). HRQOL includes various domains, including physical status, psychological wellbeing, social interaction, economic and religious/spiritual status (Bennett, Torrance & Spilker 1996). Researchers are beginning to consider patient reported health related outcomes as descriptors of QOL, including pain, fatigue, depression and physical symptoms (Fayers & Machin, 2013).

Only recently did the United States Food and Drug Administration begin to formally introduce patient reported outcomes into their surveillance (Food, 2013). The overarching reason for this change in practice is that these outcomes express information described by the patient that has not been filtered by a clinician or observer (Food, 2013). With the increased focus on patient-centered health care, patient reported outcomes such as QOL are becoming paramount (Deshpande, Rajan, Sudeepthi & Abdul Nazir, 2011). According to CIHI (2016), patient reported outcomes are valuable and essential tools to realizing health system goals. Deshpande et al. (2011) explained that in a disease like cancer, for example, determining a patient reported outcome such as QOL is extremely important due to the burden of symptoms, economic loss, challenges with home management and lack of emotional well-being. Knowing what is relevant to patients as they are being treated for a disease or syndrome and how their health care and symptoms influence these outcomes is important and can and should influence treatment decisions.

Agreement on the relevance of patient reported outcomes has further highlighted the importance of using QOL as an outcome measure in health care research (Richards, 1994). However, the issue of which tool to use is debatable. There are multiple measures of QOL, often developed for specific patient subgroups. Examples of disease-specific quality of life measures include: the Lehman QOL interview for mental health patients (Siu et al., 2015), the Parkinson's Disease Questionnaire (PDQ-39) (Kegelmeyer et al., 2015), and the Quality of Life in Autism Questionnaire (QoLA) (Eapen, Crncec, Walter & Tay, 2014). In a general population of older adults the SF-36 general health survey has been used to measure HRQOL (LaMacciha et al., 2014).

The M2E study used the SF-12 general health survey (Ware, J. E., Kosinski, M., Turner-Bowker, D. M., & Gandek, B., 1995) designed specifically for acute care to measure QOL. This questionnaire focuses on both physical and emotional wellbeing and is relatively concise. A recent review suggested, "the SF-12 be used for screening populations for QOL as it received positive ratings for criterion validity, construct validity, reproducibility, and interpretability. Moreover, it is a relatively short questionnaire, which makes it suitable for all patients" (Hamoen, De Rooij, Witjes, Barentsz & Rovers, 2015 p. 25). However, the succinctness of this questionnaire is also one of its limitations. As such, SF-12 does not give insight into all dimensions of QOL and it focuses solely on physical and mental wellbeing.

Numerous researchers have attempted to determine predictors of QOL in a health care/acute care context. Many of the existing predictors of QOL are physical in nature, including motor dysfunction, pain, age, sex, physical impairment/disability, fatigue, and feeding impairment (Beck, Joseph, Belisle & Pilote, 2001; Engel et al., 2003; Paul et al., 2005; Terrell et al., 2004; Yamout et al., 2013). Research has also identified many psychological and social factors impacting QOL, including: patient/physician communication, depressive symptoms, and socioeconomic status, (Beck et al., 2001; Engel et al., 2003; Grady, Jalowiec, & White-Williams, 1999; Paul et al., 2005; Tripp, Nickel, Landis, Wang & Knauss, 2004). A study conducted by Luger et al., (2016) revealed that there was a significant association between nutritional status and QOL in pre-frail community dwelling older adults. Current literature clearly demonstrates that predictors of QOL are numerous and vary based on health status or condition. However, current research has yet to explore frailty measures specifically as potential predictors of QOL during and post-discharge from acute care.

2.6 Summary

Based on this brief review of relevant literature, understanding what is associated with the construct of frailty in acute care context, how it can feasibly be identified in this setting and how frailty is implicated in LOS and QOL needs to be established. LOS is an important health outcome and marker of quality of care. Shorter LOS will improve patient flow, patient recovery and health care costs. Thus, identifying individuals who may have extended LOS using a simple indicator of frailty in addition to usual nutrition screening/assessment may support earlier treatment and thus potentially, earlier discharge. The construct of QOL and how it is measured was discussed, as well as its importance as a patient-reported outcome. Current predictors of QOL for acute care patients are limited and specifically single measures of frailty need to be investigated as potential predictors. This research will aim to strengthen the literature in this field and help to solve some of these existing gaps.

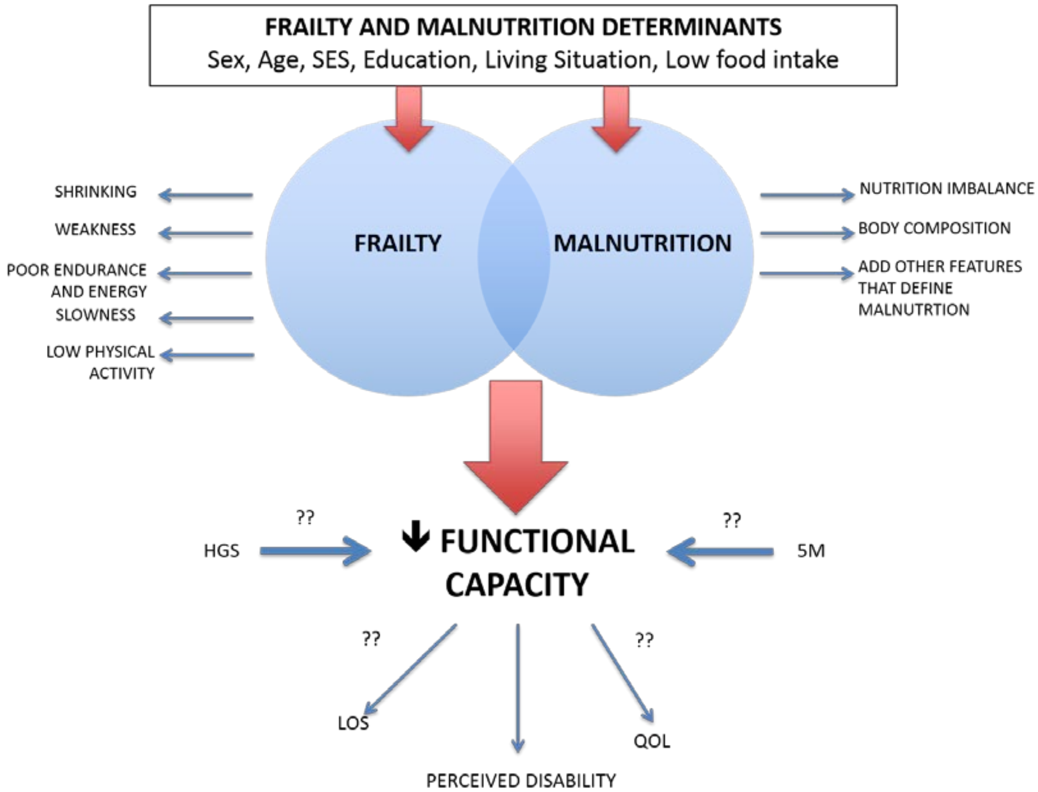

Figure 1: Summary of Background Information.

Frailty and malnutrition have specific defining criteria, but both encompass the notion of reduced functional capacity- hence the need for functional measures to add to a nutrition/frailty assessment toolkit. The proposed single indicators to be added to this toolkit are HGS and 5m. These single indicators should also predict important clinical outcomes, such as LOS and QOL.

Chapter 3: Research Questions and Hypotheses

Current frailty screening tools have not been validated for day-to-day use in acute care (Binder, 2015). Many recommended tools include subjective questions and take too much time to complete in a fast-paced clinical environment (Morley et al., 2013). It is for this reason that grip strength and gait speed have been chosen as tools to be evaluated for their feasibility and utility as single indicators of frailty for use in acute care. A useful indicator should add value to a clinical assessment, such as predicting key outcomes to identify those patients who need more intensive treatment. The predictive validity of frailty measures has been studied extensively in the literature in connection to many different health related outcomes. However, their predictive validity in relation to length of hospital stay and quality of life during and post-discharge from acute care requires further investigation. Once feasibility has been determined, the predictive validity of these measures in relation to length of stay and quality of life should then be studied. The More-2-Eat study provides an ideal opportunity to address these knowledge gaps. These research questions will be addressed in the following three manuscripts:

Feasibility of Frailty Indicators in Acute Care

1. Is there a difference in completion rate between the handgrip strength (HGS) measure and the five meter timed walk (5m) measure used for detecting frailty in an acute care setting?

   H_o: There is no difference in the proportion of M2E acute care patients who complete handgrip strength and 5m walk.
   H_a: There is a difference in the proportion of M2E acute care patients who complete handgrip strength and 5m walk.

2. What are the patient characteristics (e.g. age, sex, perceived disability, nutritional status, LOS, admission category, site) associated with the completion or non-completion of each frailty measure (HGS and 5m)?

3. To further understand the construct of frailty in acute care, what other patient characteristics are associated with HGS and 5m walk (e.g. nutritional status, perceived

functional disability, education, living situation, perception of food intake, perceived nutritional health, barriers to food intake)?

Predictive Validity of Frailty Indicators in Acute Care with Respect to LOS

1. A) What is the predictive validity of handgrip strength (HGS) for the outcome of length of stay (LOS)?

   H_o: HGS does not add significant predictive value to models predicting LOS

   H_a: HGS does add significant predictive value to models predicting LOS

   B) What is the predictive validity of 5-metre timed walk (5m) for the outcome of length of stay (LOS)?

   H_o: 5m does not add significant predictive value to models predicting LOS

   H_a: 5m does add significant predictive value to models predicting LOS

2. What are the best cut-off points for handgrip strength (HGS) using length of stay (LOS) as the outcome?

3. Is the ≥6 or the > 5 second cut-point for the 5m appropriate for use in acute care (e.g. is sensitivity and specificity sufficient as compared to other cut-points)?

Predictive Validity of Frailty Indicators in Acute Care with Respect to QOL

1. A) What is the predictive validity of HGS for the outcome of quality of life (QOL) during and post-discharge from acute care?

   H_o: HGS does not add significant predictive value to models predicting QOL in hospital, or post-discharge**.**

   H_a: HGS does add significant predictive value to models predicting QOL in hospital, or post-discharge

   B) What is the predictive validity of 5m for the outcome of quality of life (QOL) during and post-discharge from acute care?

   H_o: 5m does not add significant predictive value to models predicting QOL in hospital, or post-discharge**.**

   H_a: 5m does add significant predictive value to models predicting QOL in hospital, or post-discharge

Chapter 4: Feasibility of Frailty Indicators in Acute Care

4.1 Introduction

Frailty has recently been defined as “a medical syndrome with multiple causes and contributors that is characterized by diminished strength, endurance, and reduced physiologic function that increases an individual's vulnerability for developing increased dependency and/or death” (Morley et al., 2013 p. 393). This group also concluded that: frailty is an important medical syndrome and all persons >70 years of age should be screened for frailty (Morley et al., 2013). It is currently estimated that over 1 million Canadians are frail (Hoover, Roterman, Sanmartin & Bernier, 2013). Prevalence rates for frailty range from 10-20% of community dwelling older adults (>65 years), with higher rates among women than men (Collard, Boter, Schoevers & Oude Voshaar, 2012; Song, Mitnitski & Rockwood, 2010). Although frailty is not unique to older adults, frailty rates increase substantially with age (Fried et al., 2001; Song et al., 2010; Collard et al., 2012). Statistics Canada predicts that by the year 2036, nearly 1 in 4 Canadians will be over the age of 65 (Statistics Canada, 2015). With a large proportion of the Canadian population at risk of being frail, screening and measuring frailty in a reliable manner is essential. Furthermore, if frailty is to be screened in all patients over the age of 70 years, then acute care is an important setting in which screening can and should occur with feasible indicators.

Much like the conceptualization of frailty, methods for assessing and screening for frailty have only recently been discussed by experts (Morley et al., 2013). Physicians have recommended a variety of screening tools, however, most rely on lengthy, subjective interview questions (Morley et al., 2013). Additionally, no current frailty-screening tools have sufficient evidence of validity for acute care settings (Binder, 2015). That being said, the Cardiovascular

Health Study Frailty Screening Measure includes a battery of objective measures, which may be a starting point for feasible use in acute care. One of the measures included is hand grip strength (HGS), which is measured clinically using a dynamometer to provide an overall measure of muscle strength (Bohannon n.d, Roberts et al., 2011). It has been suggested that HGS is the most useful single indicator of frailty (Syddall et al., 2003). HGS values have been used in the past to determine or predict a number of different health outcomes, including: mobility, cognition, mortality, functional status and hospitalization (Rijk et al., 2016). HGS has also been found to be an indicator of weight loss (Norman et al., 2011; Flood et al., 2015), another component of the phenotype definition of frailty (Fried et al., 2001, Jeejeebhoy, 2012).

Another tool included in the Cardiovascular Health Study Frailty Screening Measure is gait speed. Fried's phenotype model suggests that gait speed is an indicator of frailty, and research has confirmed this, reporting that slow gait speed (i.e., > 6 seconds during a timed 5m walk test) has successfully characterized older adults who have experienced adverse outcomes, such as frailty (Afilalo et al., 2010; Clegg et al., 2013; Wilson et al., 2013). Gait speed has also been shown to be associated with or predict a variety of health related outcomes, including: physical performance and incidence of falls (Scott et al., 2014), ambulation (Elbers et al., 2013), survival among cardiovascular patients (Chiaranda et al., 2013), and dyspnea and health related quality of life (HRQOL) among COPD patients (Kon et al., 2013). Additionally, gait speed has been determined to be a simple and effective measure in identifying those at higher risk of mortality and major morbidity in hospital (Afilalo et al., 2010). With these findings in mind, it should be noted that the feasibility of the 5m walk (5m) in acute care has not been adequately addressed in the literature. If frailty is considered to be an important predictor of acute care outcomes, feasible single measures for use in acute care are needed. Understanding which patients can and cannot complete these measures is not known, and needs to be addressed in order to understand the feasibility of these tools. Furthermore, if HGS and 5m are feasible indicators for acute care patients, further conceptualizing the construct of frailty as measured by these indicators and its covariates is worthwhile to determine potential treatment options such as nutritional care.

This study will determine the feasibility of two potential frailty indicators for use in an acute care patient population and how they are associated with relevant patient characteristics to further understand the frailty construct in this population. Data collected on HGS and 5m in a large acute care nutrition study provided the opportunity to answer the following research questions: (1) Is there a difference in completion rate between HGS and 5m in medical patients; (2) what patients (e.g., younger, male etc.) are more likely to be able to complete each indicator (HGS and 5m), and (3): what patient characteristics are significantly associated with these indicators (e.g. nutritional status and perceived functional disability, education, etc.)?

4.2 Methods

4.2.1 Sample and Participants

More-2-Eat was a multi-site participatory action research study with a before-after time series design. The primary objective of the study was to implement and evaluate the Integrated Nutrition Pathway for Acute Care (INPAC) in Canadian hospitals. Each site was led by an interdisciplinary team, which offered coaching and improvement strategies towards implementing nutrition care best practices. The study population were all patients on the chosen medical unit for implementation of INPAC at the: Royal Alexandra Hospital (Edmonton, AB), Regina General Hospital (Regina, SK), Concordia Hospital (Winnipeg, MB), Niagara Health

System, General Site (Niagara Falls, ON), and Ottawa Hospital (Ottawa, ON). There are two key aspects of data collection at the patient level; an audit of nutrition care practices for all patients on the unit during monthly audit days and a detailed assessment of nutrition, frailty, disability, quality of life and food intake on a subset of patients recruited each month. This latter data collection was used for this study. There were 1250 detailed patient data collections over a 15-month period for analysis. The proportion of males and females in the detailed patient data collection was not significantly different from the proportion in the INPAC audit data collection (45% male, 55% female vs. 48% male, 52% female respectively) ($z=1.90$, $p=0.054$). However, the mean age in the detailed patient data collection was lower than the INPAC audit data collection (68.5 years vs. 73.4 years ($t=9.96$, $p<0.0001$; 95% CI (3.99,5.88)); 66.9 years for males and 69.8 years for females vs. 72.0 years for males and 74.8 years for females respectively), indicating that the sample used for this analysis is slightly younger than the general medical unit population, potentially due to the eligibility criteria described below.

The eligibility criteria were driven by the primary objectives of the More-2-Eat study and for the detailed patient collection were as follows: 1) no cognitive impairment as per admission assessment by nursing; 2) spoke English (or French at Ottawa site); 3) consumed an oral diet, however supplemental enteral or parenteral nutrition were allowed; 4) likely to return home to the community; and 5) provided written consent to participate. The sampling design was single stage and participants were chosen through a quasi-random sampling process. Research assistants were instructed to identify which patients were eligible to participate in the study, and then starting at one end of the unit (first room, first bed), recruit patients until they had met their quota for the month. In the developmental phase (4 weeks), 40 patients per month (~10/week) was the quota, whereas in the implementation phase the quota was 20 patients per month for 12 months. For the following week/month of collection, research assistants were instructed to start at the bed number in which they last stopped in the prior week/month. They were also reminded on the importance of recruiting less well individuals and frail older adults as they are often neglected in research, and will likely encompass more of the patient reported outcome measures included in the study.

4.2.2 Data Collection and Measures

To address the research questions, only data from the detailed patient data collection was used. This includes demographics, primary admission diagnosis, length of stay, nutritional risk (and diagnosis of malnutrition if relevant), an estimate of a single meal's food intake, barriers to food intake, self-reported quality of life, self-reported disability, frailty indicators, patient reported perceptions on adequacy of food intake and nutritional health, and nutrition care provided in the hospital at the time of the data collection. All data were typically collected over one to three days for each patient. Items used in this analysis included: handgrip strength (HGS), five meter timed walk (5m), subjective global assessment (SGA), perceived functional status (Nagi scale), demographics, and reasons for non-completion of assessments. HGS was repeated for some patients on the day of discharge if this was feasible (i.e. notice was provided and the assessors were available to collect the measure) and if it was at least 48 hours since the first measure; this was done to capture current frailty status prior to discharge that may have changed due to hospitalization and/or treatments. HGS at admission will only be used in this analysis.

Clinical dietitians were seconded from their regular duties at the hospital to complete all data collection as researchers. Training was in-person and a detailed manual was provided to support consistency in procedures. Monthly phone call meetings also supported consistency in data collection and a virtual group via the Internet helped to address questions among these research staff. These researchers approached a patient for informed consent, shortly after they were admitted and determined to be eligible. On units where they were considered part of the ‘circle of care’ they were allowed to directly recruit patients; where the dietitian was solely seconded for the research and not practicing on the unit, nursing staff determined eligibility and did the initial approach as per the ethics protocol to determine if the patient was interested in participating in the study. Final recruitment and written consent with eligible patients were completed by these research dietitians.

To measure HGS, the research dietitian was trained on the Southampton protocol for HGS using a Jamar hydraulic hand dynamometer J000105 (Roberts et al., 2011). This protocol involves patients being seated in a chair with back support and arms (Roberts et al., 2011). However, if patients were not able to transfer from their bed to a chair, the measurement was to be taken in bed (Keller, 2015). The research dietitian demonstrated how to use the hand dynamometer and explained that tightly gripping the handle gave the highest score This measure was performed in the patient’s dominant hand for three trials; however, where an intravenous line was present in that arm, patients could use the opposite arm instead. All values were recorded (in kg), including the hand in which the test was performed.

The 5m-walk assessment was performed in an unobstructed, well-lit, predetermined area of the hospital, where patients were asked to walk at a comfortable pace between a previously determined 0 and 5-meter marker on the floor (Afilalo et al., 2010). Once the researcher said ‘go’, the timer was started with the first footfall over the 0-meter line, and the timer was stopped with the first footfall over the 5-meter line. If the patient was able, the assessment was repeated three times, with a rest period provided between trials to allow the patient to recuperate. The time was recorded in seconds on the data collection form; at one site, this measure was completed by the physiotherapy team on the unit. For both HGS and 5m, if patients were unable to complete the assessment, the reason for non-completion (non-ambulatory/cannot transfer, too weak, other) was also recorded (Keller, 2015).

Nutritional status was assessed after a patient had been screened 'at risk' based on the Canadian Nutrition Screening Tool (CNST) (Laporte et al., 2015); thus a portion of the patients who completed this data collection were deemed well-nourished and the subsequent diagnosis of malnutrition with SGA was not completed. Nutritional status was determined based on the completion of the SGA. The SGA is a tool used to diagnose malnutrition and is a valid assessment for acute care (Detsky et al., 1987, Fontes et al. 2014, Sheean et al. 2013). The SGA assesses dietary intake, weight, gastrointestinal symptoms and other risk factors for poor intake, functional capacity and metabolic requirements, presence of edema, fat and muscle masses. Patients were then classified as either well nourished (A), mildly/moderately malnourished (B), or severely malnourished (C) (Detsky et al., 1987). Additionally, all patients who were deemed severely malnourished (C) were referred to a unit registered-dietitian (RD) for further assessment and treatment (Keller, 2015). Patients were also asked their perception of the adequacy of their food intake and the quality of nutritional health. This first question involved asking "in general, do you think you are currently eating __________ to meet your body's needs?" and respondents could choose "more than enough, enough, not enough". The perceived adequacy of nutritional health question asked, "in general, would you say your nutritional health is currently…" and respondents could choose between "excellent, very good, good, fair or poor".

Perceived functional status was assessed using the 7-item Nagi scale, which suggests that significant disability is present with any self-reported difficulty in performing ≥3 of the 7 items (Nagi, 1976). The Nagi scale asks respondents to choose their level of difficulty in performing various daily activities (pulling or pushing a large object, bending over, crouching, kneeling, raising arms over head, etc.). Respondents can then choose between “no difficulty, some difficulty, and great deal of difficulty/cannot do”, the latter two indicating perceived disability in completing that particular task. Questions on ability to carry out daily functions using this standardized scale were posed by the research associates. The SF-12 questionnaire was used to assess quality of life, and asks questions pertaining to physical health, emotional health, pain, and social experiences (Ware et al., 1995). Food intake was used in these analyses, and was collected via the My Meal Intake Tool (MMIT) (McCullough & Keller, 2016). The MMIT assesses food intake at a single meal (McCullough & Keller, 2016). The tool can be completed by the patient, a family member or staff member, and indicates whether a person completed 0%, 25%, 50%, 75%, or 100% of their food/beverages (McCullough & Keller, 2016). The total number of barriers to food intake as reported on the Mealtime Audit Tool (MAT) (McCullough, J., Marcus, H., & Keller, H., 2017) was also used for these analyses. The MAT is also self-reported, and asks patients about the mealtime experience (e.g. Did the meal come at an appropriate time? Did you get the food that you ordered? Were your meals appetizing?) (McCullough, J., Marcus, H., & Keller, H., 2017). The patient then responds yes/no and all “no” responses are added to indicate a summary score of barriers experienced (McCullough, J., Marcus, H., & Keller, H., 2017).

Relevant demographics used in this analysis were either collected from the health record or asked of the patient and included: sex, age, primary admission diagnosis, highest level of education, and living situation. Length of stay was collected from the admission database for the unit. Admission diagnosis was categorized as cardiovascular, gastrointestinal, respiratory, musculoskeletal, neurological, infection, and other. Education was categorized as some primary to graduated secondary school; some post-secondary to post grad; and other/don't know. Living situation was categorized as: alone; with spouse; with spouse and other family; with other family or friends; and other.

University of Waterloo (ORE #20590) and site ethics boards: Niagara Health Ethics Board (2015-07-001), Ottawa Health Science Network Research Ethics Board (20150345-01H), Health Research Ethics Board of the University of Alberta (Pro00056577), Regina Qu'Appelle Health Region Research Ethics Board (REB-15-68), University of Manitoba Health Research Ethics Board (H2015: 208) and Concordia Hospital Research and Ethics Committee (H2015: 208), approved and provided clearance for this research study. Data collection directly from patients or staff required informed written consent, which was attained prior to data collection.

4.2.3 Data Analysis

A secondary data analysis was performed. Data was analyzed using SAS Studio 9.4 for Windows. The sample characteristics were descriptively presented as proportions and means/medians with standard deviations. Perceived functional status was collapsed into a binary score with two categories: no disability and disability (≥3 on the Nagi scale). Nutritional status was also collapsed into two categories: well-nourished (no risk/SGA A) and malnourished (SGA B/C). Proportions completing 5m or HGS were determined. A Z-test was conducted to determine significant differences in the proportion of completion rates between HGS and 5m walk measures. In order to determine whether categorical variables such as sex, perceived functional status, nutritional status, admission category, and site number were associated with completion rates, chi-square tests were performed.

Nonparametric tests were used with 5m walk as it was not normally distributed, whereas HGS was normally distributed. To determine whether continuous variables such as age and LOS were associated with the completion of 5m, a non-parametric equivalent of a t-test was used (Mann-Whitney U test), whereas a t-test was used to analyze those variables with HGS.
The 5m walk assessment uses a cut point of ≥6 seconds to indicate a dichotomous frail/not-frail outcome (Afilalo et al., 2010); this dichotomization was used to determine associations with categorical patient characteristics (e.g. sex, nutritional status). T-tests were performed to determine the association between continuous HGS values and dichotomous nutritional status and perceived disability categories. An ANOVA was used to compare education/living situation/perception of eating enough/perceived current nutritional health to continuous HGS values. Non-parametric equivalent tests (Kruskal Wallis) were used for continuous 5m values with these categorical variables. 95% confidence intervals and a p-value of 0.05 were used to determine statistical significance throughout.

4.3 Results

The M2E sample included 1250 patients with detailed data collection from 5 sites for this analysis. The sample included 45% males, and 55% females. The mean age was 68.5 years (SD=15.28). Table 1 provides further characteristics of participants. The mean LOS was 12.7 days (SD=13.20), and 30% of patients had longer than the mean LOS for this sample. Based on a mean LOS of 7 days indicated in current literature (CIHI, 2014), 54% of this sample had a stay longer than this published mean. However, the CIHI mean LOS was age adjusted, and was not exclusive to medical patients. In this sample, 31% (389/1248) of patients were screened at risk, based on the CNST, or were required to have an SGA assessment completed for other reasons.

Of those at risk, 38% were categorized as SGA A, 48% SGA B, and 14% SGA C. The mean Nagi score was 4/7, and 79% had a score of ≥3 indicating that a perceived disability was present.

Of the 92% who were able to complete the HGS assessment (n=1146), the mean score was 20.8 kg (SD=12.35). Of those who completed the first HGS measure, 99% of patients completed the second trial and 94% completed the third trial. Of those who completed the HGS, 83% (n=955/1146) patients were reported to use their right hand, whereas 15% (n=174/1146) patients were reported to use their left (2% had missing data). Reasons for non-completion of the HGS assessment included being too weak, not able to comply, or other (e.g. patient discharged before assessment completed). In contrast, only 43% (n=535/1250) of patients were able to complete the 5m. Of those completers, 97% were able to complete the second trial, and 80% were able to complete the third trial. Those who were unable to complete the 5m reported reasons including difficulty with ambulation, dizziness, weakness, etc. The difference in proportion of completion for these potential frailty indicators was statistically significant (z=17.39, p=<0.00001). Of those who completed the 5m, the mean completion time was 8.98 sec (med=6.79 sec, SD=6.59). Finally, 62% of those who could complete the 5m were considered frail, as their completion time was ≥6 seconds (Table 1).

Comparisons between completers and non-completers for HGS and 5m by patient characteristics are provided in Table 2. Age was associated with the completion of only the HGS; those who were unable to complete this measure were older than those able to complete (t=2.33, p=0.020). Sex was significantly associated with completion rates of both the 5m (X^2=20.69, p<0.0001) and HGS (X^2=6.91, p=0.009) assessments, with a higher proportion of men completing both indicators. However, the proportion of female completers was closer to males in the HGS. There was a statistically significantly longer LOS for patients who could not complete the 5m (completers=10.01 days (SD=9.70); non-completers =14.78 days (SD=15.03, $p<0.0001$)), but no difference was seen in LOS by HGS completion ($p=0.39$). Perceived disability was also associated with the completion of 5 m walk ($X^2=80.05$, $p<0.0001$), with two-thirds reporting a disability being unable to do this measure. HGS completion was also associated with perceived disability ($X^2=4.85$, $p=0.028$); however, only ~10% of those reporting a disability were unable to complete the assessment. Nutritional status (no risk/SGA A vs. SGA B/C) had a minimally stronger association with the completion of HGS ($X^2=3.88$, $p=0.049$) than 5m ($X^2=3.72$, $p=0.054$). The difference in proportion of completers and non-completers for both HGS and 5m were significantly different across sites and across admission diagnosis categories ($p<0.0001$). Site 2 had the highest proportion of non-completion for the 5m (73.59%), whereas site 4 had the highest proportion of non-completion for HGS (18.51%). Musculoskeletal admission diagnoses had the highest proportion of non-completion for both 5m (75.42%) and HGS (15.25%).

Table 3 provides mean/median values for HGS and 5m for key sample characteristics. There was a significant difference in HGS ($t=22.51$, $p<0.0001$; 95% CI (12.53, 14.93)) and 5m scores ($z=6.04$, $p<0.0001$; 95% CI (1.16, 2.78)) across sexes. There was not a significant difference in 5m scores and SGA categories ($z=2.49$, $p=0.051$; 95% CI (-1.17, 2.34)), but there was a significant difference between HGS scores and SGA categories ($t=4.13$, $p<0.001$; 95% CI (2.02, 5.67)) (A/no risk vs. B/C), with malnourished patients having longer timed walk and lower (weaker) HGS. 5m and HGS scores were significantly worse when a perceived disability was present ($z=-9.56$, $t=10.69$, respectively; $p<0.0001$; 95 % CI (7.33, 10.63), (1.76, 3.18)). This association was also found when 5m walk time was dichotomized to determine frailty ($\geq$6 sec); 74.51% of those who were considered frail based on their 5m walk score reported a disability (266/535; $X^2=66.76$, $p<0.0001$).

Patients with higher levels of education had a shorter timed walk (H=23.94, p<0.0001) and higher HGS values (F=9.56, p<0.0001). Those who lived alone or with other family members had significantly poorer HGS scores (p<0.0001) and 5m walk times (p=0.0002), as compared to those who lived with a spouse. Patients whose food intake was ≤50% had lower HGS scores (t=-3.72, p=0.0002; 95% CI (-4.33, -1.34)) and slower 5m walk times (z=2.83, p=0.0023; 95% CI (-2.01, -0.05)). Patients who believed they were not eating enough to meet their body's needs had lower HGS scores (F=4.29. p=0.014); however, they did not have significantly longer 5m walk times (p=0.31). Patients who believed they had better current nutritional health had minimally higher (stronger) HGS values and longer walk times than those who believed their current nutritional health was poorer, however, these differences were not statistically significant (p=0.051; p=0.84). Finally, patients who experienced more barriers to food intake had lower (weaker) HGS values. This difference was statistically significant (F=4.64, p=0.010). No statistically significant differences were seen for 5m walk scores and those who experienced more mealtime barriers (H= 2.96, p=0.23); however, trends suggest the same association, as those who were slower tended to have more mealtime barriers.

4.4 Discussion

Screening is meant to be a quick and easy measurement to determine the likelihood of a condition (Kondrup et al., 2003). To be of greatest utility for case finding, a screening tool should be completed on the entire target population, and in this case, acute care medical patients. This study has identified that the 5m walk is likely not a suitable measure for screening of frailty in acute care, as less than half of patients could complete this measurement, as many patients felt they were too fatigued, weak, dizzy, etc. to get out of bed. In addition, the difference in sex among completers and non-completers of the 5m was significant. This reinforces the unsuitability of 5m as a potential screening tool, as the acute care setting requires a screening tool that can be used by all (Kondrup et al., 2003). Lack of ability to complete 5m (Table 2) was associated with patient reported disability and diagnosis. The former, points to the potential for 5m to capture longstanding frailty, while the latter may suggest that the acute medical status is what is being signaled by the inability to do this measure. Prior research has shown that the 5m is in fact reliable and feasible in a community-dwelling sample of older adults (Tiedemann, et al. 2008), indicating that there is potentially a need to consider different indicators for screening frailty in different settings. A significantly longer LOS, and a high proportion of perceived disability was seen in those who could not complete the 5m, indicating that perhaps completion status of the 5m in and of itself, rather than slow gait speed could be a helpful indicator of frailty or other patient reported outcomes.

Almost the entire sample was able to complete the HGS measure, demonstrating that it is a more feasible tool than 5m to use in acute care medical patients. Although age was a factor in the completion of HGS, the mean age of the group of completers was 68.2 years, indicating that the tool is still feasible for use among older adults (>65 years). In terms of feasibility by sex, HGS also had significantly higher completion rates among males. That being said, the proportion of female completers was much closer to the proportion of male completers for HGS than the 5m. Nutritional status as measured by SGA was barely significantly associated with HGS, and not with 5m completion (Table 2). This is an important finding since, if clinicians are inclined to add a frailty indicator to their nutrition assessment to provide more information about the patient, it will be important that indicators be completed regardless of nutritional status. Furthermore, those with musculoskeletal primary admission diagnoses had the highest rates of non-completion for both HGS and 5m, as assessments that are physical in nature would likely be difficult to complete for these patients.

There was considerable overlap between nutritional status and frailty (as measured by 5 m), with 71% of those being malnourished, also being frail. The significant difference in HGS scores across nutritional status categories demonstrates construct validity for this particular frailty indicator, as frailty and malnutrition are theoretically related (Clegg et al., 2013; Chung et al., 2014; Jeejeebhoy, 2012; Savva et al., 2012; Studenski et al., 2003). The contention that 5m and HGS could be potential frailty indicators is also reinforced with significant differences in both HGS and 5m scores for those who did and did not perceive any disability, as disability is considered an outcome of frailty (Morley, 2017). In addition, patients who had lower HGS scores typically had lower perceived and actual food intake, and experienced more barriers to food intake. These associations suggest that HGS may be more closely aligned with malnutrition than 5m, and thus it is not surprising that some have considered HGS as a potential indicator for malnutrition (Norman et al., 2011) or even part of a comprehensive nutritional assessment (White et al., 2012). These associations between HGS and food intake and barriers to intake reinforce the potential utility of the use of HGS in acute care, as it may point to an individual who needs further interventions to support intake while in hospital. Both HGS and 5m were associated with lower levels of education and living situation, further confirming their potential as frailty indicators as education or socioeconomic status are associated with frailty (Hoogendijk et al., 2014; Laing et al., 2009).

4.5 Limitations

A limitation of this study is the eligibility criteria for recruitment of patients, as the resulting sample was not representative of all medical patients on this unit when compared to other data collected in the M2E study. The sample used in these analyses tended to be slightly younger patients than patients on this medical unit, who may have been different on their health and frailty characteristics as well. To mitigate this potential, research dietitians were informed of the importance of recruiting less well and frail older adults, as they are often underrepresented in research. Furthermore, there was likely some variability in terms of recruitment of patients due to the busyness of the project and capacity of hospital staff to do the initial recruitment of patients; this may have led to noted site differences in addition to type of medical patients eligible for recruitment.

Other limitations include the potential for inter-rater differences when assessing HGS and 5m. For example, some researchers may have been more diligent or motivating when encouraging patients to perform the assessments, resulting in superior scores or completion rates. However, researchers were trained on the appropriate protocol, and given detailed manuals and online support; there were site differences in completion rate and it is unknown if differences are due to patient type/unit issues or assessors. Another limitation to consider includes the fact that only the Southampton protocol for HGS was used, and many protocols for assessing HGS exist. However, training and protocol were standardized and the same dynamometer was used in all sites. Similarly, other measures used in this study could have been influenced by rater differences, resulting in inter-rater error.

This study is only beginning to unpack how the identification of frailty in hospitals will change the care and treatment process. The identification of frailty in this setting ultimately affects health care utilization (e.g. LOS), outcomes (e.g. mortality), discharge decisions, and need for community services, and these should be addressed in future research. However, strengths of this study include the large sample size, and the diversity of the sample due to the use of multiple sites. These strengths are important to consider, as the magnitude and rigor of this study are unparalleled in current literature and prior knowledge gaps on feasibility of measures could be addressed.

4.6 Conclusion

This analysis demonstrates that HGS is a more feasible indicator of frailty than the 5m in acute care medical patients, which included a large proportion of older adults. HGS had high completion rates across all sites, and was found to be feasible among older men and women (>65 years). The 5m completion status in and of itself may be helpful to indicate frailty or other outcomes rather than the time taken to complete the test, as non-completion was associated with longer LOS and perceived disability. It is of particular interest that the completion of both measures was not significantly associated with SGA, suggesting that they can be completed regardless of nutritional status. This is important if clinicians wish to add a frailty indicator to the SGA to provide a representation of frailty in a patient. Further, the association between HGS and other indicators of nutrition such as lower perceived food intake and more barriers to food intake, suggests its potential utility in clinical nutrition assessment to identify patients who are more likely to have more challenges with food consumption. Results from this rigorous secondary data analysis can be used to enhance the knowledge of researchers, health care providers and stakeholders regarding the identification of frailty in acute care. Given the growing population of older adults, their susceptibility to frailty and malnutrition, and their health care utilization, it is critical that this research be continued to address their developing needs.

Table 1 - Characteristics of Patients in Acute Care

Variable	Mean	Median	SD
Age (n=1250)	68.48 years	70.00 years	15.28
HGS (n=1146)	20.82 kg	19.33 kg	12.35
5M (n=535)	8.98 seconds	6.79 sec	6.59
Nagi (n=1250)	4/7	4/7	1.90
LOS (n=1233)[1]	12.71 days	8.00 days	13.20
	% (n)		
Male	45 (560/1250)		
Female	55 (690/1250)		
LOS </= 7 days[2]	46 (565/1233)		
LOS >7 days	54 (668/1233)		
LOS </= 13 days	70 (864/1233)		
LOS > 13 days	30 (369/1233)		
Well nourished (SGA A/No risk)	81 (777/962)		
Malnourished (SGA B/C)	19 (185/962)		
Self-reported Disability (Nagi scale ≥ 3/7)	79 (983/1250)		
Frail (5M > 6 sec)	62 (334/535)		

[1] (15 missing entries, 3 outliers removed)

Abbreviations: HGS= Handgrip strength; 5M= Five meter timed walk; LOS=Length of Stay; SGA= Subjective Global Assessment

Table 2- Characteristics of Completers and Non-Completers of HGS and 5M Assessments

	HGS			5M		
	Completers (n=1146/1250)	Non-Completers (n=104/1250)	P value/ 95% CI	Completers (n=535/1250)	Non-Completers (n=715/1250)	P value/ 95% CI
Mean Age (yrs) (n=1250)	68.19 (SD=15.32)	71.86 (SD=14.44)	0.020 (0.58, 6.76)	68.00 (SD=15.17)	68.86 (SD=15.31)	0.12 (-4.31, 0.31)
Sex (%)			0.009			<0.0001
Male (n=560)	94.10	5.90		49.91	52.09	
Female (n=690)	90.00	10.00		37.10	62.90	
Mean LOS (days) (n=1233)[1]	12.81 (SD=13.25)	11.64 (SD=12.73)	0.39 (-3.90, 1.52)	10.01 (SD=9.70) Med=7.0	14.78 (SD=15.03) Med=9.0	<0.0001 (-2.94, -1.06)
Perceived disability (%)			0.028			<0.0001
Yes (n=983)	90.95	9.05		36.32	63.68	
No (n=267)	95.11	4.89		66.92	33.08	
Nutritional status (%)			0.049			0.054
Malnourished[2] (n=241)	88.8	11.20		44.19	62.66	
Not at risk/Well-nourished[3] (n=1007)	92.65	7.35		37.34	55.81	
Primary Diagnosis Admission Category (%)			<0.0001			<0.0001
Cardiovascular (n=156)	92.31	7.69		57.69	42.31	
Gastrointestinal (n=116)	84.48	15.52		42.24	57.76	
Respiratory (n=360)	96.67	3.33		46.39	53.61	
Musculoskeletal (n=119)	84.75	15.25		24.58	75.42	
Neurological (n=115)	93.04	6.96		50.43	49.57	
Infection (n=146)	91.78	8.22		36.30	63.70	
Other (n=238)	90.76	9.24		37.90	62.61	
Site number (%)			<0.0001			<0.0001
1 (n=262)	99.62	0.38		52.67	47..33	
2 (n=232)	88.74	11.26		26.41	73.59	
3 (n=282)	93.97	6.03		59.22	40.78	
4 (n=281)	81.49	18.51		36.30	63.70	
5 (n=193)	96.89	3.11		34.72	65.28	

[1] 15 missing entries, 3 outliers removed [2]; Malnourished group includes: SGA Bs and Cs; [3]Well-nourished group includes: No risk and SGA A; Abbreviations: HGS= Handgrip strength; 5M= Five meter timed walk; LOS=Length of Stay

Table 3- Patient Characteristics Associated with HGS and 5M

	HGS (n=1146)			5M (n=535)		
	Mean (SD)	Median	P value/ 95% CI	Mean (SD)	Median	P value 95% CI
Sex			<0.0001 (12.53, 14.93)			<0.0001 (1.16, 2.78)
Male	28.26 (12.76)	28.00		7.80 (5.70)	6.09	
Female	14.54 (8.16)	14.67		10.27 (7.24)	8.09	
SGA			<0.0001 (2.02, 5.67)			0.051 (-1.17, 2.34)
Well-nourished[1]	21.54 (12.43)	20.00		8.73 (6.37)	6.66	
Mal-nourished[2]	17.69 (11.96)	15.67		10.20 (7.51)	7.39	
Perceived disability			<0.0001 (7.33, 10.63)			<0.0001 (1.76, 3.18)
No	27.83 (14.00)	28.00		6.13 (2.46)	5.49	
Yes	18.85 (11.08)	18.00		10.40 (7.49)	7.97	
Education			<0.0001			<0.0001
Some primary-graduated H.S	19.45 (11.52)	18.00		9.70 (6.79)	7.73	
Some post-secondary-post grad	22.79 (13.60)	20.67		7.71 (5.37)	6.13	
Other/don't know	21.57 (10.73)	22.00		10.20 (9.28)	6.47	
Living Situation			<0.0001			0.008
Alone	18.83 (11.68)	18.00		9.81 (SD=6.99)	7.91	
W/ spouse	22.80 (12.57)	21.33		8.25 (SD=6.50)	6.30	
W/ spouse and other family	25.90 (13.12)	23.00		7.26 (SD=4.32)	5.95	
W/ other family or friends	18.86 (11.27)	18.33		10.27 (SD=6.95)	7.81	
Other	16.12 (14.67)	13.17		7.15 (2.76)	6.33	
Food Intake			0.0002 (-4.33, -1.34)			0.0023 (-2.01, -0.05)
</= 50%	18.92 (11.15)	18.00		9.90 (7.18)	7.66	
> 50%	21.82 (12.86)	20.58		8.52 (6.25)	6.52	
Perception of food intake			0.014			0.31 (-0.23, 0.52)
> Enough	23.12 (14.78)	20.17		7.85 (4.00)	6.23	
Enough	20.77 (11.92)	19.33		9.30 (7.33)	6.79	
< Enough	19.63 (11.65)	18.67		8.92 (5.86)	6.88	

Perceived current nutritional health			0.051			0.84
Excellent	23.12 (12.02)	21.00		8.24 (5.12)	6.51	
Very good	20.77 (13.13)	18.67		8.59 (5.96)	6.66	
Good	21.63 (12.54)	20.67		8.87 (6.68)	6.76	
Fair	19.47 (12.41)	18.00		9.95 (7.98)	6.92	
Poor	19.56 (10.51)	18.00		8.99 (5.09)	7.20	
Total # MAT barriers			0.010			0.23
0-2	21.62 (12.07)	20.00		8.68	6.64	
3-5	19.53 (12.67)	18.33		9.07	6.66	
≥6	18.42 (13.24)	13.24		9.40	8.43	

[1]Well-nourished group includes: No risk and SGA A; [2]Malnourished group includes: SGA Bs and Cs; Abbreviations: HGS= Handgrip strength; 5M= Five meter timed walk; SGA=Subjective Global Assessment; MAT=Mealtime Audit Tool

Chapter 5: Predictive Validity of Frailty Indicators in Acute Care with Respect to LOS

5.1 Introduction

In the 2012-2013 fiscal year, acute inpatient hospitalizations in Canada cost 24.4 billion dollars (CIHI, 2014). According to the Canadian Institute of Health Information (CIHI), in 2013-2014 there were more than 2.9 million acute care hospitalizations in Canada, and after adjusting for age, the average length of hospital stay (ALOS) was 7.0 days (CIHI). Currently, 10% of the acute care population is experiencing length of stays (LOS) longer than 30 days (CIHI, 2015). The high cost of acute care hospitalizations and efforts to reduce LOS indicates that LOS is an important acute care outcome. Identification of factors that predict LOS is relevant to understanding how improvements can be made in care processes to support an earlier discharge. Frailty is likely one of these factors. A variety of measures consistent with the frailty concept (e.g. weight loss, hand grip strength, gait speed, food intake, nutrition support in hospital) have been found to be associated with LOS (Allard et al., 2015; Shinkai et al., 2000, 2003; Sarkisian et al., 2001; Corbett, Dalton, Young, Silman & Shipley, 1993; Pichard et al., 2004). Yet, research on frailty per se as a predictor of LOS has been limited by use of complex measures that include subjective components, which are not easily used in clinical settings by non-experts (Morley et al., 2013). The Cardiovascular Health Study Frailty Screening Measure contains a battery of objective measures (including grip strength and gait speed), which may be a starting point in terms of determining feasible, single or joint indicators of frailty that can predict length of stay.

Presently, few studies have explored the predictive validity between a single indicator of frailty and length of stay. Peel et al. (2014) investigated the predictive validity of gait speed for length of stay in post-acute transitional care for older adults white adjusting for age and sex. They determined that gait speed at admission was significantly and negatively correlated with length of stay. However, this was a relatively small sample (n=351) from a single site, and was conducted in transitional care, rather than acute care. Additionally, this study did not use age or sex-specific cut-off points for 5m walk (5m) using LOS as the outcome and did not use the recommended cut-point of ≥6 seconds to indicate the presence of frailty (Afilalo et al., 2010). This cut-point needs to be tested to determine sensitivity (SE) and specificity (SP) for acute care using LOS as an outcome.

Similarly, Kerr et al. (2006) conducted a small (n=120) clinical study with the aim of investigating associations between handgrip strength (HGS) and LOS, and found that a higher admission HGS was associated with increased likelihood of discharge (Kerr et al., 2006). However, no cut-off points were determined, limiting the practicality of using this measure in a clinical setting to identify those at risk for a longer LOS. Additionally, the small data set, lack of consideration of other covariates and limited generalizability of this study warrants further research on handgrip strength and length of hospital stay in a larger sample. Although research has been conducted on components of frailty and length of stay in a variety of specific patient populations, it is important to consider the potential association in a diverse medical population, while adjusting for covariates such as age.

A key consideration in using a frailty indicator is the identification of cut-points that not only predict key outcomes, but also do not lead to such a high prevalence that they are not feasible (i.e. overly sensitive). Cut points for HGS have been established in the literature for related outcomes, including mortality, mobility and functional status (Rijk et al. 2016), but none have been created specifically for a general acute care population. Specifically, Sallinen et al. (2010) created cut points for HGS to screen community-living older adults (>55 years) for risk of mobility limitations (37kg for men, 21kg for women) in Finland. Alley et al. (2014) also developed cut points for HGS to predict clinically relevant weakness (measured by gait speed). These were derived from a large sample of 20,847 from a variety of health studies and clinical trials (Alley et al. 2014). The results showed that the best cut points to predict clinically relevant weakness were 26kg and 16kg for men and women respectively (Alley et al. 2014). Giulani et al. (2008) created a cut point from a sample of 1791 participants in assisted living. This study defined a cut point of 14kg as a HGS value to predict functional impairment. These cut-points derived in a variety of samples and associated with frailty concepts are potential starting points for identifying values useful in the acute care population as a measure of frailty.

This research aims to bridge this gap in the literature by addressing the following research questions: (1) What is the predictive validity of a) handgrip strength (HGS) and b) 5m walk (5m) for the outcome length of stay (LOS) when adjusting for other relevant covariates? (2) What are the best published cut-off points for HGS using length of stay LOS as the outcome?, and (3) What is the sensitivity (SE) and specificity (SP) for the ≥6 second cut-point for the 5m for use in acute care using LOS as the outcome?

5.2 Methods

5.2.1 Sample and Participants

More-2-Eat was a multi-site participatory action research study with a before-after time series design. The primary objective of the study was to implement and evaluate the Integrated Nutrition Pathway for Acute Care (INPAC) in Canadian hospitals. Each site was led by an interdisciplinary team, which offered coaching and improvement strategies towards implementing nutrition care best practices. The study population were all patients on the chosen medical unit for implementation of INPAC at the: Royal Alexandra Hospital (Edmonton, AB), Regina General Hospital (Regina, SK), Concordia Hospital (Winnipeg, MB), Niagara Health

System, General Site (Niagara Falls, ON), and Ottawa Hospital (Ottawa, ON). There are two key aspects of data collection at the patient level (Keller et al., 2017); an audit of nutrition care practices for all patients on the unit during monthly audit days and a detailed assessment of nutrition, frailty, disability, quality of life and food intake on a subset of patients recruited each month. This latter data collection was used for this study.

The eligibility criteria were driven by the primary objectives of the More-2-Eat study and for the detailed patient collection were as follows: 1) no cognitive impairment as per admission assessment by nursing; 2) spoke English (or French at Ottawa site); 3) consumed an oral diet, however supplemental enteral or parenteral nutrition were allowed; 4) likely to return home to the community; and 5) provided written consent to participate. The sampling design was single stage and participants were chosen through a quasi-random sampling process. Research assistants were instructed to identify which patients were eligible to participate in the study, and then starting at one end of the unit (first room, first bed), recruit patients until they had met their quota for the month. In the developmental phase (4 weeks), 40 patients per month (~10/week) was the quota, whereas in the implementation phase the quota was 20 patients per month for 12 months. For the following week/month of collection, research assistants were instructed to start at the bed number in which they last stopped in the prior week/month. They were also reminded on the importance of recruiting less well individuals and frail older adults as they are often neglected in research, and will likely encompass more of the patient reported outcome measures included in the study.

5.2.2 Data Collection and Measures

Data from the patient demographic and health form from M2E resulted in the collection of various patient level characteristics and scores by trained researchers. Those used in this analysis and collected from the patient demographic and health form included: HGS, 5m, and LOS as well as key covariates. Clinical dietitians were seconded from their regular duties at the hospital to be M2E research associates and complete all data collection. Training for these research dietitians was in-person and a detailed manual was provided to support consistency in procedures. Monthly phone call meetings supported consistency in data collection and a virtual group via the Internet helped to address questions among these research staff. These researchers approached a patient for informed consent, shortly after they were admitted and determined to be eligible. On units where they were considered part of the 'circle of care' they were allowed to directly recruit patients; where the dietitian was solely seconded for the research and not practicing on the unit, nursing staff determined eligibility and did the initial approach as per the ethics protocol to determine if the patient was interested in participating in the study. Final recruitment and written consent were completed by these research dietitians. Data collection typically occurred early during the hospitalization (i.e. second or third day).

HGS was collected by the site More-2-Eat research associates who were trained on the Southampton protocol for measuring HGS using a Jamar hydraulic hand dynamometer J000105 (Roberts et al., 2011). This protocol involves patients being seated in a chair with back support and arms (Roberts et al., 2011). However, if patients were not able to transfer from their bed to a chair, the measurement was taken in bed (Keller, 2015). The research dietitian demonstrated how to use the hand dynamometer and explained that tightly gripping the handle gives the highest score. This measure was performed in the patient's dominant hand for three trials; however, where an intravenous line was present in that arm, patients could use the opposite arm instead. All values were recorded (in kg), including the hand in which the test was performed.

The 5m assessment was performed in an unobstructed, well-lit, predetermined area of the hospital, where patients were asked to walk at a comfortable pace between a previously determined 0 and 5-meter marker on the floor (Afilalo et al., 2010). Once the researcher said ‘go’, the timer was started with the first footfall over the 0m line, and the timer was stopped with the first footfall over the 5m line (Afilalo et al., 2010). If the patient was able, the assessment was repeated three times, with a rest period provided between trials to allow the patient to recuperate (Keller, 2015). The time was recorded in seconds on the data collection form. At one site this measure was completed by the physiotherapy team on the unit.

Length of stay was quantified as day of admission, to day of discharge and collected by the M2E research associate from the patient’s chart. For the purpose of determining sensitivity and specificity of published cut-points for HGS and 5m with respect to LOS, LOS was dichotomized into >/≤7 days categories, indicating above and below age-adjusted mean LOS, based on relevant literature (CIHI, 2014). Further, analyses were also completed using the median of this sample >/≤13 days. Other relevant variables collected and used in this analysis included sex, admission diagnosis, and age, all abstracted from the health record. Primary reasons for admission were categorized into disease specific groups (cardiovascular, gastrointestinal, respiratory, musculoskeletal, neurological, infection or other). Nutritional risk, and where relevant, nutritional status was determined for all of these patients, either by the M2E research associate or unit staff as INPAC was implemented. The Canadian Nutrition Screening Tool (CNST) was used to determine nutrition risk. For those at risk, the Subjective Global Assessment was used to diagnose malnutrition (Detsky et al., 1987), which includes information on dietary intake, weight, symptoms, functional capacity and metabolic requirements, as well as the physical exam for fat, muscle and edema. Patients were then classified as either well nourished (A), mildly/moderately or suspected of being malnourished (B), or severely malnourished (C) (Detsky et al., 1987). Additionally, all patients who were deemed severely malnourished (C) were referred to a unit registered-dietitian (RD) for further assessment and treatment. Nutritional status was dichotomized for analysis. To include all patients in the sample in analyses ‘No nutritional risk’ (based on nutrition screening by the CNST) and SGA A were amalgamated into a well-nourished group, and SGA B and C categories were amalgamated to make up the malnourished group. Perceived functional status was assessed using the 7-item Nagi scale, which suggests that significant disability is present with any self-reported difficulty in performing ≥3 of the 7 items (Nagi, 1976). The Nagi scale asks respondents to choose their level of difficulty in performing various daily activities (pulling or pushing a large object, bending over, crouching, kneeling, raising arms over head, etc.). Respondents can then choose between “no difficulty, some difficulty, and great deal of difficulty/cannot do”, the latter two indicating perceived disability in completing that particular task. Questions on ability to carry out daily functions using this standardized scale were posed by the research associates.

University of Waterloo (ORE #20590) and site ethics boards: Niagara Health Ethics Board (2015-07-001), Ottawa Health Science Network Research Ethics Board (20150345-01H), Health Research Ethics Board of the University of Alberta (Pro00056577), Regina Qu’Appelle Health Region Research Ethics Board (REB-15-68), University of Manitoba Health Research Ethics Board (H2015:208) and Concordia Hospital Research and Ethics Committee (H2015:208), approved and provided clearance for this research study. Data collection directly from patients or staff required informed written consent, which was attained prior to data collection.

5.2.3 Data Analysis

A secondary data analysis was performed. Data was analyzed using SAS Studio 9.4 for Windows. To determine the predictive validity of frailty indicators (HGS and 5m) with respect to LOS (continuous), multiple linear regression analyses were performed, while relevant covariates were adjusted for. All theoretically relevant covariates were added to an initial model for the dependent variable LOS with the frailty indicator then included in a second model. Covariates in this analysis included: site, age, sex, primary reason for admission, and nutritional status. Initial sex effects were seen in the model, so further models were stratified by sex. The assumptions of linear regression were assessed by the examination of scatter plots, and a p-value of 0.05 and 95% CI were used to determine statistical significance. Correlation analyses were conducted to determine multi-colinearity among covariates. Separate regression models were developed for HGS and 5m as continuous values. The strength of the association of the frailty indicator was based on a likelihood ratio test (LRT) comparing the initial and second model to determine whether the addition of the frailty indicator added any significant predictive value to the model. A sensitivity analysis was conducted by including only readable HGS scores (n=846) (non-zero values in at least 1 trial) vs. all HGS scores (n=885). The difference between readable and all HGS scores was negligible; thus all HGS scores are presented in results. Models including HGS and 5m cut points together, as well as a combined HGS and 5m variable were also created (data not shown), but found to have no meaningful differences from single-indicator models shown in results.

Sensitivity and specificity analyses were also conducted to determine the best published cut-point for predicting LOS with HGS values and the established cut-point of ≥6 sec for 5m (Afilalo et al., 2010). Values >70% indicate adequate SE and SP of the cut-point for predictive validity of outcome (Streiner, D. L. & Norman, G.R., 1995). The only other specific cut-point found in the literature used to predict health related events in older adults was > 1 m/s (> 5m/s for the 5m) (Cesari et al., 2005). This cut-point was determined from a large sample (n=3047) with a mean age of 64.2 years. A variety of cut-points exist in the literature for HGS to indicate functional disability (Alley et al., 2014; Bahat et al., 2016; Giulani et al., 2008; Martin-Ponce et al., 2014; Sallinen et al., 2010; Yang et al., 2014). The cut-points chosen to indicate frailty in this study were from large, diverse samples (n>1700) that provided a range of cut-points and also considered the potential for sex-specific values. The cut-points for functional impairment by Giulani et al., 2008 (< 14 kg), Sallinen et al., 2010 (<37 kg for males, <21 kg for females), and Alley et al., 2014 (<26 kg for males, <16 kg for females) were used to indicate frailty in this study. No cut-points were derived in this sample as it was anticipated that the sample was potentially unrepresentative of medical patients in these hospitals due to the eligibility criteria (e.g. exclusion of persons with dementia and delirium) and it was also considered appropriate to evaluate current cut-points before creating new ones. The SE and SP of a given cut-point was qualitatively compared to other potential cut-points identified for that measure; higher SE and SP for a cut-point indicated an improved or better value for determining frailty in this sample. Prevalence based on cut-points is also presented.

5.3 Results

There were 1250 detailed patient data collections over a 15-month period for analysis. The proportion of males and females in the detailed patient data collection was not significantly different from the proportion in the INPAC audit data collection (45% male, 55% female vs. 48% male, 52% female respectively) (z=1.90, p=0.054). However, the mean age in the detailed patient data collection was lower than the INPAC audit data collection (68.5 years vs. 73.4 years (t=9.96, p<0.0001; 95% CI (3.99,5.88)); 66.9 years for males and 69.8 years for females vs. 72.0 years for males and 74.7 years for females respectively), indicating that the sample used in this analysis is slightly younger than the medical unit population in these 5 hospitals.

The mean LOS was 12.71 days (SD=13.20), and 30% of patients had longer than average (13+ days) for this sample. Based on an age-adjusted average LOS of 7 days indicated in current literature (CIHI, 2014), 54% of this sample had longer than this average LOS. Almost all (92%) of the sample completed the HGS assessment (n=1146/1250), and 43% (n=535/1250) of patients were able to complete the 5m assessment.

Table 4 summarizes the descriptive statistics and correlation results. Nagi score was correlated with both HGS (rho= -0.38, p<0.0001) and 5m (rho=0.38, p<0.0001), and therefore not included in regression models. HGS was negatively correlated with LOS (rho=-.11, p=0,0002), indicating that decreased grip strength was associated with a longer LOS, while 5M (rho= 0.18, p<0.001) was positively correlated with LOS (longer walk times associated with longer LOS). Site (F=4.98, p=0.0002), being malnourished (t=-5.72, p<0.0001) and admission diagnosis category (F= 5.93, p<0.0001) were also significantly associated with LOS. Age and sex were considered theoretically relevant, and therefore added to the models regardless of statistical significance. Preliminary results showed a sex interaction, so further models were stratified by sex, and separate models were created for HGS, 5m.

To determine the predictive validity of HGS and 5m with respect to LOS, all associated variables except for HGS/5m were included in an initial model, and then a second model was created including HGS/5m walk. Likelihood ratio tests indicated that HGS did add significant predictive value for both the male sex-stratified model (X^2=18.62, p<0.0001) and the female sex-stratified model (X^2=5.2, p<0.05) with respect to LOS. Conversely, 5m only added significant predictive value for the male sex-stratified model (X^2=3.9, p<0.05). In essence, final models indicate the additional predictive value of HGS/5m for LOS when adjusted for these meaningful covariates. As noted in these final models, the addition of HGS as an indicator of frailty significantly improved the predictive value of both the male and female sex-stratified models, whereas 5m was not useful to predict LOS across both sexes (Tables 6 and 7).

Sensitivity and specificity analyses were conducted on HGS and 5M with various cut-points identified in the literature to determine which were potentially most useful when considering the outcome of LOS in acute care patients. LOS was dichotomized for this analysis at 7 and 13 days. These results are summarized in Tables 8 and 9. The HGS cut-point with the highest SE was Sallinen (<37kg for men (SE=0.81; SP=0.27), <21 kg for women (SE=0.84; SP=0.25)). Using this cut-point, 77% of the males were considered frail, while 80% of the females were considered frail. This high prevalence and the low specificity indicate that these sex-specific cut-points lack discriminatory power. The Giulani cut point (<14 kg) for males and females had the lowest sensitivity, and highest specificity (SE=0.32, SP=0.75), and only 30% of the sample were considered frail. The Alley cut-point (<26 kg for males, <16 kg for females) produced the best balance of sensitivity and specificity (SE=0.47, 0.61; SP=0.57, 0.49 respectively) and the prevalence of frailty was 41% and 57% for males and females respectively. However, the AUCs for all cut-points indicate that HGS was not sufficient to predict LOS while adjusting for age (Table 8). The Afilalo (≥6 s) cut-point for 5m had an SE=0.68, SP=0.43 with an AUC=0.55, while the Cesari (2005) (>5 s) had a SE=0.84, SP=0.21, and AUC=0.52. Both of these cut-points do not have sufficient discriminatory value and prevalence was 62% and 81% respectively. However, ability to complete the 5M at all was also tested as an indicator of frailty;

completion vs. non-completion produced SE=0.34, SP=0.57, AUC=0.56 but had the poorest sensitivity for this frailty indicator for this sample.

5.4 Discussion

Experts agree that screening for frailty needs to occur in hospital settings, especially among older adults (>70 years) (Morley et al., 2016). Objective, physical performance measures, which are more focused on the functioning of the individual are preferable to subjective evaluations for measuring frailty, especially in a clinical or hospital setting (Cesari et al., 2016). These tools also need to be relevant for predicting important outcomes such as LOS to support clinical decision-making.

Correlations between HGS/5m and LOS were significant and in the anticipated direction, confirming that lower HGS values and longer 5m walk times are associated with a longer LOS. Yet, an association is not sufficient to demonstrate the relevance of a new tool in clinical practice. The inclusion of a new clinical measure on all patients needs to demonstrate at minimum that it adds value to treatment decisions and is associated with patient outcomes, as well is responsive to treatment. This analysis demonstrated that HGS provided additional predictive value for LOS when adjusting for other covariates that would be collected in a clinical setting, whereas 5m did not provide this additional predictive value for females. Based on this analysis, HGS appears to be an adequate tool for measuring frailty and predicting clinical outcomes such as LOS in this setting. The overall low R^2 values of the predictive models may in part be attributed to the amount of variance inherent in the outcome (LOS). It is recommended that further predictive validity of these tools be assessed for other clinical outcomes to determine their utility while adjusting for other relevant covariates (e.g. disease severity) that likely influence these outcomes.

If objective tools are to be used in clinical practice, they require a score or cut-point upon which decisions are made with respect to treatment options. Development of new cut-points for HGS and 5M based on this sample was not considered appropriate, as eligible patients included in this data collection were not representative of all medical patients (i.e. no delirium or dementia). Thus, this analysis was focused on determining if current cut-points would be appropriate when considering the outcome of LOS. The cut-points chosen in this study to identify frailty with HGS have been used in the past to determine functional disability and mobility limitations (Alley et al., 2014; Giulani et al., 2008; Sallinen et al., 2010) and are below the 50th percentile HGS reference values for similar age categories (Stats Canada, 2007 to 2013 Canadian Health Measures Survey (reference equations)), indicating that they are likely capturing less well individuals. However, these existing HGS and 5m cut-points for frailty do not appear to be useful for predicting LOS, as all cut-points produced SE/SP/AUC values <0.70. These results reveal that if further work is pursued with these objective measures cut-points need to be improved and re-assessed to capture and predict clinical outcomes such as LOS in an unbiased sample.

This analysis also warrants further exploration of whether or not HGS is truly measuring the entire construct of frailty. Criterion and construct validity testing needs to be done in further research to determine the validity of these tools for this purpose. The Clinical Frailty Scale (CFS) is a subjective tool that has been shown to be effective and valid for measuring frailty, and provides important predictive information about death, and other adverse outcomes (Rockwood et al., 2005). Current work is being done to improve the utility of the CFS. The Frailty Assessment for Care-planning Tool (FACT) is a modification of the CFS that can be used by non-experts/non-geriatricians, includes validated screening tools for cognitive assessment, relies on collateral history instead of self-report, and combines some scores for easier scoring without losing information pertinent to clinical decision making (Moorehouse et al., 2017 *not published*). This tool has been shown to be more closely associated the Frailty Index (Fried, 2001) than the CFS. Both the CFS and FACT tools may be a starting to point to determine the criterion/construct validity of single objective measures such as HGS or 5m. Further, research using HGS cut-points to influence decision-making is needed to determine if it adds value to clinical assessment and treatment.

5.5 Limitations

A limitation of this study is the eligibility criteria for recruitment of patients, as the resulting sample was not representative of all medical patients on this unit when compared to other data collected in the M2E study. The sample used in these analyses tended to be slightly younger patients than the medical patients in these 5 hospital units, who may have been different on their health and frailty characteristics as well. However, researchers were informed on the importance of recruiting less well and frail older adults, as they are often underrepresented in research and the average age is consistent with prior work on medical patients (Bowles et al., 2014; Buendgens et al., 2014; Donzé, Bates & Schnipper 2013). Furthermore, there was some variability in terms of recruitment of patients due to the busyness of the project and capacity of hospital staff to complete initial recruitment. Systematic error may also be present as a result of some missing data. Other limitations include the potential for inter-rater differences when assessing HGS and 5m. For example, some researchers may be more diligent or motivating when encouraging patients to perform the assessment, resulting in superior scores. However, researchers were trained on the appropriate protocol, and given detailed manuals and online support, which may have helped to resolve this limitation. Another limitation to consider includes the fact that only the Southampton protocol for HGS was used, and many protocols for assessing HGS exist; specific protocols for unwell, acute care patients who cannot transfer easily from bed are warranted. In addition, LOS as the outcome variable being predicted has implications for interpretation, as many factors contribute to LOS. That being said, a fully adjusted analysis considering diverse covariates to determine the independent effect of HGS and 5m on LOS was not the objective of this analysis, but rather to demonstrate predictive validity.

5.6 Conclusion

HGS appears to add significant additional predictive value with respect to predicting LOS, and is thus a more appropriate tool to use on both male and female acute care patients than the 5m. Additionally, if HGS is to be pursued for use in clinical practice, better cut-points than those available in the current literature and specific to acute care patients are needed. Given the growing population of older adults, their susceptibility to frailty, and their health care utilization, it is critical that further research be conducted to identify frailty in the clinical setting and how this can impact treatment decisions and outcomes.

Table 4- Correlation with LOS

Variable	Mean (SD)	Pearson Correlation
LOS (n=1233)[1]	12.31 days (13.20)	----
LOS (sex stratified)	M: 12.88 days (13.82) F 12.58 days (12.68)	
HGS (n=1146)	20.82 kg (12.35)	-0.11**
HGS (sex stratified)	M: 28.26 kg (12.45) F: 14.54 kg (8.01)	
5m (n=535)	median=8.98 s (6.59)	0.18***
5m (sex stratified)	M: median=7.80 s (5.70) F: median=10.27 s (7.24)	
Age (n=1250)	68.48 years (15.28)	0.070
Age (sex stratified)	M: 66.91 years (15.09) F: 69.76 years (15.32)	
Nagi (n=1250)	4/7 (1.90)	0.22***
Nagi (sex stratified)	M: 3.68/7 (1.99) F: 4.40/7 (1.76)	

* p<.05 **p<.01 ***p<0.001
[1] 15 missing entries, 3 outliers removed; Abbreviations: HGS= Handgrip strength; 5M= Five meter timed walk; LOS=Length of Stay; M=Male; F=Female

Table 5- Summary Statistics

Variable	Mean LOS	Test Statistic
Sex		T= 0.40
Male (n=537)	12.88	
Female (n=426)	12.58	
Site		F= 4.98**
1 (n=215)	12.77	
2 (n=166)	12.13	
3 (n=213)	14.55	
4 (n=223)	10.13	
5 (n=146)	14.42	
Nutritional Status		T= -5.72***
Malnourished[1] (n=185)	17.05	
Well-nourished[2] (n=777)	11.68	
Admission Category		F= 5.93***
Cardiovascular (n=113)	11.81	
Gastrointestinal (n=93)	10.48	
Respiratory (n=295)	11.85	
Musculoskeletal (n=83)	18.59	
Neurological (n=96)	10.10	
Infection (n=111)	13.98	
Other (n=172)	13.30	

* p<.05 **p<.01 ***p<0.001
[1]Malnourished group includes: SGA Bs and Cs; [2]Well-nourished group includes: No risk and SGA A
Abbreviations: HGS= Handgrip strength; 5M= Five meter timed walk; LOS=Length of Stay; M=Male; F=Female

Table 6- Regression Analysis of LOS with Covariates and for HGS Stratified by Sex

	Model 1				Model 2			
	Male (n=521)		Female (n=609)		Male (n=521)		Female (n=609)	
	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value
HGS	N/A	N/A	N/A	N/A	-0.25 (-0.4,-0.1)	<.0001	-0.18 (-0.3, -0.02)	0.02
Age	0.02 (-0.06, 0.1)	0.58	0.02 (-0.05, 0.09)	0.52	-0.05 (-0.1, 0.03)	0.25	-0.001 (-0.07,0.07)	0.98
Site		0.12		0.009		0.005		0.0009
1	0.76 (-3.5, 5.0)		-1.89 (-5.8, 2.0)		-0.56 (-4.7, 3.6)		-2.44 (-6.4, 1.5)	
2	-2.16 (-6.3,1.9)		-5.34 (-8.8, -1.9)		-5.65 (-9.9, -1.4)		-7.82 (-11.9, -3.7)	
3	1.14 (-2.7,5.0)		-0.83 (-4.3, 2.6)		0.81 (-3.0, 4.6)		-1.32 (-4.8, 2.1)	
4	-3.73 (-8.2, 0.7)		-3.73 (-7.2, -0.3)		-4.82 (-9.2, -0.5)		-4.36 (-7.9, -0.9)	
5	-----		-----		-----		-----	
SGA		<.0001		<.0001		<.0001		<.0001
A/no risk	-----		-----		-----		-----	
B/C	7.31 (4.2,10.4)		5.74		6.15 (3.1, 9.2)		5.37 (2.8, 7.9)	
Adm Cat		0.23		<.0001		0.25		<.0001
Cardio	-----		-----		-----		-----	
Gastr	-1.68 (-7.3,3.9)		-1.89 (-6.5, 2.7)		-1.95 (-7.4, 3.5)		-1.52 (-6.1, 3.0)	
Resp	-0.54 (-5.0, 4.0)		-1.90 (-5.6, 1.8)		-0.02 (-4.4, 4.4)		-1.68 (-5.4, 2.0)	
Musc	4.01 (-1.9, 9.9)		8.90 (4.7, 13.1)		4.87 (-0.9, 10.7)		8.66 (4.4, 12.9)	
Neuro	0.32 (-4.7, 5.4)		-2.05 (-6.5, 2.4)		0.73 (-4.2, 5.7)		-1.99 (-6.5, 2.5)	
Infect	3.90 (-0.9, 8.7)		0.01 (-4.2, 4.2)		3.36 (-1.3, 8.1)		0.15 (-4.1, 4.4)	
Other	1.48 (-2.9, 5.9)		0.29 (-3.4, 4.0)		0.87 (-3.4, 5.2)		0.35 (-3.4, 4.1)	
R^2	0.067		0.11		0.10		0.11	
Log liklihood	-2085.19		-2383.97		-2074.88		-2381.37	
LRT	N/A		N/A		X^2=18.62, p<0.0001		X^2=5.2, p<0.05	

Abbreviations: HGS= Handgrip strength; 5M= Five meter timed walk; LOS=Length of Stay; Adm.Cat.= Admission Category; Cardio.= Cardiovascular; Gastro.= Gastrointenstinal; Resp.= Respiratory; Musc.= Musculoskeletal; Neuro.= Neurological; Infect.= Infection.

Table 7- Regression Analysis of LOS with Covariates and for 5m Stratified by Sex

	Model 1				Model 2			
	Male (n=278)		Female (n=254)		Male (n=278)		Female (n=254)	
	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value
5m (s)	N/A	N/A	N/A	N/A	0.18 (-0.01,0.4)	0.06	0.14 (-0.06, 0.3)	0.17
Age	0.02 (-0.05, 0.08)	0.66	0.05 (-0.04, 0.1)	0.31	-0.004 (-0.1,0.1)	0.91	0.04 (-0.05, 0.12)	0.43
Site		0.02		0.003		0.007		0.004
1	2.20 (-1.4, 5.8)		-5.80 (-11.5, -0.1)		2.48 (-1.1, 6.1)		-5.47 (-11.2, 0.3)	
2	-3.77 (-7.7, 0.2)		-10.18 (-15.5, -4.9)		-3.52 (-7.5, 0.4)		-9.67 (-15.0, -4.3)	
3	0.89 (-2.4, 4.1)		-7.22 (-12.1, -2.4)		1.35 (0.8, 12.0)		-7.14 (-12.0, -2.3)	
4	-2.06 (-5.8, 1.7)		-8.52 (-13.7, -3.3)		-2.50 (-6.2, 1.2)		-8.58 (-13.8, -3.4)	
5	-----		-----		-----		-----	
SGA		0.06		0.07		0.17		0.08
A/no risk	-----		-----		-----		-----	
B/C	2.53 (-0.1, 5.2)		3.23 (-0.2, 6.7)		1.90 (-0.8, 4.6)		3.12 (-0.4, 6.6)	
Adm Cat		0.11		<.0001		0.12		0.0007
Cardio	-----		-----		-----		-----	
Gastro	-0.20 (-4.7, 4.3)		1.73 (-3.9, 7.3)		0.12 (-4.4, 4.6)		1.54 (-4.1, 7.1)	
Resp.	-0.42 (-3.7, 2.9)		-0.02 (-4.9, 4.8)		-0.12 (-3.4, 3.1)		-0.16 (-5.0, 4.7)	
Musc.	6.33 (0.7, 12.0)		14.48 (8.6, 20.3)		6.41 (0.8, 12.0)		13.21 (7.1, 19.3)	
Neuro	-0.77 (-4.5, 3.0)		0.99 (-4.6, 6.6)		-0.26 (-4.0, 3.5)		0.47 (-5.1, 6.1)	
Infect	3.20 (-0.6, 7.0)		-0.72 (-6.2, 4.8)		3.40 (-0.4, 7.2)		-0.71 (-6.2, 4.8)	
Other	1.43 (-1.8, 4.7)		0.96 (-3.9, 5.8)		1.75 (-1.5, 5.0)		0.66 (-4.2, 5.5)	
R^2	0.097		0.19		0.11		0.20	
Log Liklihood	-958.66		-945.16		-956.73		-944.16	
LRT	N/A		N/A		X^2=3.9, p<0.05		X^2=2.0, p>0.10	

Abbreviations: HGS= Handgrip strength; 5M= Five meter timed walk; LOS=Length of Stay; Adm. Cat.=Admission Category; Cardio= Cardiovascular; Gastro=Gastrointenstinal; Resp= Respiratory; Musc=Musculoskeletal; Neuro=Neurological; Infect=Infection.

Table 8- Sensitivity and Specificity Analysis of HGS Cut Points

	LOS >/= 7 days			LOS >/= 13 days			Proportion Screened Frail
HGS cut-points	**SE**	**SP**	**AUC**	**SE**	**SP**	**AUC**	
Giulani (<14kg)	0.32	0.75	0.56	0.34	0.73	0.55	29.76% (341/1146)
Sallinen-Men (<37 kg)	0.81	0.27	0.53	0.59	0.25	0.55	77.14% (405/525)
Sallinen-Women (<21 kg)	0.84	0.25	0.56	0.87	0.23	0.55	80.35% (499/621)
Alley- Men (<26 kg)	0.47	0.57	0.58	0.50	0.63	0.57	41.14% (216/525)
Alley-Women (<16 kg)	0.61	0.49	0.56	0.65	0.47	0.56	57.17% (355/621)

Table 9- Sensitivity and Specificity Analysis of 5M Cut Points

	LOS >/= 7 days			LOS >/= 13 days			Proportion Screened Frail
5m cut-points	**SE**	**SP**	**AUC**	**SE**	**SP**	**AUC**	
Afilalo (2010) (≥6s)	0.68	0.43	0.55	0.74	0.41	0.57	62.4% (334/535)
Cesari (2005) (>5s)	0.84	0.21	0.52	0.89	0.21	0.55	81.3% (435/535)
5m completion	0.34	0.57	0.56	0.69	0.48	0.59	42.8% (535/1250)

Chapter 6: Predictive Validity of Frailty Indicators in Acute Care with Respect to QOL

6.1 Introduction

Patient reported outcomes are becoming of greater importance to researchers and stakeholders as health care philosophies shift to become more patient-centered (Desphande et al., 2011). Quality of life (QOL) is an important patient reported outcome in acute care, as it reflects a patient's overall physical, mental and social wellbeing (WHO, 1997 page 1). Research has shown that reduced health related quality of life is significantly associated with mortality (Brown, D. S., Thompson, W. W., Zack, M. M., Arnold, S. E., & Barile, J. P., 2015). Consequently, knowledge of what contributes to patients' self-perceived QOL in acute care and after discharge is essential for developing and improving health care interventions.

In order to ensure that QOL is not reduced as a result of hospitalization, it is important to determine if health care factors are associated with decreased QOL. More importantly, predicting or anticipating decreased QOL throughout hospital admission can help guide interventions that target key risk factors and support transition back to the community. Many researchers have attempted to determine predictors of quality of life in health care/acute care contexts. Examples of factors associated with QOL include: motor dysfunction, communication problems between patient/physician, depressive symptoms, pain, age, hemiplegia, socioeconomic status, psychological problems, the presence of a feeding tube, and physical functioning (Beck et al., 2001; Engel et al., 2003; Grady et al., 1999; Paul et al., 2005; Terrell et al., 2004; Tripp et al., 2004). Furthermore, research has been conducted to investigate predictors of QOL post-discharge from hospital. Examples of these predictors include: health competence, mood state, environmental factors, mobility, social integration, access to meaningful activities, socioeconomic factors, and stress levels among others (Erosa et al., 2014; Grady et al., 2003; Mortensen et al., 2010). Predictors of QOL are numerous and vary based on health status or medical condition being investigated. Recent literature has highlighted frailty as a syndrome that is predictive of negative outcomes such as mortality, functional decline and hospitalization (Rijk et al., 2016, Stessman et al., 2017). However, current research has yet to explore frailty indicators specifically as potential predictors of QOL for acute care patients during hospitalization and post-discharge as they transition back to the community.

This study aims to address these areas of the literature on QOL that have been neglected. Specifically, the predictive validity of frailty measures for self-reported QOL during hospitalization and 30-days post-discharge will be examined. The following research question will be answered: Do frailty indicators, and specifically handgrip strength or 5 meter walk (HGS and 5m), add predictive value when adjusting for relevant covariates to QOL during hospitalization and 30-days post-discharge for patients discharged to the community? This research will offer a better understanding of the relationship between frailty and QOL for acute care patients.

6.2 Methods

6.2.1 Sample and Participants

More-2-Eat was a multisite participatory action research study with a before-after time series design. The primary objective of the study was to implement and evaluate the Integrated Nutrition Pathway for Acute Care (INPAC) in 5 Canadian hospitals. Each site was led by an interdisciplinary team that offered coaching and improvement strategies towards implementing best practices for nutrition care. The study population recruited were all patients on the chosen medical unit participating in this implementation study: Royal Alexandra Hospital (Edmonton, AB), Pasqua Hospital (Regina, SK), Concordia Hospital (Winnipeg, MB), Niagara Health System (Niagara Falls, ON), Ottawa Hospital (Ottawa, ON). There were two key aspects of data collection at the patient level; an audit of nutrition care practices for all patients on the unit during audit days and a detailed assessment of nutrition, frailty, disability, quality of life and food intake on a subset of patients recruited each month. This latter group will be used in this secondary data analysis. There were 1250 patients recruited for this detailed data collection over a 15-month period with 278 having 30-day post-discharge data; these samples are used to determine the predictive validity of frailty indicators for QOL. This sample was younger (68 years vs. 73 years; $t=9.96$, $p<0.0001$; 95% CI 3.99,5.88) than the INPAC audit data collection, indicating that this sample is slightly younger than medical patients on these 5 hospital units. The eligibility criteria as described below explain these differences in demographics.

The eligibility criteria for the detailed patient collection were as follows: 1) no cognitive impairment as per admission assessment by nursing; 2) spoke English (or French at Ottawa site); 3) consumed an oral diet, however supplemental enteral or parenteral were allowed; 4) were likely to return home to the community; and 5) must have provided written consent to participate. It should be noted that these eligibility criteria were for the primary More-2-Eat study, and not this secondary data analysis. The sampling design was single stage and participants were chosen through a quasi-random sampling process. Site researchers were instructed to identify which patients were eligible to participate in the study, and then starting at one end of the unit (first room, first bed), recruit patients until they had met their quota. In the baseline phase (4 weeks), 10 patients per week was the target, whereas in the implementation phase the quota was 20 patients per month for 12 months. For the following week/month of collection, site researchers were instructed to start at the bed number in which they last stopped. Site researchers were also encouraged to ensure that less well individuals and frail older adults were recruited to provide diversity on QOL and frailty indicators, as well as other outcome measures included in the main study.

6.2.2 Data Collection and Measures

Clinical dietitians were seconded from their regular duties at the hospital to complete all data collection. Training for these research dietitians was in-person and a detailed manual was provided to support consistency in procedures. Monthly phone call meetings supported consistency in data collection and a virtual group via the Internet helped to address questions among these research staff. Site researchers approached a patient for informed consent, shortly after they were admitted and determined to be eligible. On units where they were considered part of the 'circle of care' they were allowed to directly recruit patients; where the dietitian was solely seconded for the research and not practicing on the unit, nursing staff determined eligibility and did the initial approach as per the ethics protocol to determine if the patient was interested in participating in the study. Final recruitment and written consent were completed by these research dietitians.

All relevant data used in this analysis were collected shortly after admission and typically on the same day as recruitment and included: handgrip strength (HGS), five meter timed walk (5m), and self-reported QOL (SF-12). To measure HGS, the research dietitians were trained on the Southampton protocol for HGS using a hydraulic hand dynamometer J000105 (Roberts et al., 2011). This protocol involves patients being seated in a chair with back support and arms (Roberts et al., 2011). However, if patients were not able to transfer from their bed to a chair, the measurement was taken in bed (Keller, 2015). The research dietitian demonstrated how to use the hand dynamometer and explained that tightly gripping the handle gives the highest score. This measure was performed in the patient's dominant hand for three trials; however, where an intravenous line was present in that arm, patients could use the opposite arm instead (Keller, 2015). All values were recorded (in kg), including the hand in which the test was performed.

The 5m assessment was performed in an unobstructed, well-lit, predetermined area of the hospital, where patients were asked to walk at a comfortable pace between a 0m and 5m marker on the floor (Afilalo et al., 2010). Once the assessor said ‘go’, the timer was started with the first footfall over the 0m line, and the timer was stopped with the first footfall over the 5m line (Afilalo et al., 2010). If the patient was able, the assessment was repeated three times, with a rest period provided between trials to allow the patient to recuperate (Keller, 2015). The time was recorded in seconds. At one site, this measure was completed by the physiotherapy team on the unit. For both HGS and 5m, if patients were unable to complete the assessment, the reason for non-completion (non-ambulatory/cannot transfer, too weak, other) was also recorded (Keller, 2015).

Quality of life was collected via in-person interviews on the day of recruitment in the hospital and for a subset, 30-days post-discharge via follow-up phone calls completed by trained researchers at the University of Waterloo. Participants for 30-day follow-up were only recruited at baseline, at approximately 4-5 month, and the 11-12 month time points during implementation with a goal of 40 patients at each site being recruited. Quality of life was measured using the SF-12 questionnaire, and trained researchers asked questions as they were written in the questionnaire. Questions on the SF-12 reflect self-perceived health and well-being, via questions such as “In general, would you say your health is: Excellent, very good, good, fair or poor?” (Ware et al., 1995). Scoring of the SF-12 derives a physical and mental summary score, both of which are continuous and independent numerical scores (Ware et al., 1995). Although many tools exist to measure quality of life, the SF-12 general health survey is a leading measure for acute care patients (Hamoen, 2015; Ware et al., 1995). This questionnaire focuses on both physical and emotional wellbeing and is relatively concise. A recent review suggested that, "the SF-12 be used for screening populations for QOL as it received positive ratings for criterion validity, construct validity, reproducibility, and interpretability. Moreover, it is a relatively short questionnaire, which makes it suitable for all patients" (Hamoen et al., 2015 p. 25).

The covariates to be included in models for QOL included: site, age and sex, diagnosis (from health record, 7 categories), nutritional status determined via the subjective global assessment (SGA) (Detsky et al., 1987), education and living situation. Nutritional status via SGA was assessed after a patient had been screened 'at risk' based on the Canadian Nutrition Screening Tool (CNST) (Laporte et al., 2015). The SGA includes information on dietary intake, weight, symptoms, functional capacity and metabolic requirements, as well as a physical exam assessing adequacy of fat and muscle tissues and presence of edema. Patients were classified as either well nourished (A), mildly/moderately or suspected of being malnourished (B), or severely malnourished (C) (Detsky et al., 1987). Those patients identified to be 'not at risk' as per the CNST and thus not assessed by the SGA for a malnutrition diagnosis, were coded as 'well nourished' for this analysis.

University of Waterloo (ORE #20590) and site ethics boards: Niagara Health Ethics Board (2015-07-001), Ottawa Health Science Network Research Ethics Board (20150345-01H), Health Research Ethics Board of the University of Alberta (Pro00056577), Regina Qu'Appelle Health Region Research Ethics Board (REB-15-68), University of Manitoba Health Research Ethics Board (H2015:208) and Concordia Hospital Research and Ethics Committee

(H2015:208), approved and provided clearance for this research study. Data collection directly from patients required informed written consent, which was attained prior to data collection.

6.2.3 Data Analysis

A secondary data analysis was performed using SAS Studio 9.4 for Windows. Descriptive (mean, SD) statistics were completed and associations among patient characteristics and frailty and QOL were determined with t-test, ANOVA and Spearman's rho. To determine whether frailty indicators (HGS and 5m) added significant predictive validity with respect to predicting QOL during hospitalization and 30-days post-discharge (30DQOL), multiple linear regression analyses were performed, adjusting for relevant covariates. Separate models were derived for each frailty indicator (HGS and 5m) and each outcome variable (QOL and 30DQOL). Separate models were derived for each summary SF12 score of physical (PCS) and mental (MCS) QOL. Covariates in this analysis included: site, age, sex, nutritional status, admission diagnosis category, education and living situation. Nutritional status was categorized into well-nourished and malnourished, with SGA categories B and C were amalgamated as a 'malnourished' group. QOL/30DQOL- the dependent variable- and HGS/5m- the independent variables- were continuous and were used in a numerical manner for this analysis. All relevant covariates were first added to the model for the dependent variable QOL/30DQOL. Preliminary results showed a sex interaction, so multivariate models were stratified by sex. Some variables were significant in the initial model, while other variables were added despite their significance, due to theoretical relevance to QOL. Next, the frailty indicator, either HGS or 5m, was added to this initial model to determine if the indicator added any predictive value. The assumptions of linear regression were assessed by the examination of scatter plots; 95% CI for estimates were used to determine statistical significance of covariates. To determine if frailty indicators added anything to the models, likelihood ratio tests (LRT) were derived for each model were compared.

6.3 Results

The final sample included 1250 from 5 sites; 45% were male, and 55% female and the average age was 68.5 years (SD=15.28). The mean LOS was 12.7 days (SD=13.20), and 30% of patients had longer than average (13+ days) LOS for this sample (Table 1). Based on an age-adjusted average LOS of 7 days indicated in current literature (CIHI, 2014), 54% of this sample had longer than this average LOS. Almost all (92%) of the sample completed the HGS assessment (n=1146/1250), and 43% (n=535/1250) of patients were able to complete the 5m assessment. QOL in hospital (PSC1/MCS1) were collected on 1247 patients (3 missing data entries), whereas 30-day follow-up quality of life (PSC2/MCS2) was assessed on a subset of 278 patients. The average quality of life scores were as follows: in hospital PCS1: 34.64, MCS1: 46.46; post discharge PCS2: 36.20; MCS2: 51.23; thus the subset with 30-day follow up had similar physical but higher mental QOL scores as compared to the sample in hospital.

Tables 10 summarizes the correlation results between covariates, HGS, 5m and QOL. HGS and 5m were significantly associated with PCS1 (rho=0.23, p<0.0001; rho=-0.21, p<0.0001 respectively) and PCS2 (rho=0.26, p<0.0001; rho=-0.21 p<0.05 respectively), in the anticipated direction, but not with the mental summary scores (MCS1/MCS2). Those who were considered well-nourished in hospital had significantly higher PCS1 (t=4.42, p<0.0001) and MCS1 (t=4.17, p<0.0001) scores than those who were considered malnourished. In addition, QOL in hospital (PCS1 and MCS1) was significantly different across admission diagnosis categories (F=10.37, p<0.0001; F=5.43, p<0.0001); those with musculoskeletal diagnoses had the lowest mean PCS1 scores (30.02), while those with respiratory diagnoses had the lowest mean MCS1 scores

(44.24). Age, site, sex, education and living situation were considered theoretically relevant, and therefore added to the models regardless of lack statistically significant association with QOL.

To determine the predictive validity of HGS and 5m with respect to QOL/30DQOL, all associated variables except for HGS/5m were included in an initial model (model 1), and then a second model (model 2) was created including HGS/5m. Likelihood ratio tests indicated that HGS added significant predictive value with respect to PCS1 for both the male sex-stratified model (X^2= 31.78, $p<0.01$) and the female sex-stratified model (X^2= 21.02. $p<0.01$) (Table 11), while it only added significant predictive value for MCS1 for the female sex-stratified model (X^2=4.02, $p<0.05$) (Table 12). 5m also added significant predictive value for PCS1 for both the male sex-stratified model (X^2=9.42, $p<0.01$) and the female sex-stratified model (X^2= 15.72, $p<0.01$) (Table 13), but only added predictive value with respect to MCS1 for the male sex-stratified model (X^2=4.36, $p<0.05$) (Table 14). HGS also added significant predictive value to PCS2 for the male sex-stratified model (X^2=10.62, $p<0.01$) and the female sex-stratified model (X^2=10.75, $p<0.01$) (Table 15), but only added significant predictive value for MCS2 for the male sex-stratified model (X^2=4.00, $p<0.05$) (Table 16). 5m added significant predictive value with respect to PCS2 for the female sex-stratified model only (X^2=4.38, $p<0.05$) (Table 17), and not with respect to MCS2 (Table 18). In essence, final models indicate the additional predictive value of HGS and 5m for PCS1/MCS1/PCS2/MCS2 when adjusted for these meaningful covariates. As noted in these final models, the addition of HGS (including other variants as discussed in methods) as an indicator of frailty significantly improved the predictive value of both the male and female models with respect to the physical component of QOL in hospital (PCS1) and post-discharge (PCS2), whereas 5m added significant predictive value across sexes for the physical component of QOL in hospital (PCS1), but not 30 days post-discharge (PCS2). It should be noted that R^2 values increased after the addition of the frailty indicator variable, which should be expected. Neither frailty indicator was adequate for predicting the mental component of QOL in hospital or post-discharge across both sexes, as expected given the correlation results.

6.4 Discussion

Research has indicated that screening for frailty needs to occur in hospital settings, especially among older adults (>70 years) (Morley et al., 2016). In order to do this, simple, objective tools are required as objective, physical performance measures, which are more focused on the functioning of the individual, are preferable to subjective evaluations for measuring frailty, especially in a clinical or hospital setting (Cesari et al., 2016). These tools also need to be relevant for predicting important outcomes and support clinical decision-making.

Correlations between HGS/5m and physical components of QOL were significant and in the anticipated direction, confirming that lower HGS values and longer 5m walk times are associated with poorer physical QOL. However, these frailty indicators do not appear to be consistently associated with the mental summary scores generated by the SF-12 for either sex. 5m could only be completed on a subset of participants and there was a less consistent association between PCS during and post-hospitalization. The small sample size of those who completed the 5m and also included in the 30-day follow-up assessment of QOL likely contributed to the weaker association seen between 5m and PCS2 among both sexes. Based on this analysis, HGS appears to be a superior tool as compared to 5m for measuring frailty and predicting clinical outcomes such as QOL in this setting, and as noted in this sample can be completed by almost all cognitively well patients. Despite the correlation with physical QOL, an association is not sufficient to demonstrate the relevance of a new tool in clinical practice. The inclusion of a new clinical measure on all patients needs to demonstrate at minimum that it adds value to treatment decisions and is associated with patient outcomes, and is also responsive to treatment. It is recommended that further predictive validity of these tools be assessed for other clinical outcomes as well as clinical treatment in a more representative sample to determine their utility while adjusting for other relevant covariates (e.g. disease severity) that likely influence these outcomes and treatment decisions. Research that demonstrates the responsiveness of HGS to treatment during a relatively short time frame of a hospitalization is also required.

This analysis also warrants further exploration of whether or not HGS is truly measuring the entire construct of frailty. Construct validity testing needs to be done in further research to determine the validity of HGS as a frailty indicator. The Clinical Frailty Scale (CFS) is a subjective tool that has been shown to be effective and valid for measuring frailty, and provides important predictive information about death, and other adverse outcomes (Rockwood et al., 2005). The Frailty Assessment for Care-planning Tool (FACT) is a modification of the CFS that can be used by non-experts/non-geriatricians and has been shown to be more closely associated the Frailty Index (Fried, 2001) than the CFS. FACT includes validated screening tools for cognitive assessment, relies on collateral history instead of self-report, and combines some variables for easier scoring without losing information pertinent to clinical decision making (Moorehouse et al., 2017 *not published*). Both the CFS and FACT tools may be a starting point to determine the construct validity of single objective indicators of frailty such as HGS.

6.5 Limitations

A limitation of this study is the eligibility criteria for recruitment of patients, as the resulting sample was not representative of all medical patients on this unit when compared to other data collected in the M2E study. The sample used in these analyses tended to be slightly younger patients than general hospital population, who may have been different on their health and frailty characteristics as well. However, researchers were informed on the importance of recruiting less well and frail older adults, as they are often underrepresented in research and the average age is consistent with prior work on medical patients (Bowles et al., 2014; Buendgens et al., 2014; Donzé, Bates & Schnipper 2013). Busyness of the unit and reluctance of staff to recruit unwell patients may have also biased this sample. As noted in our comparisons to INPAC audit data, this sub-sample was slightly younger. The 30 day follow-up sample are likely unrepresentative as the participation rate for these calls was 53%. As well, researchers at the university completed these telephone calls and were potentially less expert than site researchers who completed more SF-12 assessments. Other limitations include the potential for inter-rater differences when assessing HGS and 5m and QOL post-discharge from hospital and measurement error. For example, some researchers may be more diligent or motivating when encouraging patients to perform the assessment, resulting in superior scores. Another limitation to consider includes the protocol used for completion of HGS, which had to be adapted for an unknown proportion of patients who were in bed. Many protocols for assessing HGS exist, but none specific to the bedridden patient. Additionally, the succinctness of the SF-12 questionnaire does not give insight into all dimensions of quality of life as it focuses solely on physical and emotional well-being. Finally, other potential predictors of quality of life were not collected for M2E, as this was not the primary purpose of the study. Therefore, they cannot be controlled for in this secondary data analysis.

6.6 Conclusion

This study offers an enhanced understanding of the relationship between frailty and QOL in acute care patients. HGS appears to add significant additional predictive value with respect to predicting physical QOL during hospitalization, and 30 days post-discharge from hospital, and is an appropriate tool to use for both male and female acute care patients. Although similar results were found 5m, it was less feasible for patients to complete. Future work on HGS as a measure to conduct with nutritional screening or malnutrition assessment should be done to describe potential comorbidity with frailty, which often overlaps with malnutrition (Laur et al., 2017). Frailty assessment should be completed in all health care sectors and the results of this study indicate growing confidence in the use of HGS to be an objective indicator for predicting QOL. Given the growing population of older adults, their susceptibility to frailty, and their health care utilization, it is critical that further research be conducted on HGS as a potential frailty measure for the clinical setting to support clinical decision making and course of treatment, as it appears to be a relevant predictor of the patient reported outcome of QOL.

Table 10- Descriptive Statistics and Correlations with QOL

Variable	Mean (SD)	Correlation PCS1	Correlatio n MCS1	Correlati on PCS2	Correlatio nMCS2
PCS1 (n=1247)	34.64	-----	-----	-----	-----
MCS1 (n=1247)	46.46	-----	-----	-----	-----
PCS2 (n=278)	36.20	-----	-----	-----	-----
MCS2 (n=278)	51.23	-----	-----	-----	-----
HGS (n=1146)	20.82 kg (12.35)	0.23***	0.043	0.26***	0.085
HGS (sex stratified)	M: 28.26 kg (12.45) F: 14.54 kg (8.01)				
5m (n=535)	Median= 8.98 s (6.59)	-0.21***	-0.038	-0.21*	-0.059
5m (sex stratified)	M: median=7.80 s (5.70) F: median=10.27 s (7.24)				
Age (n=1250)	68.48 years (15.28)	0.019	0.14***	-0.14*	0.23***
Age (sex stratified)	M: 66.91 years (15.09) F: 69.76 years (15.32)				

Variable	Mean PCS1	Mean MCS1	Mean PCS2	Mean MCS2
Sex				
Male	35.53	47.35	37.59	51.91
Female	33.92	45.75	35.13	50.71
Test Statistic	*2.79*	*2.43**	*1.94*	*1.01*
Site				
1	35.64	42.69	38.23	50.71
2	32.04	46.23	35.45	51.26
3	33.95	48.64	34.85	50.91
4	38.03	47.90	36.50	51.63
5	32.45	46.61	35.93	51.68
Test Statistic	*15.42****	*10.86****	*0.84*	*0.10*
Nutritional Status				
Malnourished[1]	32.04	43.68	35.81	51.08
Well-nourished[2]	35.25	47.13	36.28	51.24
Test Statistic	*4.42****	*4.17****	*0.27*	*0.10*
Diagnosis				
Cardiovascular	35.82	48.69	33.45	52.51
Gastrointestinal	34.62	45.73	36.69	50.44
Respiratory	35.14	44.24	36.48	50.50
Musculoskeletal	30.02	48.92	30.96	52.99
Neurological	39.53	49.31	40.70	49.87
Infection	32.68	46.65	34.54	52.55
Other	34.25	46.02	38.59	51.35
Test Statistic	*10.37****	*5.43****	*2.78**	*0.52*
Education Level				
Primary-graduated HS	34.45	46.87	36.21	51.26
Some post-sec.-Post-grad	34.78	46.43	36.13	51.54
Other/Not identified	35.38	43.74	36.51	49.23
Test Statistic	*0.42*	*3.14**	*0.01*	*0.43*
Living Situation				
Alone	34.02	45.57	35.74	51.23
W/ spouse	35.80	48.07	35.71	52.49
W/ spouse & other family	34.77	45.38	35.65	48.78
W/ other family/friends	33.51	46.18	38.13	47.85
Other	34.54	42.36	43.99	53.65
Test Statistic	*2.53**	*3.91***	*1.24*	*2.07*

Test statistic: * p<.05 **p<.01 ***p<0.001

[1]Malnourished group includes: SGA Bs and Cs; [2]Well-nourished group includes: No risk and SGA A

Abbreviations: HGS= Handgrip strength; 5M= Five meter timed walk; PCS1=Physical QOL in hospital; PCS2=Physical QOL 30 days post discharge; MCS1= Mental QOL in hospital; MCS2=Mental QOL 30 days post discharge; M=Male; F=Female; HS= High School

Table 11- Regression Analysis of In Hospital Physical QOL (PCS1) and HGS Stratified by Sex

	Model 1				Model 2			
	Male (n=525)		Female (n=621)		Male (n=525)		Female (n=621)	
	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value
HGS	N/A	N/A	N/A	N/A	0.23 (0.1, 0.3)	<.0001	0.28 (0.2, 0.4)	<.0001
Age	-0.01 (-0.1, 0.05)	0.75	0.03 (-0.02, 0.09)	0.21	0.06 (-0.01,0.1)	0.07	0.07 (0.02, 0.1)	0.003
Site		0.32		<.0001		0.16		<.0001
1	1.60 (-1.6, 4.8)		5.24 (2.2, 8.2)		2.64 (-0.5, 5.8)		6.03 (3.1, 9.0)	
2	-0.79 (-3.9, 2.4)		1.86 (-0.8, 4.5)		2.08 (-1.1, 5.3)		5.52 (2.5, 8.6)	
3	0.55 (-2.3, 3.4)		1.45 (-1.2, 4.1)		0.96 (-1.8, 3.8)		2.07 (-0.6, 4.7)	
4	2.59 (-0.7, 5.9)		6.30 (3.6, 9.0)		3.67 (0.4, 6.9)		7.16 (4.5, 9.8)	
5	-----		-----		-----		-----	
SGA		0.005		0.05		0.06		0.17
A/no risk	-----		-----		-----		-----	
B/C	-3.30 (-5.6, -1.0)		-1.92 (-3.9, 0.03)		-2.18 (-4.5, 0.1)		-1.35 (-3.3, 0.6)	
Diagnosis		0.07		0.005		0.04		0.01
Cardio	-----		-----		-----		-----	
Gastro	-3.01 (-7.2, 1.2)		1.75 (-1.8, 5.3)		-2.86 (-6.9, 1.2)		1.25 (-2.2, 4.8)	
Resp	-2.10 (-5.5, 1.3)		0.16 (-2.7, 3.0)		-2.42 (-5.7, 0.8)		-0.14 (-3.0, 2.7)	
Musc	-4.75 (-9.2, -0.3)		-3.50 (-6.8, -0.2)		-5.33 (-9.7, -1.0)		-3.09 (-6.3, 0.1)	
Neuro	1.62 (-2.2, 5.4)		3.57 (0.07, 7.1)		1.35 (-2.4, 5.0)		3.52 (0.1, 7.0)	
Infect	-3.54 (-7.1, 0.1)		-1.94 (5.2, 1.3)		-3.15 (-6.7, 0.3)		-2.13 (-5.3, 1.1)	
Other	-1.0 (-4.3, 2.3)		-0.15 (-3.0, 2.7)		-0.34 (-3.6, 2.9)		-0.23 (-3.1, 2.6)	
Education		0.57		0.45		0.81		0.48
Primary-graduated HS	-----		-----		-----		-----	
Some post-sec.-Post-grad	1.02 (-0.9, 2.9)		-0.69 (-2.7, 0.8)		0.61 (-1.2, 2.4)		-1.0 (-2.7, 0.7)	
Other/Not identified	0.49 (-2.8, 3.8)		0.64 (-2.5, 3.8)		0.37 (-2.8, 3.5)		0.27 (-2.8, 3.4)	
Living Situation		0.58		0.57		0.90		0.53
Alone	-----		-----		-----		-----	
W/ Spouse	1.51 (-0.6, 3.6)		0.41 (-1.5, 2.3)		0.89 (-1.2, 3.0)		0.44 (-1.4, 2.3)	
W/ Spouse & other family	1.47 (-1.7, 4.6)		-1.40 (-4.5, 1.7)		0.56 (-2.5, 3.6)		-1.18 (-4.2, 1.9)	
	-0.15 (-3.0, 2.7)		-0.82 (-2.9, 1.3)		0.28 (-2.5, 3.1)		-0.59 (-2.6, 1.5)	

W/ Other family & friends Other	1.20 (-5.1, 7.5)		2.70 (-3.6, 9.0)		2.11 (-4.0, 8.2)		3.74 (-2.4, 9.9)	
R^2	0.081		0.118		0.135		0.147	
Log likelihood	-1947.25		-2271.20		-1931.36		-2260.69	
LRT	N/A		N/A		X^2= 31.78, p<0.01		X^2=21.02, p<0.01	

Abbreviations: HGS= Handgrip strength; QOL: Quality of life; PCS1=Physical QOL in hospital Adm.Cat.= Admission Category; Cardio.= Cardiovascular; Gastro.= Gastrointenstinal; Resp.= Respiratory; Musc.= Musculoskeletal; Neuro.= Neurological; Infect.= Infection.

Table 12- Regression Analysis of In Hospital Mental QOL (MCS1) and HGS Stratified by Sex

	Model 1				Model 2			
	Male (n=525)		Female (n=621)		Male (n=525)		Female (n=621)	
	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value
HGS	N/A	N/A	N/A	N/A	0.03 (-0.06, 0.1)	0.52	0.14 (0.001, 0.3)	0.05
Age	0.05 (-0.01, 0.1)	0.12	0.14 (0.1, 0.2)	<.0001	0.06 (-0.01, 0.1)	0.09	0.16 (0.09, 0.2)	<.0001
Site		0.003		0.07		0.003		0.02
1	-2.24 (-5.8, 1.3)		-3.92 (-7.4, -0.4)		-2.10 (-5.7, 1.5)		-3.51 (-7.0, -0.01)	
2	1.10 (-2.4, 4.6)		0.18 (-2.9, 3.3)		1.48 (-2.2, 5.2)		2.07 (-1.5, 5.7)	
3	2.88 (-0.3, 6.1)		0.27 (-2.8, 3.4)		2.93 (-0.3, 6.1)		0.59 (-2.5, 3.7)	
4	5.12 (1.5, 8.8)		-1.34 (-4.5, 1.8)		5.27 (1.6, 9.0)		-0.90 (-4.0, 2.2)	
5	-----		-----		-----		-----	
SGA		0.02		0.004		0.03		0.008
A/no risk	-----		-----		-----		-----	
B/C	-3.05		-3.40 (-5.7, -1.1)		-2.90 (-5.5, -0.3)		-3.10 (-5.4, -0.8)	
Diagnosis		0.63		0.43		0.69		0.38
Cardio	-----		-----		-----		-----	
Gastr	-0.59 (-5.2, 4.1)		0.55 (-3.6, 4.7)		-0.57 (-5.2, 4.1)		0.30 (-3.8, 4.4)	
Resp	0.80 (-2.9, 4.5)		-2.10 (-5.5, 1.3)		0.76 (-3.0, 4.5)		-2.26 (-5.6, 1.1)	
Musc	2.07 (-2.9, 7.0)		0.73 (-3.1, 4.5)		2.00 (-3.0, 6.9)		0.94 (-2.9, 4.7)	
Neuro	0.01 (-4.2, 4.2)		0.77 (-3.3, 4.8)		-0.03 (-4.2, 4.2)		0.75 (-3.3, 4.8)	
Infect	0.11 (-3.9, 4.1)		1.23 (-2.7, 4.9)		0.16 (-3.8, 4.1)		1.02 (-2.8, 4.8)	
Other	-1.89 (-5.6, 1.8)		-1.02 (-4.4, 2.3)		-1.81 (-5.5, 1.9)		-1.06 (-4.4, 2.3)	
Education		0.29		0.17		0.28		0.15
Primary-graduated HS	-----		-----		-----		-----	
Some post-sec.-Post-grad	-1.94 (-3.3, 0.9)		1.38 (-0.6, 3.4)		-1.25 (-3.3, 0.8)		1.37 (-0.6, 3.4)	
Other/Not identified	0.34 (-6.0, 1.2)		-1.90 (-5.6, 1.8)		-2.45 (-6.1, 1.2)		-2.10 (-5.8, 1.6)	
Living Situation		0.06		0.67		0.06		0.68
Alone	-----		-----		-----		-----	
W/ Spouse	3.14 (0.8, 5.5)		1.68 (-0.5, 3.9)		3.06 (0.7, 5.4)		1.69 (-0.5, 3.9)	
	0.34 (-3.2, 3.8)		0.73 (-2.9, 4.3)		0.22 (-3.3, 3.7)		0.84 (-2.8, 4.4)	

W/ Spouse & other family	2.77 (-0.4, 5.9)		0.60 (-1.8, 3.0)		2.83 (-0.3, 6.0)		0.72 (-1.7, 3.2)	
W/ Other family & friends	-1.38 (-8.3, 5.6)		0.01 (-7.3, 7.3)		-1.26 (-8.2, 5.7)		0.54 (-6.7, 7.8)	
Other								
R^2	0.106		0.105		0.106		0.110	
Log likelihood	-2000.23		-2365.90		-2000.01		-2363.89	
LRT	N/A		N/A		X^2= 0.44, 0.50<p<0.75		X^2=4.02, p<0.05	

Abbreviations: HGS= Handgrip strength; QOL: Quality of life; MCS1=Mental QOL in hospital Adm.Cat.= Admission Category; Cardio.= Cardiovascular; Gastro.= Gastrointenstinal; Resp.= Respiratory; Musc.= Musculoskeletal; Neuro.= Neurological; Infect.= Infection.

Table 13- Regression Analysis of In Hospital Physical QOL (PCS1) and 5M Stratified by Sex

	Model 1				Model 2			
	Male (n=279)		Female (n=256)		Male (n=279)		Female (n=256)	
	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value
5m	N/A	N/A	N/A	N/A	-0.36 (-0.6, -0.1)	0.003	-0.36 (-0.5, -0.2)	0.0001
Age	-0.04 (-0.1, 0.05)	0.36	0.04 (-0.1, 0.1)	0.45	-0.003 (-0.1, 0.1)	0.96	0.06 (-0.03, 0.1)	0.21
Site		0.13		0.001		0.03		0.0003
1	3.49 (-1.4, 8.3)		4.65 (-0.8, 10.1)		2.56 (-2.3, 7.4)		3.67 (-1.6, 9.0)	
2	-0.15 (-5.5, 5.2)		2.47 (-2.6, 7.6)		-0.78 (-6.0, 4.5)		0.84 (-4.2, 5.9)	
3	1.10 (-3.3, 5.5)		-0.25 (-5.0, 4.4)		0.20 (-4.2, 4.6)		-0.44 (-5.0, 4.1)	
4	5.26 (0.2, 10.4)		7.31 (2.4, 12.3)		6.35 (1.3, 11.4)		7.56 (2.7, 12.4)	
5	-----		-----		-----		-----	
SGA		0.0004		0.20		0.004		0.19
A/no risk	-----		-----		-----		-----	
B/C	-6.61 (-10.2, -3.0)		-2.18 (-5.5, 1.1)		-5.42 (-9.1, -1.8)		-2.15 (-5.4, 1.1)	
Diagnosis		0.06		0.42		0.09		0.54
Cardio	-----		-----		-----		-----	
Gastr	0.05 (-6.0, 6.0)		-0.84 (-6.1, 4.5)		-0.50 (-6.4, 5.4)		-0.22 (-5.4, 5.0)	
Resp	-1.51 (-5.8, 2.8)		-2.52 (-7.1, 2.1)		-1.86 (-6.1, 2.4)		-1.92 (-6.4, 2.6)	
Musc	-7.65 (-15.2, -0.09)		-5.12 (-10.7, 0.5)		-7.64 (-15.1, -0.2)		-1.42 (-7.2, 4.3)	
Neuro	1.59 (-3.4, 6.6)		0.85 (-4.5, 6.2)		0.58 (-4.4, 5.6)		2.28 (-2.9, 7.5)	
Infect	-2.36 (-7.4, 2.6)		-3.84 (-9.1, 1.4)		-2.66 (-7.6, 2.3)		-3.71 (-8.8, 1.4)	
Other	3.31 (-1.2, 7.5)		-0.89 (-5.5, 3.7)		2.54 (-1.7, 6.8)		0.15 (-4.4, 4.7)	
Education		0.15		0.78		0.32		0.81
Primary-graduated HS	-----		-----		-----		-----	
Some post-sec.-Post-grad	2.32 (-0.5, 5.1)		-0.53 (-3.3, 2.3)		1.00 (-0.8, 4.7)		-0.79 (-3.5, 1.9)	
Other/Not identified	-1.29 (-6.3, 3.7)		-1.58 (-6.3, 3.1)		-0.51 (-5.5, 4.5)		-1.02 (-5.6, 3.6)	
Living Situation		0.19		0.33		0.21		0.65
Alone	-----		-----		-----		-----	
W/ Spouse	1.01 (-1.7, 4.2)		1.03 (-1.7, 4.2)		0.69 (-2.2, 3.6)		1.05 (-1.9, 3.9)	
	1.02 (-3.2, 5.6)		-1.13 (-6.2, 3.9)		1.04 (-3.1, 5.6)		-1.58 (-6.5, 3.3)	

W/ Spouse & other family W/ Other family & friends Other	 -3.21 (-7.5, 1.1) -6.72 (-19.0, 5.6)		 -2.79 (-6.5, 1.0) -2.21 (-12.4, 8.0)		 -3.37 (-7.6, 0.9) -7.02 (-19.2, 5.1)		 -1.50 (-5.2, 2.2) -2.96 (-12.9, 7.0)	
R^2	0.149		0.157		0.177		0.207	
Log likelihood	-1036.08		-934.36		-1031.37		-926.50	
LRT	N/A		N/A		X^2=9.42, p<0.01		X^2=15.72, p<0.01	

Abbreviations: 5m= 5 meter walk test; QOL: Quality of life; PCS1=Physical QOL in hospital Adm.Cat.= Admission Category; Cardio.= Cardiovascular; Gastro.= Gastrointenstinal; Resp.= Respiratory; Musc.= Musculoskeletal; Neuro.= Neurological; Infect.= Infection.

Table 14- Regression Analysis of In Hospital Mental QOL (MCS1) and 5M Stratified by Sex

	Model 1				**Model 2**			
	Male (n=279)		**Female (n=256)**		**Male (n=279)**		**Female (n=256)**	
	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value
5m	N/A	N/A	N/A	N/A	-0.25 (-0.5, -0.01)	0.04	-0.05 (-0.3, 0.2)	0.65
Age	0.15 (0.06, 0.3)	0.002	0.15 (0.04, 0.3)	0.006	0.18 (0.1, 0.3)	0.0004	0.15 (0.05, 0.3)	0.005
Site		0.12		0.74		0.06		0.73
1	-5.68 (-10.6, -0.8)		-3.61 (-9.7, 2.5)		-6.33 (-11.3, -1.4)		-3.75 (-9.9, 2.4)	
2	-1.27 (-6.6, 4.1)		-1.57 (-7.3, 4.1)		-1.71 (-7.1, 3.6)		-1.79 (-7.6, 4.0)	
3	-5.04 (-9.5,-0.5)		-1.04 (-6.3, 4.2)		-5.67 (-10.2, -1.2)		-1.07 (-6.3, 4.2)	
4	-3.52 (-87, 1.6)		-2.46 (-8.0, 3.1)		-2.77 (-7.9, 2.4)		-2.42 (-8.0, 3.1)	
5	-----		-----		-----		-----	
SGA		0.18		0.04		0.38		0.04
A/no risk	-----		-----		-----		-----	
B/C	-2.49 (-6.1, 1.2)		-3.87 (-7.6, -0.2)		-1.67 (-5.4, 2.0)		-3.87 (-7.6, -0.1)	
Diagnosis		0.42		0.31		0.33		0.32
Cardio	-----		-----		-----		-----	
Gastr	-0.82 (-6.9, 5.3)		-3.76 (-9.7, 2.1)		-1.21 (-7.3, 4.9)		-3.67 (-9.6, 2.4)	
Resp	-1.15 (-5.5, 3.2)		-0.79 (-5.9, 4.4)		-1.39 (-5.7, 3.0)		-0.71 (-5.9, 4.5)	
Musc	1.36 (-6.3, 9.0)		0.15 (-6.1, 6.4)		1.36 (-6.2, 9.0)		0.64 (-6.0, 7.3)	
Neuro	-0.89 (-6.0, 4.2)		-2.17 (-8.1, 3.8)		-1.59 (-6.7, 3.5)		-1.97 (-8.0, 4.0)	
Infect	-2.40 (-7.5, 2.7)		3.93 (-1.9, 9.8)		-2.61 (-7.7, 2.4)		3.95 (-1.9, 9.8)	
Other	-4.56 (-8.9, -0.2)		-1.75 (-6.9, 3.4)		-4.97 (-9.3, -0.6)		-1.61 (-6.8, 3.6)	
Education		0.12		0.24		0.14		0.26
Primary-graduated HS	-----		-----		-----		-----	
Some post-sec.-Post-grad	-1.87 (-4.7, 0.9)		1.10 (-2.0, 4.2)		-2.15 (-5.0, 0.7)		0.5 (-2.1, 4.2)	
Other/Not identified	-4.92 (-10.0, 0.2)		-3.54 (-8.8, 1.7)		-4.38 (-9.5, 0.7)		-3.46 (-8.7, 1.8)	

Living Situation		0.05		0.76		0.09		0.79
Alone	-----		-----		-----		-----	
W/ Spouse	2.96 (-0.03, 5.9)		2.12 (-1.2, 5.4)		2.60 (-0.4, 5.6)		2.08 (-1.2, 5.4)	
W/ Spouse & other family	-3.19 (-7.7, 1.3)		1.93 (-3.7, 7.6)		-3.15 (-7.6, 1.3)		1.86 (-3.8, 7.5)	
W/ Other family & friends	0.53 (-3.8, 4.9)		0.39 (-3.8, 4.6)		0.42 (-3.9, 4.7)		0.57 (-3.7, 4.8)	
Other	-2.89 (-15.4, 9.6)		1.60 (-9.8, 13.0)		-3.10 (-15.5, 9.3)		1.50 (-9.9, 12.9)	
R^2	0.164		0.124		0.177		0.124	
Log likelihood	-1039.55		-962.6201		-1037.37		-962.51	
LRT	N/A		N/A		X^2=4.36, p<0.05		X^2=0.22, 0.50<p<0.75	

Abbreviations: 5m= 5 meter walk test; QOL: Quality of life; MCS1=Mental QOL in hospital Adm.Cat.= Admission Category; Cardio.= Cardiovascular; Gastro.= Gastrointenstinal; Resp.= Respiratory; Musc.= Musculoskeletal; Neuro.= Neurological; Infect.= Infection

Table 15- Regression Analysis of 30D Physical QOL (PCS2) and HGS Stratified by Sex

	Model 1				Model 2			
	Male (n=111)		Female (n=147)		Male (n=111)		Female (n=147)	
	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value
HGS	N/A	N/A	N/A	N/A	0.35 (0.1, 0.6)	0.003	0.38 (0.1, 0.6)	0.003
Age	-0.12 (-0.3, 0.04)	0.13	-0.03 (-0.1, 0.1)	0.75	0.005 (-0.1, 0.1)	0.99	0.02 (-0.09, 0.1)	0.70
Site		0.15		0.90		0.05		0.61
1	9.07 (0.3, 17.8)		-1.68 (-8.9, 5.5)		11.69 (3.2, 20.2)		0.27 (-6.3, 6.8)	
2	1.99 (-7.3, 11.2)		-2.59 (-9.4, 4.2)		7.49 (-1.0, 16.1)		3.56 (-3.5, 10.6)	
3	4.55 (-3.4, 12.5)		-3.39 (-10.2, 3.4)		8.02 (0.9, 15.2)		-1.70 (-7.8, 4.4)	
4	-1.73 (-9.5, 6.0)		-2.26 (-9.0, 4.5)		1.71 (-5.2, 8.6)		0.20 (-6.0, 6.4)	
5	-----		-----		-----		-----	
SGA		0.51		0.19		0.25		0.22
A/no risk	-----		-----		-----		-----	
B/C	2.07 (-4.1, 8.2)		-3.18 (-8.0, 1.6)		3.50 (-1.3, 8.8)		-2.9 (-7.2, 1.4)	
Diagnosis		0.01		0.77		0.008		0.77
Cardio	-----		-----		-----		-----	
Gastr	2.77 (-8.1, 13.7)		3.81 (-3.4, 11.1)		5.71 (-3.8, 15.2)		3.17 (-3.3, 9.6)	
Resp	-3.23 (-12.3, 5.9)		4.36 (-1.7, 10.4)		-1.85 (-9.7, 6.0)		4.21 (-1.2, 9.6)	
Musc	-7.88 (-19.7, 3.9)		1.02 (-6.3, 8.3)		-6.82 (-17.0, 3.3)		1.43 (-5.1, 7.9)	
Neuro	12.11 (2.5, 21.7)		4.74 (-1.9, 11.4)		12.74 (4.5, 21.0)		4.18 (-1.8, 10.1)	
Infect	-4.05 (-13.8, 5.8)		2.46 (-5.3, 10.2)		-0.32 (-9.0, 8.4)		0.92 (-6.1, 7.9)	
Other	3.04 (-5.6, 11.6)		3.67 (-2.9, 10.3)		5.74 (-1.8, 13.3)		4.04 (-1.8, 9.9)	
Education		0.65		0.84		0.83		0.74
Primary-graduated HS	-----		-----		-----		-----	
Some post-sec.-Post-grad	-0.14 (-5.1, 5.1)		-0.80 (-4.6, 3.0)		-0.12 (-4.5, 4.2)		-1.22 (-4.6, 2.2)	
Other/Not identified	-4.12 (-13.2, 5.0)		1.24 (-7.3, 9.8)		-2.64 (-10.5 5.2)		0.93 (-6.7, 8.6)	
Living Situation		0.54		0.65		0.17		0.48
Alone	-----		-----		-----		-----	
W/ Spouse	-0.56 (-6.4, 5.2)		-0.68 (-4.6, 3.0)		-1.44 (-6.4, 3.6)		-0.93 (-4.5, 2.6)	
W/ Spouse & other family	-0.64 (-10.5, 9.2)		-0.30 (-6.7, 6.1)		-2.31 (-10.8, 6.2)		-0.79 (-6.5, 4.9)	
W/ Other family & friends	4.08 (-4.4, 12.5)		1.76 (-3.7, 7.2)		6.44 (-0.9, 13.8)		1.51 (-3.1, 6.3)	
Other	12.48 (-6.0, 31.0)		7.53 (-4.9, 20.0)		14.68 (-1.2, 30.6)		8.96 (-2.2, 20.1)	
R^2	0.238		0.088		0.307		0.152	
Log likelihood	-419.47		-530.94		-414.28		-525.61	
LRT	N/A		N/A		X^2=10.62, p<0.01		X^2=10.75, p<0.01	

Abbreviations: HGS= Handgrip strength; QOL: Quality of life; PCS2=Physical QOL 30 days post-discharge; Adm.Cat.= Admission Category; Cardio.= Cardiovascular; Gastro.= Gastrointenstinal; Resp.= Respiratory; Musc.= Musculoskeletal; Neuro.= Neurological; Infect.= Infection.

Table 16- Regression Analysis of 30D Mental QOL (MCS2) and HGS Stratified by Sex

	Model 1				Model 2			
	Male (n=111)		Female (n=147)		Male (n=111)		Female (n=147)	
	Parameter estimate	P value	Parameter estimate	P value	Parameter estimate	P value	Parameter estimate	P value
HGS	N/A	N/A	N/A	N/A	0.19 (-0.006, 0.4)	0.07	-0.04 (-0.3, 0.2)	0.80
Age	0.004 (-0.1, 0.1)	0.95	0.08 (-0.04, 0.2)	0.20	0.07 (-0.07, 0.2)	0.36	0.08 (-0.04, 0.2)	0.24
Site		0.53		0.59		0.33		0.58
1	0.47 (-7.4, 8.3)		0.14 (-6.9, 7.2)		1.92 (-5.1=2, 9.0)		-0.06 (-6.6, 6.5)	
2	1.84 (--6.5, 10.2)		-2.57 (-9.2, 4.1)		4.95 (-3.0, 12.9)		-3.20 (-10.3, 3.9)	
3	-1.27 (-8.5, 5.9)		-4.40 (-11.0, 2.2)		0.69 (-5.9, 7.3)		-4.58 (-10.7, 1.6)	
4	4.86 (-2.1, 11.8)		-1.94 (-8.5, 4.7)		6.79 (0.4, 13.2)		-2.19 (-8.5, 4.1)	
5	-----		-----		-----		-----	
SGA		0.79		0.77		0.99		0.78
A/no risk	-----		-----		-----		-----	
B/C	-0.76 (-6.3, 4.8)		0.69 (-4.0, 5.4)		0.04 (-4.9, 5.0)		0.66 (-3.7, 5.0)	
Diagnosis		0.51		0.53		0.32		0.54
Cardio	-----		-----		-----		-----	
Gastr	-0.86 (-10.7, 9.0)		-3.08 (-10.1, 3.9)		0.80 (-8.0, 9.6)		-3.01 (-9.5, 3.5)	
Resp	-1.73 (-9.9, 6.5)		-4.24 (-10.1, 1.6)		-0.95 (-8.2, 6.3)		-4.23 (-9.7, 1.2)	
Musc	-3.49 (-14.1, 7.1)		2.95 (-4.2, 10.1)		-2.89 (-12.3, 6.5)		2.91 (-3.7, 9.5)	
Neuro	-6.50 (-15.2, 2.2)		-2.47 (-9.0, 4.0)		-6.14 (-13.8, 1.5)		-2.42 (-8.4, 3.6)	
Infect	3.40 (-5.4, 12.2)		-2.23 (-9.8, 5.3)		5.50 (-2.6, 13.6)		-2.10 (-9.1, 5.0)	
Other	-0.30 (-8.0, 7.4)		-3.50 (-9.9, 2.9)		1.22 (-5.8, 8.2)		-3.54 (-9.5, 2.4)	
Education		0.94		0.82		0.97		0.83
Primary-graduated HS	-----		-----		-----		-----	
Some post-sec.-Post-grad	0.56 (-4.0, 5.1)		-0.39 (-4.0, 3.3)		0.50 (-3.5, 4.5)		-0.35 (-3.8, 3.1)	
Other/Not identified	-0.79 (-9.0, 7.4)		-2.63 (-11.0, 5.7)		0.04 (-7.3, 7.3)		-2.59 (-10.3, 5.1)	
Living Situation		0.02		0.23		0.07		0.25
Alone	-----		-----		-----		-----	
W/ Spouse	4.94 (-0.3, 10.2)		-0.07 (-3.9, 3.8)		4.44 (-0.2, 9.1)		-0.05 (-3.6, 3.5)	
W/ Spouse & other family	-0.10 (-9.0, 8.8)		-5.50 (-11.7, 0.7)		-1.04 (-8.9, 6.8)		-5.45 (-11.2, 0.3)	
W/ Other family & friends	-7.90 (-15.5, -0.3)		-1.46 (-6.7, 3.8)		6.56 (-13.4, 0.3)		-1.44 (-6.3, 3.4)	
Other	-0.59 (-17.2, 16.1)		6.80 (-5.3, 18.9)		0.66 (-14.1, 15.4)		6.66 (-4.6, 17.9)	
R^2	0.157		0.103		0.187		0.104	
Log likelihood	-408.04		-526.78		-406.03		-526.73	
LRT	N/A		N/A		X^2=4.0, $p<0.05$		X^2=0.06, $0.75<p<0.90$	

Abbreviations: HGS= Handgrip strength; QOL: Quality of life; MCS2=Mental QOL 30 days post-discharge; Adm.Cat.= Admission Category; Cardio.= Cardiovascular; Gastro.= Gastrointenstinal; Resp.= Respiratory; Musc.= Musculoskeletal; Neuro.= Neurological; Infect.= Infection

Table 17- Regression Analysis of 30D Physical QOL (PCS2) and 5M Stratified by Sex

	Model 1				Model 2			
	Male (n=66)		Female (n=73)		Male (n=66)		Female (n=73)	
	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value
5m	N/A	N/A	N/A	N/A	-0.22 (-0.7, 0.3)	0.36	-0.34 (-0.7, 0.03)	0.08
Age	-0.06 (-0.3, 0.2)	0.61	0.07 (-0.1, 0.3)	0.46	-0.006 (-0.3, 0.3)	0.96	0.06 (-0.1, 0.3)	0.53
Site		0.85		0.16		0.85		0.12
1	2.61 (-9.8, 15.0)		-0.11 (-11.8, 11.5)		0.53 (-12.7, 13.7)		-2.64 (-14.4, 9.1)	
2	-2.69 (-16.8, 11.4)		-0.12 (-11.4, 11.2)		-4.90 (-19.8, 13.7)		-3.70 (-15.5, 8.1)	
3	-2.49 (-14.0, 9.0)		-8.10 (-18.2, 2.0)		-4.27 (-16.4, 7.9)		-10.24 (-20.5, -0.03)	
4	-2.96 (-14.8, 8.9)		1.62 (-7.9, 11.1)		-1.95 (-14.0, 10.1)		-0.54 (-10.2, 9.1)	
5	-----		-----		-----		-----	
SGA		0.19		0.17		0.13		0.16
A/no risk	-----		-----		-----		-----	
B/C	5.63 (-2.9, 14.1)		-5.50 (-13.5, 2.5)		6.80 (-2.1, 15.7)		-5.63 (-13.5, 2.2)	
Diagnosis		0.11		0.94		0.27		0.95
Cardio	-----		-----		-----		-----	
Gastr	-1.77 (-15.5, 11.9)		0.36 (-10.5, 11.2)		-1.04 (-14.9, 12.8)		-0.75 (-11.4, 9.9)	
Resp	-1.37 (-12.6, 9.8)		-3.39 (-13.8, 7.0)		-1.59 (-12.8, 9.6)		-4.26 (-14.5, 6.0)	
Musc	-7.64 (-26.1, 10.8)		-1.42 (-17.6, 14.8)		-6.03 (-24.8, 12.8)		-0.88 (-16.8, 15.0)	
Neuro	9.37 (-2.1, 20.8)		-0.97 (-11.1, 9.1)		7.04 (-5.5, 19.6)		-1.49 (-11.4, 8.4)	
Infect	-9.78 (-23.8, 4.2)		4.50 (-6.9, 15.9)		-10.35 (-24.5, 3.8)		3.13 (-8.1, 14.4)	
Other	4.85 (-4.7, 14.4)		-1.88 (-12.1, 8.4)		4.35 (-5.3, 14.0)		-1.61 (-11.6, 8.4)	
Education		0.93		0.56		0.78		0.80
Primary-graduated HS	-----		-----		-----		-----	
Some post-sec.-Post-grad	-0.20 (-6.9, 6.5)		0.23 (-2.9, 9.1)		-0.36 (-7.1, 6.4)		1.70 (-4.4, 7.8)	
Other/Not identified	2.05 (-10.6, 14.6)		3.45 (-8.8, 15.7)		4.17 (-9.3, 17.6)		3.00 (-9.0, 15.0)	

Living Situation Alone	-----	0.97	-----	0.81	-----	0.97	-----	0.95
W/ Spouse	1.37 (-5.9, 8.7)		-1.75 (-7.9, 4.4)		0.65 (-6.8, 8.1)		-1.93 (-7.9, 4.1)	
W/ Spouse & other family	2.40 (-10.6, 15.4)		2.92 (-7.1, 12.9)		2.50 (-10.5, 15.5)		0.68 (-9.5, 10.8)	
W/ Other family & friends	0.23 (-9.7, 16.5)		-1.36 (-9.5, 6.8)		0.23 (-9.7, 16.6)		-0.74 (-8.8, 7.3)	
Other	5.60 (-19.5, 30.7)		5.22 (-12.2, 22.6)		6.07 (-19.1, 31.3)		2.23 (-15.1, 19.6)	
R^2	0.308		0.210		0.321		0.256	
Log likelihood	-239.48		-259.42		-238.87		-257.23	
LRT	N/A		N/A		X^2=1.22, 0.25<p<0.50		X^2=4.38, p<0.05	

Abbreviations: 5m= 5 meter walk test; QOL: Quality of life; PCS2=Physical QOL 30 days post-discharge; Adm.Cat.= Admission Category; Cardio.= Cardiovascular; Gastro.= Gastrointenstinal; Resp.= Respiratory; Musc.= Musculoskeletal; Neuro.= Neurological; Infect.= Infection.

Table 18- Regression Analysis of 30D Mental QOL (MCS2) and 5M Stratified by Sex

	Model 1				Model 2			
	Male (n=66)		Female (n=73)		Male (n=66)		Female (n=73)	
	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value
5m	N/A	N/A	N/A	N/A	-0.34 (-0.8, 0.2)	0.18	0.09 (-0.3, 0.4)	0.63
Age	-0.13 (-0.4, 0.1)	0.29	0.23 (-0.07, 0.3)	0.23	-0.05 (-0.3, 0.2)	0.73	0.11 (-0.07, 0.3)	0.22
Site		0.80		0.97		0.58		0.99
1	0.40 (-12.4, 13.2)		-3.40 (-14.2, 7.4)		-2.77 (-16.3, 10.8)		-2.76 (-14.0, 8.5)	
2	0.24 (-14.4, 14.9)		-1.74 (-12.3, 8.8)		-3.12 (-18.5, 12.2)		-0.84 (-12.1, 10.4)	
3	-4.77 (-16.7, 7.1)		-2.72 (-12.1, 6.7)		-7.48 (-19.9, 5.0)		-2.17 (-11.9, 7.6)	
4	0.44 (-11.8, 12.7)		-2.36 (-11.2, 6.5)		1.98 (-10.4, 14.3)		-1.82 (-11.0, 7.4)	
5	-----		-----		-----		-----	
SGA								
A/no risk	-----		-----		-----		-----	
B/C	-1.30 (-10.1, 7.5)		4.51 (-2.9, 11.9)		0.48 (-8.7, 9.6)		4.54 (-3.0, 12.0)	
Diagnosis		0.87		0.90		0.84		0.93
Cardio	-----		-----		-----		-----	
Gastr	-2.98 (-17.2, 11.2)		-5.29 (-15.3, 4.7)		-1.87 (-16.0, 12.3)		-5.01 (-15.2, 5.2)	
Resp	-3.39 (-15.0, 8.2)		-1.01 (-10.7, 8.6)		-3.73 (-15.3, 7.8)		-0.79 (-10.5, 9.0)	
Musc	-3.42 (-22.6, 15.7)		-2.15 (-17.2, 12.9)		-0.96 (-20.3, 18.4)		-2.28 (-17.5, 12.9)	
Neuro	-0.90 (-12.8, 11.0)		-4.55 (-13.9, 4.8)		-4.43 (-17.3, 8.4)		-4.42 (-13.9, 5.1)	
Infect	7.10 (-7.44, 21.6)		-2.76 (-13.3, 7.8)		6.22 (-8.3, 20.7)		-2.42 (-13.2, 8.3)	
Other	1.05 (-8.9, 10.9)		-0.11 (-9.6, 9.4)		0.28 (-9.6, 10.2)		-0.18 (-9.8, 9.4)	
Education		0.88		0.66		0.99		0.62
Primary-graduated HS	-----		-----		-----		-----	
Some post-sec.-Post-grad	-0.26 (-7.2, 6.7)		1.71 (-3.9, 7.3)		-0.50 (-7.4, 6.4)		2.07 (-3.7, 7.9)	
Other/Not identified	-3.22 (-16.3, 9.8)		-2.76 (-14.2, 8.6)		0.01 (-13.8, 13.8)		-2.65 (-14.1, 8.9)	

Living Situation		0.05		0.25		0.09		0.24
Alone	-----		-----		-----		-----	
W/ Spouse	6.22 (-1.4, 13.8)		1.90 (-3.8, 7.6)		5.13 (-2.6, 12.8)		1.95 (-3.8, 7.7)	
W/ Spouse & other family	1.29 (-12.2, 14.8)		-1.93 (-11.2, 7.4)		1.44 (-11.9, 14.8)		-1.36 (-11.0, 8.3)	
W/ Other family & friends	-13.47 (-27.1, 0.1)		-5.07 (-12.7, 2.5)		-13.46 (-17.0, 0.04)		-5.23 (-12.9, 2.5)	
Other	-8.03 (-34.1, 18.1)		9.53 (-6.6, 25.7)		-7.33 (33.2, 18.6)		10.29 (-6.3, 26.9)	
R^2	0.249		0.216		0.279		0.219	
Log likelihood	-241.91		-254.04		-240.59		-253.88	
LRT	N/A		N/A		X^2=2.64, 0.10<p<0.25		X^2=0.32, 0.50<p<0.75	

Abbreviations: 5m= 5 meter walk test; QOL: Quality of life; MCS2=Mental QOL 30 days post-discharge; Adm.Cat.= Admission Category; Cardio.= Cardiovascular; Gastro.= Gastrointenstinal; Resp.= Respiratory; Musc.= Musculoskeletal; Neuro.= Neurological; Infect.= Infection

Chapter 7: Discussion

7.1 Introduction

The purpose of this research was to help create a better understanding of how frailty can be identified in an acute care setting with single indicators and whether these indicators (HGS/5m) could be used to predict important health outcomes. More specifically, the first goal of this research was to gain a better understanding of the feasibility of two objective frailty indicators to ultimately promote the use of the most appropriate tools in acute care. Another important goal of this research was to determine the predictive value of these tools to make important clinical decisions around treatment to promote best care practices with respect to LOS and QOL. Understanding what is associated with the construct of frailty in the acute care context, how it can feasibly be identified in this setting and how frailty is implicated in LOS and QOL had not yet been established in current literature. It is known that LOS is an important health outcome, and shorter LOS will improve patient flow and health care costs. Thus, identifying individuals who may have extended LOS using a simple indicator of frailty may support earlier treatment and thus potentially earlier discharge. In addition, current predictors of QOL for acute care patients are limited in research, and specifically single measures of frailty have yet to be investigated as potential predictors. This research aimed to strengthen the literature in this field and help to solve some of these existing gaps.

7.2 Feasibility of single indicators (HGS and 5m)

Experts have indicated that screening for frailty needs to occur in hospital settings, especially among older adults (>70 years) (Morley et al., 2016). For busy clinical environments, simple, objective tools are required. Such objective, physical performance measures, which are more focused on the functioning of the individual, are preferable to subjective evaluations for measuring frailty (Cesari et al., 2016). Screening should also be a quick and simple, preferably using as few indicators as possible to determine the likelihood of a condition (Kondrup et al., 2003). It has been shown that tests taken earlier or are quicker to complete produce better health outcomes (di Ruffano et al., 2012). Furthermore, to be of greatest utility for case finding, a screening tool should be completed on the entire target population, and in this case, acute care medical patients (Dans et al., 2011). In order to do this, the tool should ideally be able to be completed by any member of the medical team to avoid increasing the burden of a single discipline.

Study 1 (Chapter 4) identified that the 5m is likely not a suitable measure for screening of frailty in acute care, as less than half of patients could complete this measurement; many patients felt they were too fatigued, weak, dizzy, etc. to get out of bed. In addition, the difference in capacity to complete the 5m by sex was significant. This reinforces the unsuitability of 5m as a potential screening tool, as the acute care setting requires a screening tool that can be used by all (Kondrup et al., 2003). Furthermore, test-treatment pathways are typically unsuccessful if patients are unwilling to undergo a test or procedure (di Ruffano et al., 2012). Prior research has shown that the 5m is in fact reliable and feasible in community-dwelling older adults (Tiedemann, et al. 2008), indicating the need to potentially consider different measures in different settings. A significantly longer LOS, and a high proportion of perceived disability was seen in those who could not complete the 5m, indicating that perhaps completion status of the 5m in and of itself, rather than slow gait speed could be a helpful indicator of frailty or other patient reported outcomes.

Almost the entire sample was able to complete the HGS measure, indicating that it is likely a more feasible tool to use in acute care medical patients for decision-making with respect to treatment and care activities. This tool was feasible in older adults, and had higher completion rates among both males and females as compared to the 5m. Another important consideration for determining an appropriate screening tool for frailty is the association with nutritional status. In addition to overall feasibility, patients were able to complete the HGS assessment, regardless of nutritional status. This is critical if clinicians are inclined to add SGA to a frailty indicator to provide a more comprehensive representation of frailty. As a result of Study 1 findings, further discussion will be focused on the use of HGS as a frailty measure for hospital patients.

7.2 Is HGS a measure of frailty (and not malnutrition)?

There was considerable overlap between nutritional status and frailty (as measured by the 5 m), with 71% of those being malnourished, also being frail. The significant association for both HGS and 5m scores with nutritional status, helps to demonstrate construct validity in these frailty indicators, as frailty and malnutrition are theoretically related (Clegg et al., 2013; Chung et al., 2014; Jeejeebhoy, 2012; Savva et al., 2012; Studenski et al., 2003). In addition, patients in this analysis who had lower HGS scores typically had lower perceived and actual food intake, and experienced more barriers to food intake. These associations suggest that HGS may be more related to malnutrition than 5m, and thus it is not surprising that some have considered HGS as a potential indicator for malnutrition (Norman et al., 2011). Yet, this association with functional capacity to eat suggests that HGS is measuring risk factors for poor food intake rather than malnutrition per se. This evidence could be used to substantiate the view that HGS has potential utility for use in acute care, as it may point to an individual with barriers to food intake while in hospital that needs intervention. As well, HGS (using the cut-points in chapter 5) was found to be a poor proxy measure for malnutrition due to inadequate SE and SP when compared to the SGA in this sample (Giulani: SE= 0.42, SP=0.73; Sallinen Male: SE=0.88, SP=0.25; Sallinen Female:

SE=0.86, SP=0.21; Alley Male: SE=0.59, SP=0.63; Alley Female: SE=0.70, SP=0.46). These findings confirm Jeejeebhoy's early findings (Jeejeebhoy et al., 2015) that HGS is measuring a construct that is different from but associated with malnutrition, and in this context, potentially frailty.

The construct validity of these indicators was further reinforced with significant differences in both HGS and 5m scores in those who did not perceive any disability vs. those who did perceive that they had a disability. This suggests that 5m and HGS are likely measuring something analogous to physical frailty rather than malnutrition. Yet, this analysis also warrants further exploration of whether or not HGS is truly measuring the entire construct of frailty. Criterion validity testing needs to be done in further research to determine the validity of these tools for this purpose. The Clinical Frailty Scale (CFS) is a subjective tool that has been shown to be effective and valid for measuring frailty, and provides important predictive information about death, and other adverse outcomes (Rockwood et al., 2005). Current work is being done to improve the utility of the CFS. The Frailty Assessment for Care-planning Tool (FACT) is a modification of the CFS that can be used by non-experts/non-geriatricians, includes validated screening tools for cognitive assessment, relies on collateral history instead of self-report, and combines some scores for easier scoring without losing information pertinent to clinical decision making (Moorehouse et al., 2017 *not published*). This tool has been shown to be more closely associated the Frailty Index (Fried, 2001) than the CFS. Both the CFS and FACT tools may be a starting to point to determine the criterion validity of single objective measures such as HGS by collecting frailty data on acute care patients from CFS, FACT and HGS and completing SE and SP analyses.

7.3 Who has a low HGS and what could this mean for hospital patients?

In this sample, those who had low HGS also experienced a variety of negative health related characteristics. These people tended to be malnourished, perceived that they had a disability, had lower levels of education, did not live with their spouse/immediate family, had low food intake in hospital, perceived that they were not eating enough, and had more barriers to food intake while in hospital. The multitude of negative health related characteristics captured in this analysis in association with low HGS indicates that perhaps this tool is capturing those who are frail as defined by Rockwood (2005), who defined frailty as an accumulation of deficits over time that reduces one's capacity to resist stressors (Rockwood, 2005). These negative health characteristics are also related to many of the indicators used to make up the Frailty Index (from which the Clinical Frailty Scale was derived from) (Rockwood et al., 2005). This is also consistent with the Fried (2001) criteria for frailty that suggests that weight loss is a significant component of frailty. These associations suggest that perhaps those who have low HGS in this sample, are in fact those who are frail. Based on this rationale, there is great utility in finding those who have low HGS in clinical practice. Those who have low HGS likely need greater treatment with respect to nutrition care as they experience more barriers to food intake, and actually consume less food in hospital than those who have higher HGS. Further consideration of how these patients can be supported upon discharge to avoid readmission could be another potential use for HGS measurement in hospital. These patients need to be identified in hospital to address these important care issues and be provided necessary treatments.

7.4 Predictive validity of HGS with respect to LOS and QOL

As mentioned, screening tools need to be simple, objective measures that can be used to determine the likelihood of a condition occurring. However, these tools also need to be relevant for predicting important outcomes and need to support clinical decision-making. Of particular importance and relevance are LOS (with obvious financial implications for the health care system) and QOL (to promote the delivery of patient centered care).

Correlations between HGS and LOS were significant and in the anticipated direction, confirming that lower HGS values are associated with longer LOS. Yet an association is not sufficient to demonstrate the relevance of a new tool in clinical practice. The inclusion of a new clinical measure on all patients needs to demonstrate at minimum that it adds value to treatment decisions and is associated with patient outcomes, as well as being responsive to treatment. This analysis demonstrated that HGS provided additional predictive value for LOS when adjusting for other covariates that would be collected in a clinical setting. Based on this analysis, HGS appears to be a promising tool for measuring frailty and predicting clinical outcomes such as LOS in this setting. The overall low R^2 values of the predictive models may in part be attributed to the amount of variance inherent in the outcome (LOS). It is recommended that further predictive validity of HGS be assessed for other clinical outcomes in a more representative sample to determine its utility while adjusting for other relevant covariates (e.g. disease severity) that likely influence these outcomes.

Correlations between HGS and physical components of QOL were also significant and in the anticipated direction, confirming that lower HGS values are associated with poorer physical QOL. However, HGS does not appear to be strongly associated with the mental summary scores generated by the SF-12, indicating it is not reflective of mental QOL. As with LOS, this analysis demonstrated that HGS provided additional predictive value for PCS1/PCS2 when adjusting for other covariates that would be collected in a clinical setting. Based on this analysis, HGS appears to be a potential tool for measuring frailty and predicting clinical outcomes such physical QOL in this setting.

If objective tools are to be used in clinical practice, they require a score or cut-point upon which decisions are made with respect to treatment options. Development of new cut-points for HGS based on this sample was not considered appropriate, as eligible patients included in this data collection were not representative of all medical patients (i.e. excluded persons with dementia, not living in the community, too unwell to participate). Thus, this analysis was focused on determining if current published cut-points would be appropriate when considering the outcome of LOS. The cut-points chosen in this study to identify frailty with HGS have been used in the past to determine functional disability and mobility limitations (Alley et al., 2014; Giulani et al., 2008; Sallinen et al., 2010) and are below the 50th percentile HGS reference values for similar age categories (Stats Canada, 2007 to 2013 Canadian Health Measures Survey (reference equations)), indicating that they are likely capturing less well individuals. However, these existing HGS and 5m cut-points for frailty do not appear to be useful for predicting LOS, as all cut-points produced SE/SP/AUC values <0.70. These results reveal that if further work is pursued with HGS cut-points need to be improved and re-assessed to capture and predict clinical outcomes such as LOS in an unbiased sample.

7.5 HGS- a superior single indicator for frailty in acute care

Overall, HGS appears to be a more appropriate single indicator for frailty for consideration of use in acute care. This tool has shown that it is feasible, and can be completed by both male and female medical patients and those who are >65 years. This tool appears to be related with nutritional status and perceived functional disability, indicating that it is likely measuring frailty (as defined by Fried, 2001). HGS also appears to be relevant for predicting important outcomes and clinical decision-making. Lower HGS values were correlated with longer LOS and poorer physical QOL. HGS also provided additional predictive value for LOS and physical QOL in hospital and 30 days post-discharge when adjusting for other covariates that would be collected in a clinical setting, including nutritional status. Consideration for use of this tool in acute care should be considered once appropriate cut-points have been determined.

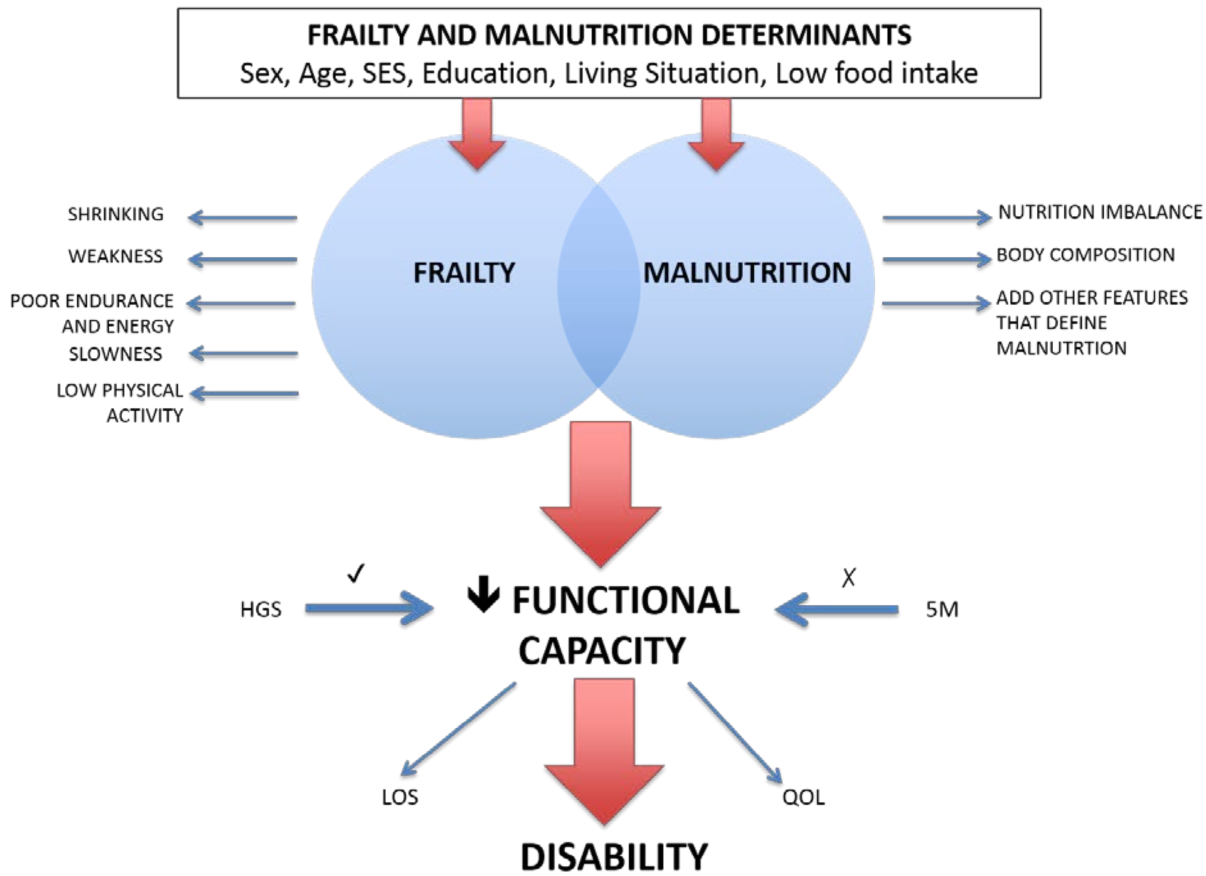

Figure 2: Summary of Findings

Frailty and malnutrition have specific defining criteria, but both encompass the notion of reduced functional capacity- hence the need for functional measures to add to a nutrition/frailty assessment toolkit. HGS is the most appropriate functional measure to suggest for use in acute care. HGS was feasible across sexes and in those >65 years. HGS added significant predictive validity for LOS and physical QOL. Construct validity for HGS was reinforced by associations with nutritional status, food intake, SES (education, living situation) and perceived disability). However, SE/SP of HGS cut points were not sufficient to predict LOS, indicating that perhaps this tool needs to be used in addition to other existing measures to add predictive value.

7.6 Next Steps

In order to fully develop HGS as an indicator, the validity of cut-points needs to be considered. Existing HGS cut-points do not appear to be useful for predicting LOS. If further work is pursued with this measure, cut-points need to be improved and re-assessed to capture and predict clinical outcomes such as LOS in an unbiased sample. Furthermore, validation testing against a criterion such as the CFS or FACT tool needs to be done in the acute care setting (Jones, 2004). This should also be done in an unbiased sample, large enough to produce generalizable results in a Canadian context. Finally, the clinical utility of the tool needs to be explored further. More specifically, the transition from screening to changes in treatment needs to be focused on. When suggesting a new screening tool, it is important to consider the benefits, risks, and costs associated with the implementation of screening (Silvestre et al., 2011). It is also important to consider addressing the time taken to deal with false positives, and ensure that these cases are minimized in a fast-paced acute care setting (Phillips & Zechariah, 2017). Although we can assume that the utility of this tool would be highest if screening happened at admission (to implement greater care strategies during hospitalization), further research needs to be conducted on how and when this tool can be used by clinicians, and what treatment strategies can be used to mitigate the effects of frailty in hospitalized patients (e.g. addressing barriers to food intake). Finally, future work on HGS as a measure to conduct with nutritional screening or malnutrition assessment should be done to describe potential comorbidity with frailty.

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