Factors Associated with Weight Change in Older Adults Throughout Acute Hospitalization

by

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ABSTRACT

FACTORS ASSOCIATED WITH WEIGHT CHANGE IN OLDER ADULTS ADMITTED TO CANADIAN ACUTE CARE HOSPITALS

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Multivariable modeling was performed using data from the Nutrition Care in Canadian Hospitals Study, identifying factors independently associated with weight change, and specifically weight loss, prior to, during, and following acute hospitalization in older patients (≥65y, n=503). Male gender (OR=1.83, 95% CI 1.23-2.73) and oral nutrition supplement use (OR=2.1, 95% CI 1.31-3.36) were associated with self-reported weight loss (n=445, R^2=0.06). Higher BMI (β=-0.2, p=0.001), occurrence of adverse events (β=-0.15, p=0.008), mean intake <75% of meals during admission (β=-0.19, p=0.001), and antibiotic use during admission (β=-0.11, p=0.049) were significantly associated with weight loss during admission (n=290, R^2=0.14). Post hospital weight loss was associated with a poor self-reported appetite at follow-up (OR=3.82, 95% CI 2.1-6.97), eating with others never or rarely (OR=2.48, 95% CI 1.31-4.69), and having been admitted to a surgical ward (OR=1.86, 95% CI 1.03-3.35) (n=279, R^2=0.16).

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1.0 INTRODUCTION

Malnutrition in healthcare institutions is an established concern with existing literature demonstrating prevalences ranging from 20%-50% depending on the diagnosis criteria and study population (Barker, Gout, & Crowe 2011; *The Canadian Malnutrition Task Force*, 2011). As hospitalization has the potential to promote a cycle of nutritional decline in patients, the need for increased awareness and treatment of malnutrition in hospitals is crucial (Corish & Kennedy, 2000). Patients who become undernourished often lack micronutrients, energy, and protein, accelerating the deterioration of their nutritional and health status (Corish & Kennedy, 2000).

The effects of poor nutrition in hospital have been extensively studied. Affected patients have consistently longer periods of illness, length of hospital stay, as well as increased risk of complications, increased readmissions and mortality (Feldblum, German, Castel, Harman-Boehm, & Shahar, 2001; Harris & Haboubi, 2005; Kondrup et al., 2002; Kruizenga, et al., 2003; Lim, Ong, Chan, Loke, Ferguson, & Daniels, 2012). Because aging promotes physiological and pathological changes that promote weight loss, the older adult population may be more susceptible to the development of hospital malnutrition relative to their younger counterparts (Chapman, 2011).

Identifying factors associated with malnutrition in older adults pre-hospitalization, during admission, and post discharge may help to identify potentially modifiable factors that can improve outcomes. Unfortunately, to date, most studies have been conducted internationally in a small number of health care facilities, and have relatively small

sample sizes, limiting the generalizability of results. Furthermore, the focus on factors associated with malnutrition at only one time point during the peri-hospitalization

period limits our understanding of all of the potential modifiable factors as well as their potential influences across transitions. Finally, few studies have focused specifically on older adults; hence, there is a need for a larger study addressing these research gaps.

The Canadian Malnutrition Task Force (CMTF), a standing committee of the Canadian Nutrition Society (CNS), is a collaboration of clinicians and investigators dedicated to closing the gaps between research and practice in the prevention, detection and treatment of malnutrition to improve nutrition in Canadian clinical care (*The Canadian Malnutrition Task Force,* 2011). The committee strives to generate knowledge to address gaps between research and practice and better nutrition care throughout the peri-hospitalization period in Canada (*The Canadian Malnutrition Task Force,* 2011). The Nutrition Care in Canadian Hospitals study specifically aims to assess the nutritional trends of hospitalized patients including nutritional status, prevalence and consequences of malnutrition, changes in nutrition status, as well as to examine nutrition care and the costs and benefits of quality care (*The Canadian Malnutrition Task Force,* 2011).

The purpose of this study was to identify factors independently associated with weight change and specifically, weight loss in older adults admitted to acute care hospitals. Regression analyses were performed using data from the CMTF Nutrition Care in Canadian Hospitals study. Data collected in this study consisted of information from multiple institutions countrywide, and is the first of its kind in Canada (H. Keller, personal communication, 2012).

Data from 503 participants admitted to 18 hospitals in 8 provinces was used in this secondary analysis. Results of this research highlight the association of certain variables with weight change in older adults throughout the stages of hospitalization. This

study has begun to address the gaps in existing literature and provides a good foundation for more research aimed at targeting and prioritizing nutrition interventions in this population.

2.0 REVIEW OF LITERATURE

2.1 Malnutrition

Definitions of malnutrition vary among institutions, disciplines, and cultures (Chen, Schilling, & Lyder, 2001). In simplest terms, malnutrition can be described as 'any nutrient imbalance' (Dorland's Illustrated Medical Dictionary, 2011 as cited in White et al., 2012). As a result of the many definitions that exist, there is a lack of consensus on approaches for the identification and documentation of malnutrition in adults (White et al., 2012). Initial definitions for adult malnutrition were established on the knowledge of pediatric malnutrition syndromes in developing countries. As such, these dated definitions are seen as flawed and have limited use for current practitioners and investigators (Jensen, Bistrian, Roubenoff, & Heimburger, 2009). The use of these definitions has resulted in the reliance on diagnostic criteria that lack validity and interobserver reliability and have poor specificity and/or sensitivity; this limits the credibility of these characterizations (Jensen et al., 2009). Furthermore, disparities in defining malnutrition are problematic as they increase the chance for misdiagnosis or diagnostic inconsistencies in practice or research (Jensen et al., 2009).

In the more comprehensive definitions, malnutrition is typically characterized as encompassing several nutritional states: overnutrition, caused by an extended period of consuming unwarranted amounts of food (specifically energy); undernutrition, caused by an extended period of consumption of inadequate amounts of food; a specific nutrient deficiency, caused by the relative or absolute absence of a certain nutrient; and, an imbalance of nutrients, with or without the deficiency of a specific nutrient, caused by a disproportionate intake of essential nutrients or metabolic disparity (Jelliffe, 1966; Keller,

1993). More recent definitions have expanded further to include effects of nutrition status on function and inflammatory components. For example, Soeters et al. (2008) proposed that malnutrition be defined as a state of nutrition and inflammation resulting in body composition changes and reduced function that can be either acute or chronic. Moreover, it is common to include functional decline in definitions of malnutrition due to changes in body composition resulting from poor nutritional status (Soeters et al., 2008). The remainder of this review will focus on undernutrition, as it is the outcome of interest in this study.

2.1.1 Undernutrition

Undernutrition exists on a continuum from mild to severe (Corish & Kennedy, 2000; White et al., 2012). The etiology of undernutrition is complex and potentially multifactorial due to a single or combination of various mechanisms including: inadequate consumption, increased nutrient requirements, impaired absorption, altered transport, and/or altered nutrient utilization (Corish & Kennedy, 2000; White et al., 2012). Also, Norman, Pichard, Lochs, & Pirlich (2008) have demonstrated the cyclical process of disease-related malnutrition. In chronic or severe disease, anorexia frequently leads to malnutrition and specifically weight loss. The combination of malnutrition and stress-related catabolism caused by inflammation promotes infection and organ dysfunction, and compromises healing. Consequently, this combination promotes further starvation and catabolism, further aggravating nutritional status (Norman et al., 2008).

In the past, two clinical definitions have been used in older adults: the identification of undernutrition as the insufficient intake of essential nutrients; and, the identification of

malnutrition as protein-energy undernutrition (PEU) or protein-calorie malnutrition (PCM). Using the approach of insufficient intake, it is presumed that malnutrition results from a diet providing nutrient intakes below requirements, resulting in malnutrition (Chen et al., 2001). The second definition concerning PEU/PCM attributes undernutrition specifically to the inadequate consumption of protein and energy resulting in either: (a) marasmus, weight loss from inadequate intake accompanied with the depletion of fat and muscle stores but maintenance of serum albumin levels, characterized by the decrease of skeletal protein and fat with conservation of serum albumin; or, (b) kwashiorkor, marked by a decrease in serum albumin and other visceral proteins, accompanied by edema but without perceivable changes in anthropometrics (Bistrian, 1977; Chen et al., 2001). In adults, kwashiorkor and marasmus typically result from anorexia induced by illness or the catabolic response to stress, disease, or infection (Bistrian, 1977).

More recently, adult undernutrition has been described in terms of its relationship to inflammatory responses (Jensen et. al, 2010; White et al., 2012). Inflammation increases the risk for malnutrition as it promotes the catabolism of skeletal muscle and may contribute to less than ideal responses to nutrition interventions (Jensen et. al, 2010; White et al., 2012). Varying degrees of acute or chronic inflammation have been found to contribute to the pathogenesis of undernutrition in the presence of disease or injury (Jensen & Wheeler, 2012). Three categories of malnutrition have been defined: (1) starvation-related malnutrition, caused by pure, chronic starvation (such as that experienced with anorexia nervosa) with no inflammatory response; (2) chronic disease-related malnutrition, caused by chronic conditions or diseases (organ failure, pancreatic cancer, rheumatoid arthritis or sarcopenic obesity) which inflict continued inflammation

of a mild to moderate degree; and, (3) acute disease- or injury-related malnutrition, caused by acute injury or disease states (major infection, burns, trauma or closed head injury) with a clear inflammatory response (Jensen et al., 2010).

With these new definitions, six key indicators for the diagnosis of adult malnutrition have been established: insufficient energy intake; weight loss; loss of muscle mass; loss of subcutaneous fat; localized or generalized fluid accumulation that may sometimes mask weight loss; and, diminished functional status as measured by hand-grip strength (White et al., 2012). Malnutrition is diagnosed when at least two of these clinical signs are present (White et al., 2012). The presence of inflammation needs to be determined by clinical and biochemical exam to determine whether weight shifts can be attributed to changes in nutritional status or inflammatory responses (White et al. 2012).

Systematic inflammatory response syndrome (SIRS) is a hypermetabolic response common in patients with severe tissue injury (Hoffer, 2001). SIRS prompts nutritional changes such as fluctuations in acute-phase serum protein concentrations, heightened energy expenditure and whole-body protein turnover, anorexia, and wasting of protein (Hoffer, 2001). Cachexia is a metabolic condition resulting from illness that is similar to, but milder than, SIRS (Hoffer, 2001; Jeejeebhoy, 2012). Cachexia is characterized by unintentional weight loss comprised of muscle loss, with or without fat mass loss (Jeejeebhoy, 2012). Common in medical and surgical wards, this syndrome is often inexorable, frequently advancing to states of tremendous weakness and even death (Jeejeebhoy, 2012). Cachexia causes changes in the concentration of acute-phase serum proteins, and leads to anemia of chronic disease, anorexia, and the partial cancellation of formerly effective starvation adaptations (Hoffer, 2001).

2.1.2 Undernutrition in Older adults

The incidence of undernutrition, and more often identified as malnutrition, in the general community increases with age. Compared to younger adults, individuals over the age of 60 years are approximately 1.8 times more likely to be malnourished with prevalences ranging from 10% to 85% (Chen et al., 2001; Waitzberg & Baxter, 2004). The large range in prevalence is likely due to variations in research methods and settings, as well as the indicators used to determine nutritional status (Chen et al., 2001). Regardless of the true prevalence, undernutrition in older adults has been shown to lead to increased mortality and morbidity and decreased quality of life (Chen et al., 2001; Babnieau, Villalon, Laporte, & Payette, 2008). The cause of malnutrition is often multifactorial, due to factors that not only influence food intake but also heighten requirements and alter utilization, absorption, and transport of nutrients (White et al., 2012). Decreased appetite is likely to be a primary factor and in the elderly and has been coined 'anorexia of aging' (Chapman, 2011). A decline in appetite and energy intake is typical in healthy older adults as well as those with chronic and acute illnesses. Research has shown that between the ages of 20 and 80 years, average daily energy intake decreases by around 30% (Chapman, 2011). Much of this decline in energy intake is thought to be a response to the decrease in energy expenditure that is normal with aging. If the decrease in energy consumption is greater than the decline in energy expended, a net loss of energy exists and weight loss is observed. Typically, after the age of 60, weight loss is disproportionate, with loss of lean body tissue being greater than fat loss, a condition known as sarcopenia. This condition results in adverse effects on the health of older adults (MacIntosh, Morely, & Chapman, 2000). Sarcopenia is an age-related

condition caused by the failure of the body to adjust to metabolic decline (Jeejeebhoy, 2012).

2.1.3 Hospital Malnutrition

Impaired nutritional status is frequently reported in hospitalized patients (Thomas, 2005). Research suggests varying statistics for the prevalence of malnutrition in hospital, depending on diagnostic criteria, with a recent study identifying 33% to 45% of hospitalized patients as at risk or malnourished (Keller & Allard, 2011). Consequences of hospital malnutrition include increased morbidity, increased mortality, impaired recovery from illness or surgery, and increased hospital stay, resulting in increased hospitalization costs as well as decreased quality of life for patients (Corish & Kennedy, 2000; Norman et al. 2008; Waitzberg & Baxter, 2004).

Even higher rates of malnutrition are seen in elderly patients and in certain settings such as oncology (Norman et al., 2008). Azad, Murphy, Amos, & Toppan (1999) found that 44.1% of older adults admitted to a tertiary care hospital were at moderate risk for malnutrition while 15.1% were malnourished. Observed outcomes are similar to, but often more severe, than for younger patients. For example, older adults have demonstrated up to 100% longer lengths of stay in hospital, two to 20 times more complications, and $2000- $10,000 higher hospital costs than younger populations (Chen et al., 2001).

Morbidity, defined as one's state of disease or disability, is notably increased with malnutrition in both chronic and acute illness (Nelms, Sucher, Lacey, & Roth, 2011; Norman et al., 2008). For example, in a study of 709 adult patients Correia & Waitzberg

(2003) found that those who were malnourished had significantly higher rates of morbidity (represented by infectious and non-infectious complications) than their well-nourished counterparts.

Mortality is another consequence of malnutrition in hospitalized older adults (Chima et al., 1997, Correia & Waitzberg, 2003; Harris & Haboubi, 2005; Kondrup et al., 2002; Kruizenga et al., 2003; Lim et al., 2012). For example Stratton, King, Stroud, Jackson, & Elia (2006) found that the Malnutriton Universal Screening Tool and its weight loss component were significantly associated with mortality in hospital and that mortality in patients with >5% weight loss over three to six months was significantly greater than in patients with <5% weight loss. Also, mortality in hospital increased significantly with greater nutritional risk, and mortality was significantly greater for medium and high-risk patients at both three and six months following discharge (Stratton, 2006). In terms of length of stay, Correia & Waitzberg (2003) found that well nourished patients had shorter admission periods than malnourished patients. This trend is also consistent with elderly patients. Similarly, Stratton et al. (2006) found that length of stay was increased consistently with the risk category of malnutrition, defined by the Malnutrition Universal Screening Tool.

Due to the increased risk of complications, higher mortality and morbidity, increased length of stays, and increased frequency of re-hospitalization, malnutrition effectively provides a potentially unnecessary financial burden on hospitals (Correia & Waitzberg, 2003; Waitzberg & Baxter, 2004). Using daily hospital infirmary rates to calculate the average daily expense for malnourished patients, a 60.5% increase in cost was seen in comparison to well-nourished patients (Correia & Waitzberg, 2003).

Similarly, Chima et al., (1997) found the mean hospitalization cost for patients at risk of malnutrition was significantly higher ($p<0.02$) than the not-at-risk group with per patient costs being $6,196 and $4,563, respectively.

In addition to physical and economic costs, studies of specific populations, such as cancer and hemodialysis patients, have demonstrated a close relationship between declines in quality of life and malnutrition (Norman, Kirchner, Lochs, & Pirlich, 2006). Ravasco, Monteiro-Grillo, Vidal, & Camilo (2004) identified weight loss and energy and protein deficits as independent determinants of quality of life in cancer patients. Similarly, in the examination of 64 hemodialysis patients by Laws, Tapsell, & Kelly (2000), severely malnourished patients reported lower perceived quality of life than better-nourished patients. Although mechanisms are elusive for this relationship, it is an additional consequence that cannot be ignored.

2.2 Assessment of nutritional status

Traditionally, what people eat, and its influence on body stores of micronutrients, body composition and function, and health status is examined to determine nutritional status. Domains of data collection include dietary, biochemical, anthropometric, and clinical assessment (Gibson, 2005). Numerous tools and parameters exist for use in different circumstances. Unfortunately, there is still a lack of consensus regarding the necessary parameters to support a diagnosis in the hospital setting (Burritt & Anderson, 1984; White et al., 2012). In the following review of nutritional assessment methods, emphasis will be placed on those measures used in the current study: food records,

plasma albumin, C-reactive protein, weight change, body mass index (BMI), and Subjective Global Assessment.

2.2.1 Dietary assessment

Several methods of dietary assessment exist including, but not limited to, food records, 24-hour recalls, diet histories, and food frequency questionnaires (Gibson, 2005). Focus will be placed on food records as assessment of diet by the CMTF was done using an abbreviated meal record known as the *nutritionDay Patient Intake Form* (Canadian Malnutrition Task Force, 2012a).

Food records require the subject to record all foods and beverages consumed over a specified time period. Recording is done at the time of consumption to ensure that the record is as accurate as possible. Portion sizes and food details (brand names, methods of preparation etc.) are also usually included in food records (Gibson, 2005).

The nutritionDay is an international project aimed at improving knowledge and awareness of malnutrition all over the world. It is a one-day cross-sectional audit that screens for nutritional risk and obtains and determines the prevalence of malnutrition in various institutions (*NutritionDay Worldwide,* 2012). The nutritionDay uses self-reported meal records to estimate the intake of participants at a single meal, including food, beverage, and supplement intake. Food intake is recorded as the portion of the main plate consumed (i.e., < 25% to 100%); specific foods are not identified. Quantities are used for drinks and supplements. Reasons for poor food intake are also noted (e.g., usually eat less) (Canadian Malnutrition Task Force, 2012a). The *Patient Intake Form* in the nutritionDay project was validated in a study of 100 patients from different wards of the

Vienna General Hospital (Tripamer et al., 2009). It was found that patients' self-assessment of food intake correlated with the actual portions consumed (as assessed by weighing food) ($r=0.62$; $p<0.0001$) suggesting that this questionnaire accurately estimates the portion of meals consumed by hospitalized patients (Tripamer et al., 2009)

2.2.2 Biochemical assessment

The CMTF collected C-reactive protein concentrations, an indicator of inflammation that, as previously mentioned, is related to the presence and progression of malnutrition (Canadian Malnutrition Task Force, 2012a; Normal et al., 2008). C-reactive protein (CRP) is an acute phase protein that, when elevated, demonstrates a nonspecific response to inflammation, infection, and tissue damage (Nelms et al., 2011). As CRP concentrations increase with inflammation, there is a corresponding decrease in albumin concentrations (Nelms et al., 2011; Pepys & Hirschfield, 2003). Increased CRP concentrations have also been associated with increased nutritional risk associated with stress, illness, and trauma (Nelms et al., 2011). Since serum CRP can increase in concentration as much as 1,000-fold, it is considered the most sensitive indicator of inflammation (Nelms et al., 2011). Therefore testing serum CRP protein concentrations helps to identify patients whose decline in serum albumin can be linked to an inflammatory response as compared to poor protein intake (Nelms et al., 2011). Normal CRP levels are characterized by concentrations below 3μg/ml, slightly elevated concentrations identified with amounts between 3 and 10μg/ml, and, high concentrations of C-reactive protein classified by concentrations greater than 10 μg/ml (Black, Kushner, & Samols, 2004).

2.2.3 Clinical assessment

Clinical assessment examines the body for signs and symptoms of malnutrition in addition to inquiring about symptoms and factors influencing food intake (Gibson, 2005; Jelliffe, 1966). Typically, clinical assessment is comprised of medical history and physical examination (Gibson, 2005). However, signs and symptoms may not develop until advanced stages of malnutrition, thereby limiting the usefulness of clinical assessment (Gibson, 2005). Interviews, medical charts, or a combination of the two, can be used to obtain a patient's medical history, which includes relevant social, environmental, and family factors (Gibson, 2005). CMTF used interviews, medical charts, and handgrip strength for clinical information (Canadian Malnutrition Task Force, 2012a).

Clinical observation involves the observation of signs and symptoms of malnutrition in subjects during physical examination that substantiate and add to information gathered from a medical history (Jelliffe, 1966). Unfortunately, clinical measures are unfocused as few physical signs are uniquely characteristic of specific nutrient deficiencies. Many symptoms are a consequence of various deficiencies (Jelliffe, 1966). Additionally, environmental influences or other non-nutritional factors may induce similar signs and symptoms, thereby falsely detecting malnutrition (Jelliffe, 1966). With its lack of specificity, clinical methods are often best used in combination with biochemical and dietary methods in order to identify potential nutrient deficiencies before the manifestation of clinical signs (Gibson, 2005).

2.2.4 Anthropometric assessment

Anthropometric assessment methods measure the physical dimensions and gross body composition of subjects and are generally expressed as indices, such as height-for-age or weight-for-height (Gibson, 2005). Although the identification of specific nutrient deficiencies is not possible, anthropometric measures are useful in situations of chronic protein and energy imbalance. Anthropometry is able to detect moderate and severe malnutrition and provide information on a subject's nutritional history (Gibson, 2005). Assessment of body size may include one, or a combination, of the following measures: height, knee-height or arm-span (both correlated to stature), weight, skinfolds and body circumferences (e.g., arm, calf, waist, hip, thigh). As with other assessment methods, anthropometric measures are compared to a standard, a cut-off, or an index for interpretation (Gibson, 2005). The CMTF gathered multiple anthropometric measurements of which weight, weight change and BMI were examined in the current study (Canadian Malnutrition Task Force, 2012a).

Both weight change and absolute weight are associated with outcomes in hospital patients (Sullivan, Liu, Roberson, Bopp, & Rees, 2004). For example, Sullivan et al. found the lowest mortality in subjects who were relatively weight stable (<1kg weight change/year) following admission and highest mortality in subjects whose weight changed greater than 3 kg per year. Small fluctuations in body weight (± 0.5 kg) are normal in healthy individuals, while more extreme weight changes are typical in cases of acute or chronic illness (Gibson, 2005). Weight change has also been identified as a useful indicator of malnutrition in the elderly, responding quickly to changes in food consumption (Chen et al., 2001; Keller, 2009). Weight loss for example, has been

indicated as an important marker for nutritional risk, representing a negative balance between energy consumption and expenditure leading to the loss of fat and fat free mass (Forbes, 1999; Payette, 2005).

Various references for assessing weight change exist in literature and in practice. For example, weight loss of 10% in 6 months has been proven to be a good predictor of malnutrition. This parameter is included in many nutritional assessment scores including, the Subjective Global Assessment (SGA), the Nutritional Risk Index (NRI), and other multi-parameter tools (Norman et al., 2008).

As well, weight change can be presented as a percentage of weight lost over a period of time in relation to inflammatory processes (White et al., 2012). Malnutrition in the context of acute illness or injury, chronic illness, or in the context of social or environmental circumstances is characterized as non-severe or moderate with a weight loss of 5% in 1 month or 7.5% in 3 months. However, loss of body weight is characterized as severe with a loss of greater than 5% in one month or greater than 7.5% in 3 months. Additionally, malnutrition in the context of acute illness or injury can also be characterized as non-severe or moderate with a weight loss of 1-2% in one week, or severe with a weight loss of greater than 2% in 1 week (White et al., 2012).

Unfortunately, measuring weight does not differentiate between types of weight lost or gained. Whether weight change occurs in fat stores, muscles, bone, or fluid cannot be indicated by weight alone and requires further assessment to determine such specifics (Gibson, 2005; Keller, 2009). Therefore, in cases of edema, ascites, dehydration, diuresis, massive tumor growth, organomegaly or, rapid weight loss in obese patients, weight change is potentially a poor indicator of change in body composition and thus nutritional

status. These conditions may be accompanied by relative increases in total body water and shifts in this fluid can mask the loss of fat and muscle. In these cases, weight change should be used in addition to other assessment methods to increase the validity of measurements (Gibson, 2005).

Weight-to-height ratios are also used to describe weight status (Gibson, 2005). The most commonly used ratio is the body mass index (BMI), also known as Quetelet's index, calculated as weight (kg) /height $(m)^2$ (Gibson, 2005). Categorization of weight status using BMI is presented in Appendix A, Table 1. As BMI cannot identify body composition, it is considered a rough estimate of adiposity carrying with it the potential for false classification of subjects (Nevill, Stewart, Olds, & Holder, 2006). Accordingly, it is suspected that BMI is at best, indicative of malnutrition at a population level and may not be appropriate in clinical settings due to its ability to disguise certain important weight changes and associated nutritional problems (Cook, Kirk, Lawrenson, & Sandford, 2005).

Due to the lack of consideration of function and biological age and the heterogeneity of older adults, caution should be used when referring to standards for this population (de Onis & Habicht, 1996). Past research has suggested that BMIs higher than the normal weight range are ideal for older adults as they are associated with decreased mortality (Cook et al., 2005; Weiss et al., 2008). The Nutrition Screening Initiative has suggested the BMI for older adults falls within the range of 22-27 kg/m^2 (Brown, 2011).

Valentini et al. (2009), in a study with older adults, found that the prevalence of weight loss for participants with a low BMI (<22 kg/m^2) was lower than that of participants with a higher BMI (≥22 kg/m^2). Furthermore, low BMI participants had a

higher prevalence of relevant weight gain than those with higher BMIs and the prevalence of mortality was lowest for those with a BMI ≥22 kg/m^2 (Valentini et al., 2009). These findings demonstrate a trend in which individuals with a low BMI are less likely to lose weight, and more likely to gain weight, than individuals with a high BMI. As such, the effect of BMI on relative weight change must be taken into consideration when examining predictors of weight change in hospitalized older adults.

While the use of BMI and weight loss are both accepted measures of nutritional status, researchers may prefer the use of weight loss to BMI as it is able to identify insufficiencies in energy and nutrient consumption in individuals of all weights while this may not be clear with the use of BMI (Corish, Flood, Mulligan, & Kennedy, 2000; Kruizenga et al., 2003). Additionally, with the altered BMI parameters for the elderly, it has been suggested that weight loss is a more appropriate measure of nutritional status (Corish et al., 2000).

2.2.5 Multiparameter assessment

In order to increase the sensitivity and specificity of nutritional status assessment, methods are often combined to create multiparameter indices (Gibson, 2005). The CMTF uses the multiparameter method of SGA in order to evaluate nutritional status on admission and at discharge (Canadian Malnutrition Task Force, 2012a).

The SGA relies solely on the use of medical history and physical examination (Detsky et al., 1987). The medical history component relies on patients' self-reports of various factors including changes in weight and intake, energy level/functional capacity, disease, and gastrointestinal problems, and specifically diarrhea (Detsky et al., 1987). The

physical assessment portion examines the presence and severity of subcutaneous fat loss, muscle wasting, ankle/sacral edema, and ascites (Detsky et al., 1987; Gibson, 2005). Results are used to place subjects in one of three categories: well nourished (SGA A), moderate/suspected malnutrition (SGA B), or severe malnutrition (SGA C). Subjective weighting of these variables by the clinician is used to categorize patients with particular emphasis on weight loss, poor dietary intake, subcutaneous tissue loss, and muscle wasting (Detsky et al., 1987; Gibson, 2005). The subjective approaches used in the SGA is advantageous as it allows flexibility to recognize subtle changes in clinical variables but may also cause problems with reproducibility depending on the training and experience of users (Detsky et al., 1987; Gibson, 2005).

2.2.6 Summary of nutritional assessment

A variety of tools to assess nutritional status exist in research and in practice. While BMI and weight loss are both commonly accepted measures of nutritional status, it has been suggested that the use of weight loss may be more appropriate for the evaluation of nutritional status as it is clearly manifested in cases of inadequate nutrient and energy intake while BMI may not shift to indicate these deficiencies (Corish et al., 2000; Kruizenga et al., 2003) Subjective Global Assessment, a valid measure of nutritional status, has also been used in past studies of nutritional status in hospital patients (Detsky et al., 1987; Wyszynski, Perman, & Crivelli ,2003; Correia, 2003, Pirlich et al., 2006). However, since SGA is unable to detect mild malnutrition and lacks sensitivity required to identify acute nutritional changes, weight loss is thought to be a better outcome variable for the current study (Barbosa-Silva & Barros, 2006; Sungurtekin, H., Sungurtekin, U., Hanci, & Erdem, 2004).

2.3 Prevalence of hospital malnutrition in older patients

Research has demonstrated a varied prevalence of malnutrition surrounding and during hospitalization. Variances are likely due to differences in definitions of malnutrition and samples examined. In a study of hospitalized older adults, 18.5% were identified as malnourished while another 81.5% were at risk (Feldblum et al., 2007). Kaiser et al. (2010) compared the prevalence of malnutrition in hospitalized elderly patients, those living in the community, and in nursing homes older adults, identifying values of 38.7%, 5.8%, and 13.8%, respectively. Similarly, Babineau et al. (2008) found protein energy malnutrition in 40% of elderly patients in two Canadian health care facilities.

Bruun Bosaeus, Bergstad, & Nygaard (1999) found that 28% of patients experienced a weight loss of greater or equal to 5 % weight loss in the 3 months preceding admission. In the same study, 83% of those re-assessed continued to experience a weight loss during admission. However, both younger and older adults were included in this study. Similarly, at admission, Corish et al. 2000 found that 12% of patients, including both older and younger adults, experienced a weight loss of over 10% in the past 6 months. In the same study, 65% of overweight/obese, 66% of normal weight, and 43% of underweight patients experienced weight loss during their admission period (Corish et al., 2000). McWhirter & Pennington (1994) also found that 69% of overweight, 39% of normally nourished, and 75% of undernourished patients experienced weight loss during admission. These studies demonstrate that all patients, regardless of their initial body weight, are susceptible to weight loss during admission.

In an intervention study of acutely hospitalized older adults, Gazzoti et al. (2003) found that after 60 days participants in the control group lost weight demonstrating the occurrence of weight loss during admission which continued post discharge. While prevalence varies between studies it is clear that malnutrition during the peri- hospital period is prevalent, leading researchers to examine the etiology.

2.4 Factors associated with nutritional status prior to, during, and following hospitalization

Malnutrition in the community and in hospital has been attributed to a variety of factors. Older adults requiring acute hospitalization specifically often struggle with weight instability, experiencing both increases and decreases (Sullivan et al., 2004). The following section will identify potential factors associated with nutritional status of older adults, and where available, specifically weight loss. Research conducted with community-living older adults and factors associated with nutritional status are considered to be consistent with factors potentially associated with pre-admission and post-discharge from the hospital, while actual studies conducted on admitted patients will represent the hospital admission period. Although this study will focus on weight change as an indicator of malnutrition, few studies solely examine weight change as the outcome of interest and as such the research presented is based on a variety of markers assessing nutritional status, focusing on older adults when possible.

2.4.1 Determinants of malnutrition in the community

Weight loss preceding or following hospitalization can be caused by one or a combination of factors. Evans, Barer, & Marmor (1994), as reported by Callen & Wells (2005), identifies five factors or determinant domains associated with nutritional status including: (i) social and environmental; (ii) physical; (iii) mental; (iv) individual choice; and, (v) economic. To understand factors associated with hospital malnutrition, factors need to be assessed across these domains. Because limited research is available using weight loss as a measure of nutritional status, studies reviewed have used a variety of different assessment tools.

2.4.1.1 Social and environmental factors

Social and environmental factors associated with nutritional status include interpersonal contact and living arrangements (Callen & Wells, 2005). A lack of interest in food and eating and the resulting nutritional decline is often seen in lonely and socially isolated older adults (MacIntosh et al., 2000; Walker & Beauchene, 1991). Similarly, it has been demonstrated that older adults are more likely to consume unsatisfactory diets when eating alone (de Castro, 2002). For example, when in the company of friends as compared to when eating alone, older adults have been known to consume up to 50% more food during a meal (MacIntosh et al., 2000). Similarly, Beck & Ovensen (2003) found that older adults with lower levels of social engagement were underweight (BMI<20kg/m^2). Furthermore, with the informal support systems of older adults often declining over time, a lack of support or companionship is prevalent in older adulthood and consistent with changes in nutritional status (Chen et al. 2001; Donini, Savina & Cannella, 2003; MacIntosh et al., 2000); for example, older adults may experience a

decreased availability of food if relying on family and neighbours for grocery shopping (Callen & Wells, 2005). Specific to body weight, Newman et al. (2001) found that the death of a spouse was significantly associated with weight loss in a sample of community dwelling older adults. However, they did not explain the potential mechanisms for this loss resulted in weight loss, limiting our understanding of the association.

Because the loss of a spouse and other social networks undoubtedly causes changes in the older adult's social environment, there is a need to further examine the relationship between social factors and weight loss in community dwelling older adults. The CMTF gathered participants' living arrangements, cooking, and shopping activities prior to admission and at discharge, as well as location to which they were discharged (Canadian Malnutrition Task Force, 2012a).

2.4.1.2 Physical health factors

The consumption of an adequate diet is also dependent on the older adult's capacity to secure, prepare, and consume foods that meet individual nutrition needs (Payette, 2005). Physical factors common in older adulthood such as immobility, tremor, and impaired vision may impact the nutritional status of community dwelling older adults. Vision loss for example can complicate the process of procuring and preparing food (Chen et al. 2001; MacIntosh et al., 2000). Kiessetter et al. (2013) found that the frequency of physical inabilities and functional limitations was higher in malnourished participants than their well-nourished counterparts. Newman et al. (2001) found that greater difficulties with activities of daily living and lower functional status were independently associated with weight loss in a sample of community dwelling older adults and that the highest rates of difficulty with instrumental activities of daily living

were also seen in those who lost weight. Again however, Newman et al. (2001) failed to explain the relationship between these factors and weight loss. Information regarding the shopping and cooking practices of participants gathered by the CMTF can be used to help demonstrate if subjects received help with food related activities of daily living, allowing for the examination of the influence of these factors on weight change prior to hospital admission.

Furthermore, physical changes associated with aging, such as the loss of teeth, decreased saliva production, and ill-fitting dentures, may impact the ability of the elderly to chew or swallow, thereby discouraging intake while promoting weight loss and nutritional decline (Brownie, 2006; Thomas, 2005). For example, in the examination of community dwelling older adults, Serra-Prat et al. (2012) identified impaired swallowing efficacy as a risk factor for malnutrition. No information regarding physiological factors such as dentition and dysphagia were gathered by the CMTF before and after admission. Therefore the current study was unable to examine the influence of these factors on the weight of the sample under investigation (Canadian Malnutrition Task Force, 2012a).

Other physical factors influencing the nutritional status of community-dwelling older adults are underlying medical conditions and medication use. Conditions such as gastrointestinal disease, malabsorption syndromes, acute and chronic infections, and hypermetabolism often result in anorexia, micronutrient deficiencies, and increased energy requirements (MacIntosh et al., 2000). Such conditions are prominent in the elderly population and, when left untreated, may result in a decline in nutritional status (MacIntosh et al., 2000). Newman et al. (2001) found that history of a stroke was independently associated with weight loss in a sample of community-dwelling older

adults. It was also found that the prevalence of a new diagnosis of cancer or cardiovascular disease was higher in those who had lost weight, and that these older adults were more likely to have coronary heart disease, diabetes mellitus, hypertension, or gastrointestinal illness (Newman, 2001). However, the examination of the specific diseases ignores the possibility of coexisting conditions and the additional complexity and compounding of effects. It is thought that the examination of extent of comorbidities is essential to the comprehension of the association between disease status and weight loss in older adults due to the relationships found in previous research (MacIntosh et al., 2000; Newman et al., 2001).

The Charlson Comorbidity Index (CCI) which was created to predict 1-year patient mortality risk from comorbidities of patients was collected by the CMTF on admission and at discharge by reviewing comorbidity data from hospital charts (Charlson, Szatrowski, Peterson, & Gold, 1994; Canadian Malnutrition Task Force, 2012a; Canadian Malnutrition Task Force, 2012b). Nineteen predefined comorbidities were used; each were assigned a weight of 1, 2, 3, or 6 based on the magnitude of the adjusted relative risks associated with them. It has been found that patients with scores of 5 or higher have particularly high mortality rates (Charlson, Pompei, Ales, & MacKenzie, 1987; Needham, Scales, Laupacis, & Pronovost, 2005). Roque, Salva, & Vellas (2013) identified CCI as a significant risk factor for malnutrition or risk of malnutrition, with increased CCI scores leading to increased risk in a sample of community dwelling adults with dementia. However, this study was based on cross-sectional data, which limits the understanding of the relationship, as a causal association cannot be determined. As well, they did not assess inflammatory processes, which likely are primary mechanisms linking

malnutrition with disease. In a three-year longitudinal study of 4256 non-institutionalized individuals over the age of 65 years, Barzilay, Forsberg, Heckbert, Cushman, & Newman (2006) found that participants with higher inflammatory factors at baseline were more likely to experience a significant weight loss (>5%). CMTF gathered information on medical conditions by collecting specific admitting diagnoses as well as examining CCI scores and CRP levels on admission and at discharge, allowing for an in-depth analysis of comorbidity and malnutrition (Canadian Malnutrition Task Force, 2012a).

Existing literature has demonstrated an association between polypharmacy and weight loss (Brownie, 2006; Huffman, 2002; Jyrkka, Enlund, Lavikainen, Sulkava, & Hartikainen, 2011; MacIntosh et al., 2000). Many medications may cause nutrient malabsorption, gastrointestinal symptoms, and a loss of appetite, all resulting in weight loss (MacIntosh et al., 2000). Alternatively, some medications may deplete the mineral stores, possibly resulting in a loss of taste acuity, consequently decreasing food intake and leading to muscle weakness, and anorexia (MacIntosh et al., 2000). Furthermore, some medications, such as drugs with an unfavourable taste, may indirectly influence taste perception and subsequent food intake (Brownie, 2006). Since prescription medication use is prevalent in older adults, the possible influence of pharmaceuticals on nutritional status is a highly relevant concern for this population (Brownie, 2006). Additionally, since it is common for older adults to be on multiple medications at once, there is an increased risk of drug interactions that further increase the chances of weight loss and anorexia (MacIntosh et al., 2000).

The number of medications used may be indicative of disease severity or infections, which may be responsible for weight loss. In fact, some hospital-based

research has interpreted disease severity by the number of drugs prescribed (Pirlich et al., 2006); this association, however, may not be relevant to weight change before and after hospitalization. Newman et al. (2001) found that a high number of prescription medications was associated with weight loss in a sample of community dwelling older adults. However, this study did not differentiate types of medication and specifically use of antibiotics. The unclear definition of medications creates uncertainty in understanding the relationship between medication use and weight loss in older adults. The CMTF gathered information regarding medication use of patients including the number of medications and antibiotics used prior to admission, allowing for the examination of the association between weight change and polypharmacy while differentiating between antibiotics and prescription medications (Canadian Malnutrition Task Force, 2012a).

2.4.1.3 Mental health factors

Psychological factors such as dementia, depression, and anxiety have also been identified as determinants of food intake in older adults (Chapman, 2011). For example, malnourished patients have been found to be more likely to eat an inadequate diet due to mood/anxiety disturbances as compared to their well-nourished counterparts (Patel & Martin, 2008). Malnourished patients have also been found to have an increased prevalence of mood and anxiety disturbances, demonstrating a bidirectional relationship with food intake (Patel & Martin, 2008). Additionally, depressive symptoms have been found to intensify with nutritional deficiencies, predicting malnutrition, and specifically weight change (Cabrera, Mesas, Garci, & de Andrade, 2007; Omran & Morley, 2000). For example Cabrera et al. (2007) examined functionally independent adults aged 60-74 and found an association between depression and poor nutritional status. Due to

exclusion factors, the independent effect of depression on weight change in adults ≥75 years and those with functional impairments is unknown.

In addition to depression, mental acuity has been found to be associated with malnutrition. Roque et al. (2013) found that low scores on the Mini-Mental State Examination (MMSE) were a significant predictor of malnutrition or its risk. Similarly Nykanen, Lönnroos, Kautiainen, Sulkava, & Hartikainen (2012) found an association between malnutrition risk and depression and malnutrition risk and MMSE scores. Focusing on weight loss as an outcome, Newman et al. (2001) found that lower scores of cognitive function and increased depression scores were associated with weight loss in a sample of community dwelling older adults. More research is required in order to explain the observed relationship. The only psychological variable collected by the CMTF is the effect of depression on food intake during admission, expressed as the frequency of depression affecting intake. As such, the current study overlooked the effects of depression prior to, and following hospitalization and other psychological factors throughout all stages; thus the current study is unable to address these current literature gaps (Canadian Malnutrition Task Force, 2012a).

2.4.1.4 Individual Choice Factors

Older adults often choose lifestyle and healthcare options that can influence their health. Examples include supplement/multivitamin use, use of oral nutritional supplements, adherence to diets, and visits to health care professionals (Callen & Wells (2005). In an intervention study conducted by Gazzotti et al. (2003), it was found that elderly patients at risk of malnutrition receiving oral nutritional supplementation during and after hospitalization maintained their weight in the convalescence period, while the

patients not receiving supplementation experienced weight loss at the 60-day follow-up. Vitamin and mineral supplements use has also been linked to the adequacy of one's diet in existing literature. In a study of vitamin and mineral supplement use in older adults (Sebastian, Cleveland, Goldman, & Moshfegh, 2007), vitamin and mineral supplement users were more likely to have adequate nutrient intake from food sources in comparison to non-users and nutrient adequacy was further improved by use of vitamin and mineral supplements. Limitations of this study include the use of participants aged 51 years and older which may have generated different results than if only adults 65years of age and older had been examined. Additionally this study was published over 10 years after the data were collected (US Department of Agriculture's 1994-96 CSFII and Diet and Health Knowledge Survey) resulting in potentially outdated findings (Sebastian et al., 2007). In order to assess oral nutrition supplement use, vitamin, and mineral use, the CMTF inquired about the use of these supplements prior to admission, allowing for the examination of effect of these individual choice factors on the nutritional status of a large sample of older adults requiring hospitalization.

Keller & Mckenzie (2003) identified low fruit and vegetable intake as well as avoiding foods for health reasons as factors leading to nutrition risk in a sample of community dwelling older adults. Other personal choice factors associated with malnutrition are adherence to diets, smoking, and physical activity. Newman et al. (2001) found that smoking was independently associated with weight loss in a sample of community dwelling older adults. Although the study gathered current and past smoking habits, the analyses compared those currently smoking to those never smoking forgoing the examination of past smoking habits on recent weight change. In the same study,

individuals who lost weight had lower levels of physical activity, and were more likely to be on a medically prescribed or self- imposed diet at baseline (Newman et al., 2001). Yet without describing the type of diet, it is challenging to further elaborate on how these eating regimes could influence body weight (Kumanyika, Tell, Shemanski, Polak, & Savage, 1994, cited in Newman et al., 2001). The CMTF does not gather information about physical activity or smoking habits of participants prior to or following hospitalization. The CMTF did however inquire about special diets prior to and following admission and details of the diets were provided.

2.4.1.5 Economic Factors

Addressing Evans et al.'s (1994) fifth risk factor, economic status has the potential to influence the nutritional status of community dwelling older adults by directly influencing the quality of food individuals are able to purchase and consume (Donini et al., 2003; MacIntosh et al., 2000; Walker & Beauchene, 1991). Older adults with limited financial means are often forced to forgo the purchase of nutrient dense foods, particularly if expenses such as utilities, medications, or other necessities take precedence over food (Chen et al. 2001; MacIntosh et al. 2000). Lee & Frongillo (2001) found that food insecure older adults had consistently lower mean intakes of various nutrients, including protein and energy, than their food secure counterparts. Unwell seniors requiring hospitalization may have further economic challenges if oral nutritional supplements and specialized care are needed, requiring out of pocket expenses. More recently, Donini et al. (2013) found a strong relationship between poverty, low levels of education, and malnutrition supporting previous research findings.

Specific to weight loss, Newman et al. 2001 found that, in a sample of community

dwelling older adults, lower income and education were more prevalent in those who had lost weight. However, this study categorized education as having graduated high school (≥ 12 years) or not (<12 years), limiting the ability to identify the influence of post-secondary education on weight change in older adults. Although the CMTF does not gather information regarding the economic status of participants, education level is gathered (Canadian Malnutrition Task Force, 2012a) and will be used as a proxy for socioeconomic status in this study. This substitution is thought to be valid as high levels of education and socioeconomic status have been strongly associated with better nutrition in past research (Payette & Shatenstein, 2005). Because education level is categorized by the CMTF as, grade school or less; high school (some or completed); and University or college (some or completed), the current study is able to examine the effect of education more accurately than prior work.

2.4.2 Determinants of malnutrition in hospital

Weight change in hospitals is multifactorial in cause and may be the result of the condition for which hospitalization is required, or other factors throughout hospitalization. A major cause of weight loss during hospitalization is a decreased intake due to loss of appetite, impaired food intake, and examinations or procedures that require fasting or changes in diet composition (Aquino & Philippi, 2011). Furthermore, most patients who become undernourished lack energy, protein, and micronutrients in their regular hospital meals to meet their metabolic needs, which may further accelerate the progression of weight loss (Corish & Kennedy, 2000). Weight loss is not commonly used to assess nutritional status in hospital; therefore, the following review will examine

factors leading to malnutrition identified by a variety of assessment methods during admission. Factors include: social and environmental factors of the hospital setting, physical factors (physical barriers, disease, medication use), psychological factors, as well as the satisfaction with and accessibility of food.

2.4.2.1 Social factors

Numerous social and environmental factors have been associated with the nutritional status of patients during hospitalization. Wright, Hickson, & Frost (2006) found that patients eating in a supervised dining room had higher intakes and a trend towards weight gain in comparison to patients who ate at bedside. Similarly Walton et al. (2013) observed that there was improved staff-patient interaction in hospitals with dining rooms and that patients eating together in a dining room had improved observed intakes. However because the of the absence of dining rooms in North American medical and surgical wards, the potential of this social experience is unknown to patients admitted to acute care in Canada. Similarly, Young, Mudge, Banks, Ross, & Daniels (2012) found that patients experiencing protected mealtimes, additional assistance in nursing, or a combination of the two, were more likely to have sufficient energy intake post-intervention. Unfortunately, this study failed to link outcomes with nutritional status. The CMTF did not collect any variables to examine social interactions during hospitalization. 'Family bringing in food' (one of the variables) may suggest that patients have family members eating with them; however, this could not be confirmed.

2.4.2.2 Physical health factors

As with community dwelling older adults, severe or chronic diseases are often associated with malnutrition in elderly patients (Norman et al., 2008). For example, Mudge, Ross, Young, Isenring, & Banks (2011) studied patients over the age of 65 and found that those who had insufficient energy consumption had more comorbidities than those who met their energy requirements. Barreto Penié (2005) found that diagnosis of cancer and sepsis were significantly associated with malnutrition in a hospitalized sample. However, this sample was composed of adults 19 years of age and over suggesting that more research is required specific to older patients. Similarly, Söderström et al. (2012) found that having an infectious disease was associated with a greater risk of or malnutrition while the number of diagnoses was associated with malnutrition in a sample of hospitalized elderly. Unfortunately, this study did not examine changes in nutritional status throughout hospitalization.

Similar to community dwelling older adults, medication use has been found to be a predictor of malnutrition in hospitalized elderly patients. Pirlich et al. (2006) who used the daily number of different drugs prescribed to estimate disease severity found a close association between malnutrition and polypharmacy in adult patients. Additionally, 40.2% of malnourished patients had more than five daily prescriptions, while only 19.9% of the well-nourished patients had this number of prescriptions. As older adults in general take more medication, studying the independent effect of polypharmacy in this segment is warranted. As well, a variety of covariates indicating comorbidity should be included such as new diagnoses, as medications may be an inadequate proxy.

Also similar to community dwelling older adults, physical functioning plays a role with the nutritional status of older adults in hospital. Shum, Hui, Chu, Chai, & Chow (2005) found that total dependence for activities of daily living and being restricted to bed or chair were associated with malnutrition in a sample of older adults on admission. Unfortunately, this study did not continue the examination throughout the duration of the admission period to determine the potential influence of this dependence on weight change during admission.

2.4.2.3 Mental health factors

Mental health is anticipated to be important to the onset or continuation of malnutrition in the hospital. Limited research exists evaluating weight loss in cognitively impaired patients. However, psychological factors associated with malnutrition in hospitalized elderly patients are similar to those associated with malnutrition in community dwelling older adults and include conditions such as dementia and depression (Orsitto et al., 2009). For example, in the examination 623 hospitalized patients, those with dementia or mild cognitive impairment had a higher prevalence of malnutrition or risk of malnutrition than cognitively well patients (Orsitto et al., 2009). Similarly Zekry et al. (2008) found that, in comparison to cognitively well patients of the same age, patients with dementia had poorer nutritional status on admission. More research is required to explore the relationship between weight change and mental health factors, especially during hospitalization when acute care providers may overlook or not be knowledgeable on treatments required.

Young et al. (2012) found that the nutritional intake of patients with cognitive impairment seemed to benefit substantially from protected mealtimes, additional assistance in nursing, or a combination of the two at mealtimes. While this study demonstrated the need for increased feeding assistance in the cognitively impaired, as previously mentioned, it failed to link intake to nutritional status.

2.4.2.4 Food-related factors

Other factors have been identified as determinants of malnutrition and weight change in the hospital setting, which are not pertinent to the community. While some patients are not provided with or are unable to access enough food, many do not consume all the food they are given due to dissatisfaction with meals provided (Dupertuis et al., 2003). For example, when Walton et al. (2013) asked older patients for ideas about improving meals, patients mentioned softer meats and vegetables, temperature and taste improvements for certain meals. Patient satisfaction with food has been recognized as a determinant of malnutrition during hospitalization. Factors such as taste, appearance, palatability, portion size, variety, and accessibility can influence an individual's consumption (Corish & Kennedy, 2000; Nieuwenhuizen et al., 2010). In a study conducted by Winter Falk, Bisogni, & Sobal (1996), taste was the most commonly mentioned sensory factor, with flavour- enhanced foods well liked by older adults. This may be a result of the decrease in taste perception with age (Brownie 2006; Nieuwenhuizen et al., 2010).

Other important food characteristics identified include appearance, odour, texture, temperature, and colour, often noted as palatability and found to be associated with intake (de Castro, Bellisle, Dalix, & Pearcey, 2000; Winter Falk et al., 1996). Additionally,

palatability can lead to a more rapid return of appetite, and can increase food intake in the short-to-medium term (Nieuwenhuizen et al., 2010). However, it has been argued that while the sensory characteristics of foods may influence preferences and eating habits, they are unable to predict food consumption alone (Drewnowski, 1997). Other factors such as portion size may also influence intake as large portions may discourage consumption due to their overwhelming appearance (Nieuwenhuizen et al., 2010).

Variety also impacts the consumption habits of hospitalized patients (Donini et al., 2003; Nieuwenhuizen et al., 2010). For example, Dupertis et al. (2003) found that common reasons for adult patients not eating all the food they were served was because the taste did not suit their preferences and inadequate choice was provided; yet, they did not relate these findings to food intake or nutritional status. Although a laboratory study, Hollis & Henry (2007) focused on older adults and found a significant positive association between variety and intake. While existing research examines patients' satisfaction and food intake, there is a need for research examining how satisfaction with the characteristics of meals provided influences the nutritional status of hospitalized older adults. Variables collected by the CMTF to represent choice included: understanding how to complete the menu selection sheet, being able to choose likes or preferred foods, difficulty choosing the right foods because of insufficient information on the menu sheet, and meals being served at suitable times. Food quality variables collected by the CMTF included: taste, appearance, smell, portion size, and temperature (Canadian Malnutrition Task Force, 2012a).

2.4.2.5 Organizational Factors

Another major cause of undernutrition in hospitals is the failure to provide food in patient-preferred fashions (Allison, 1995). Although hospital diets are designed to satisfy nutritional needs, they are not always appropriate to meet the needs of the ill, who leave a large portion of meals uneaten (Barton, Beigg, Macdonald, & Allison, 2000). Furthermore, while patients may be satisfied with the quality of meals, issues with food access may cause them to go hungry during hospitalization (Naithani, Thomas, Whelan, Morgan, & Gulliford, 2009). Issues surrounding food access have been categorized as: organizational barriers, such as the suitability of meals times and access to food between meals; physical barriers, such as reaching and feeding difficulties; and environmental barriers, such as disruptions by other patients, repetitive noises, or unpleasant scents (Naithani et al., 2009). If issues resulting in difficulties in food access are not addressed during hospitalization, consequences may include weight loss and decline of nutritional status during admission. This is of particular concern to older patients who, in comparison to their younger counterparts tend to be more concerned with the choice, timing, and delivery of food, and tend to have greater problems with food access (Barton et al., 2000; Naithani et al., 2009). For example, Naithani, Whelan, Thomas, Gulliford, & Morgan (2008) found that while most participants were satisfied with meal quality, nearly half reported hunger during hospitalization and older patients were among those identified as having increased difficulty with food access (Naithani et al., 2008). Unfortunately, Naithani et al. (2009) did not link their findings to nutritional status measures and included younger adults as well as older adults, which may have influenced their main findings. Similar results were found by Walton et al. (2013), where the largest

negative factor for older patients at main meals was difficulties opening packaging of food and beverages, followed by the positioning of the patient or the tray being unsuitable. However, Walton et al. (2013) also did not link these findings to nutritional status. Söderström et al. (2012) found that fasting overnight in excess of 11 hours, as well as fewer than four eating episodes per day was associated with malnutrition in a sample of hospitalized elderly. However as previously mentioned, Söderström et al. (2012) did not examine changes in nutritional status throughout hospitalization. The CMTF collected variables regarding organizational and environmental barriers at mealtimes which included: wanting food that was ordered when it arrives; not receiving food that was ordered; being disturbed by activities, noises, or unpleasant smells while eating; interruptions at mealtimes by hospital staff wanting to speak to or provide treatment to patients; missing meals because they were unavailable when served, or avoiding food for tests; being given food by hospital staff when meals were missed; and being given help to eat meals when needed (Canadian Malnutrition Task Force, 2012a).

2.4.3 Literature gaps

Despite the extensive research examining factors associated with malnutrition in elderly patients, there are some clear gaps that must be identified. In addition to the noted limitations of specific studies cited above, there are other gaps in the existing literature which need to be addressed. These limitations include: a lack of Canadian data; reliance on insufficient markers of change in nutritional status; minimal focus on older patients; limited examination of pre- and post stages of hospitalization; and, omission of variables previously identified as influential to nutritional status.

Almost all of the existing research examining malnutrition in older adults has been done internationally limiting the generalizability to older adults living in Canada (Beck & Ovensen, 2003; Donini et al., 2013; Jyrkka et al., 2011; Kiessetter et al., 2013; Lauque et al., 2000; Lee & Frongillo, 2001; Naithani et al., 2008; Nykanen et al., 2002; Orsitto et al., 2009; Pirlich et al., 2006; Sebastian et al., 2007; Serra-Prat et al., 2012; Wright et al., 2006). Small-scale studies that have been done in Canada have identified malnutrition in Canadian hospitals with one study having diagnosed protein energy malnutrition in 40% of a sample of elderly patients; however, multi-site research is needed to be able to generalize these results to the rest of Canada (Babineau et al., 2008).

Previous research specific to older adults has mostly relied on SGA and MNA for measures of nutritional status surrounding the time of hospitalization (Barreto & Penié, 2005; Donini et al., 2013; Jyrkka et al., 2011; Kiessetter et al., 2013; Nykanen et al., 2002; Serra-Prat et al., 2012; Waitzberg, Caiaffa, & Correia 2001). Although valid, SGA and MNA are not as responsive as weight change to interventions or barriers to food intake, especially during a hospitalization that is typically less than one week. As well, an objective measure that does not rely on self-report is needed for many older adults who experience cognitive impairment (Bauer, Kaiser, Anthony, Guigoz, & Sieber, 2008; Bauer et al., 2005). Newman et al. (2001) was one of the few studies that examined factors associated with weight loss. Unfortunately this study did not focus on peri-hospitalization specifically, limiting its applicability to the current study. Additionally, baseline and follow-up weight measurements were taken three years apart ignoring the trajectory of weight change. Newman et al. (2001) noted that in comparison to

individuals in general practice; participants of their study were somewhat healthier, limiting the applicability of the findings to hospitalized older adults.

A number of the more comprehensive studies, examining numerous variables from larger, more diverse samples, do not examine nutritional status in older patients exclusively (Correia, 2003; Dupertis et al., 2003; Pirlich et al., 2006; Wyszynski et al., 2003). As previously mentioned, older adults are at increased risk of malnutrition and the factors associated with malnutrition in this population may be different than those of younger patients. By exclusively examining patients aged 65 years and above this study is able to address the previous limited research on older patients.

Finally, to date, the amount of literature regarding predictors of weight change prior to, during and following hospitalization is minimal. Because of this lack of research, the predictors of malnutrition in community-dwelling older adults mentioned above have not been specifically been examined with respect to pre- and post-hospitalization periods (Beck & Ovensen et al., 2003; Donini et al., 2013; Jyrkka, et al., 2011; Kiessetter et al., 2013; Lauque et al., 2000; Lee & Frongillo, 2001; Nykanen et al., 2002; Pivi et al., 2011; Sebastian et al., 2007; Serra-Prat et al., 2012). It is likely that the most important covariates for weight loss preceding hospitalization are different from those in the general community-living population of older adults. Further, many hospital-based studies have focused on the association between a few specific variables on the nutritional status of their patients (Beck & Ovensen, 2003; Hollis & Henry, 2007; Kiessetter et al., 2013; Lee & Frongillo, 2001; Pivi et al., 2011; Serra-Prat et al., 2012; Sebastian et al., 2007; Wright et al., 2006), while excluding many others that are potential predictors of weight change during hospitalization. The CMTF has collected a wide array of variables and nutrition

outcomes encompassing all stages of hospitalization, enabling a multifactorial evaluation of weight change determinants. This will allow for a study that examines a plethora of potential predictors using one sample and with the ability to discover any important factors that may not have been identified in prior research. Such a study will help to identify potential determinants, which could be a target for intervention surrounding the hospitalization period.

3.0 STUDY OBJECTIVE

The overarching objective of this study is to understand the factors independently associated with malnutrition in older adults throughout their hospital experience (i.e., pre-admission, during hospitalization, and post-discharge) using weight change, and specifically weight loss, as a measure of nutritional status.

It is anticipated that this research will provide a foundation on which to identify key determinants amenable to treatment and help prioritize the undertaking of interventions that can address these factors, thus minimizing the risk of malnutrition and its consequences in hospitalized older adults.

3.1 Research Questions

In order to address the overarching goal of this research, three questions will be examined:

1) What are the determinants of self-reported weight loss (≥5 lbs) in older adults prior to hospital admission?
2) What are the determinants of measured weight change in older adults during their hospital stay?
3) What are the determinants of self-reported weight loss (≥5 lbs) in older adults post discharge?

4.0 METHODOLOGY

The Canadian Malnutrition Task Force (CMTF) collected the original data for the Nutrition Care in Canadian Hospitals study, conducted in 18 hospitals across Canada between 2010 and 2013 (H. Keller, personal communication, 2012). This recent and extensive data collection provides an opportunity for a very comprehensive analysis that will be more readily generalizable to the older Canadian population than research conducted to date. Furthermore, CMTF collects data longitudinally on and throughout admission as well as at thirty-days post discharge, asking questions that can be used to understand why pre-and post-admission weight change occurs (Canadian Malnutrition Task Force, 2012a).

At the time of this analysis, data from 18 hospitals and 1022 patients were available. This study is a secondary analysis of this data. Methods used for the original study as well as for the collection of the variables to be examined in the secondary analysis are described.

4.1 Ethics

The primary study protocol for the analysis of secondary data was submitted to and approved by the University of Guelph Ethics Board (10AU27), a second revision submitted in January 2012 (inclusion of new investigators), and a third in September 2012 (project extension and removal of investigators). Ethics clearance was also received from the University of Waterloo for secondary data analysis (ORE File # 17958). Each institution involved in data collection also completed individual internal ethics review. All data files provided for analyses remained anonymous, including the hospital site. The CMTF members who direct the main study approved this specific analysis.

4.2 Participants

CMTF, through the Nutrition Care in Canadian Hospitals study, collected data from both academic and community hospitals across Canada. Patients admitted, or transferred, to medical or surgical wards, were eligible to participate if, according to staff, they had an intended hospital stay of more than 2 days. Patients planned to be admitted but who were currently in ER were also eligible. Participants had to be 18 years of age or older and complete a written informed consent. Those unable to give informed consent, such as those experiencing a language barrier, incapacitation and/or cognitive impairment were eligible if translation or signing of the consent form was completed by the patient's power of attorney, or primary family decision maker for care (Canadian Malnutrition Task Force, 2012c). Exclusion criteria included: being admitted to a medical day unit, or for observation after an endoscopy procedure or other invasive treatment; and patients admitted to obstetric, psychiatry, palliative, and paediatric wards, and those directly admitted to the intensive care unit (Canadian Malnutrition Task Force, 2012c). For the purpose of this sub-study, only participants aged 65 years or older will be included (n=544).

Patients with suspected or diagnosed edema or ascites (indicated as body weight being unavailable due to patient condition or noted in adverse events) as identified by the site coordinator at any point during hospitalization were also excluded from this secondary data analysis (n=36), since weight changes experienced by these participants may be a result of fluid shifts. If participants' disease progression required the initiation of a palliative approach, the continued involvement of the participant in the study was based on the site coordinator's discretion. Movement to palliative treatment was recorded

(Canadian Malnutrition Task Force, 2012c). Due to the progression of their disease, these patients were also excluded from this secondary analysis (n=7). Patients with altered hydration statuses, identified by IV initiation were also excluded from this study (n=4). Finally outlier, patients who experienced a body weight change of ≥15% during admission were also excluded from analyses (n=7), as it was anticipated this large change in body weight was due to fluid shifts. Readmitted patients who were previously enrolled in the study were treated as new admissions as opposed to being considered as transfers (Canadian Malnutrition Task Force, 2012c).

4.2.1 Recruitment

Although there were variations in recruitment process due to labour changes and roles of seconded site coordinators, the recruitment was designed to ensure that data collection would be feasible, rotate throughout the days of the week and be efficient. Planned enrolment was to occur every other week for a period of approximately 10 weeks, in large facilities (>200 beds) and every week for smaller facilities (<200 beds). Participants were to be the first 10 to 15 admissions during recruitment weeks if they met the entry criteria and provided informed consent (Canadian Malnutrition Task Force, 2012c). Limits per recruitment week were set to ensure feasible follow-through with data collection. A target of 40 and 60 patients was set for small and large hospitals, respectively (Canadian Malnutrition Task Force, 2012c). For the most part, hospitals were able to comply with this recruitment process (Keller H. Personal communication. 2013).

Study entry dates rotated from Monday to Friday until the quota was reached for the week, ensuring that recruitment was quasi-random, covering all days of the week and promoting the attainment of a more representative sample. However, at the time of this data analysis, hospital survey data, which would allow for the determination of representativeness of the sample, were not available for use in this secondary data analysis. Monday recruitment was aimed at capturing the weekend admissions from the Friday 5 pm to Monday 5 pm. Tuesday through Friday recruitments were composed of those admissions from 5 pm of the previous day to 5 pm of the current day or, until the week's quota was met (Canadian Malnutrition Task Force, 2012c).

4.3 Data collection protocol

The entire data collection included: patient level data, physician and nurse surveys, hospital surveys, and a nutrition-care providers' focus group (Canadian Malnutrition Task Force, 2012b). Only patient level data were available and used in this analysis. All patient level data, excepting self-reported food intake, patient satisfaction questionnaire and blood measures, were completed by a trained site coordinator, who was almost always, a dietitian.

Upon admission, hospital (including site, type, province, and size), ward, patient demography (age, gender, education level; co-morbidities, represented by the Charlson Comorbidity Index (CCI); present and past cancers; number of previous surgeries; admissions in the past five years; medication (prescription and non-prescription use; antibiotic use; and living situation were collected from the admission chart or where necessary, interview with the site coordinator, representing the pre-admission stage of

hospitalization (Canadian Malnutrition Task Force, 2012a).

Within 48-72 hours of admission, participants underwent nutritional screening (using the NRS-2002 and the CMTF draft tool), Subjective Global Assessment, and measures of weight, height, mid arm circumference, calf circumference and handgrip strength. A blood sample was requested for doctor's approval for C-reactive protein and albumin levels. In some instances (n=103 for CRP and n=58 for albumin on admission and n=278 for CRP and n=248 for albumin at discharge), blood work was not completed due to suddenness of discharge, physician refusal, hospital refusal, or excessive cost of C-reactive protein that could not be supported by study funds (Keller H. Personal communication. 2013).

Self-report of recent weight change prior to hospitalization and special dietary considerations were collected by interview with the site coordinator (Canadian Malnutrition Task Force, 2012b). As well, data concerning food related activities of daily living (patient participation in cooking and shopping) and vitamin/mineral and oral nutritional supplement use prior to admission were also collected at baseline via self-report of the participant or their proxy (Canadian Malnutrition Task Force, 2012a).

Within the first week of admission, site coordinators completed a visual 3-day estimated food intake of two of the day's meals (including records of ONS use and artificial feeding) (Canadian Malnutrition Task Force, 2012c). The visual estimation data were not available for analysis at the time of this secondary data analysis (H. Keller personal communication, 2012). Food intake was also attained from patient self-report and this will be included in the analysis. Patients completed a *nutritionDay Patient Intake Form*, which indicates food intake by identifying the portion of the main plate consumed

for a single meal, foods brought in from the outside, as well as drinks and supplements consumed that day. These forms were completed on the same days as estimation by coordinators, but only included one meal. Portions of 0%, 25%, 50%, 75% and the whole meal were reported. This could be either the lunch or evening meal, but was consistent within the hospital site. Reasons for poor consumption were also reported using tick boxes on this standardized form (e.g., poor appetite, pain, don't like the food, etc.). Family members or friends who witnessed meal consumption were allowed to stand-in for the completion of this form. In the first week of admission, the *nutritionDay Patient Intake Form* was completed three times, and thereafter twice a week until discharge, except in the case where admission was greater than one month, and then it was completed only once a week, until discharge (Canadian Malnutrition Task Force, 2012c). For the purpose of this study, the average portion of main meals consumed throughout entire hospitalization was determined and used in analysis.

Weight was measured approximately every two days by the site coordinator during admission. Additionally, patient charts were reviewed throughout admission with the purpose of tracking the nutrition care process. This included: diet prescription, use of various nutrition therapies, medication changes, ICU days, antibiotic days, surgery, any adverse events (e.g. falls, dysphagia, constipation, and delirium), and length of stay, all of which will be used as covariates in this analysis (Canadian Malnutrition Task Force, 2012b).

At discharge, patients completed a questionnaire to gather data regarding their perceptions of nutrition care and food access (Canadian Malnutrition Task Force, 2012b). This questionnaire was adapted from Naithani et al. (2009). Wording was made more

appropriate for use in Canadian hospitals and some questions were removed for hospitals where there was no menu/food selection (H.Keller personal communication, 2012). Answers to these questions were rated by the participants on a Likert-like scale (e.g., never happened to everyday) (Naithani et al., 2009). Questions were grouped and scored to determine risk as described in the original publication and further clarified by M. Gulliford (Gulliford M. Personal communication. 2013).

The reassessment of nutritional status using SGA, screening tools, blood work and handgrip strength was also completed at discharge. Additionally, patients were informed that they would be receiving a call inquiring into their health 30 days following their discharge. The patient's telephone number was obtained in addition to the telephone number of a family alternate in the event that the patient could not be reached. The patient was provided with an approximate date of the follow-up telephone call (Canadian Malnutrition Task Force, 2012c). Thirty days following discharge the site co-ordinator telephoned the patient and/or his/her family contact to determine outcomes post hospitalization. Information collected included, self-reported weight change, change in diet from pre-admission, appetite, and visits to any dietary, medical, or other health professional since discharge (Canadian Malnutrition Task Force, 2012a). Missing data were a significant issue particularly at discharge and following discharge; whether the missing data were due to lack of compliance of participants or the investigators is unknown, and resulted in fewer available data for these analyses.

For the purpose of this study, not all patient-level CMTF data will be examined. Variables selected for analysis were based on the existing literature and known to

potentially influence nutritional status, food intake and/or weight change. Additionally, variables that made clinical sense were included in initial models.

4.4 *Operationalization and recoding of variables*

A complete list of variables, how they were coded, and at which stages of hospitalization they were examined for explaining outcome variables is included in Appendix A. The following will discuss the rationale behind the operationalization and recoding of variables.

Subjective Global Assessment scores are classified as well-nourished, mild/moderate and severely malnourished. Well-nourished will be compared to mild/moderate or severe malnutrition at both admission and discharge. Unfortunately discharge SGA measures were missing from ≥30% of participants. Weight change 30 days post-discharge was collected as a categorical variable and further categorized as a loss of 5 or more pounds as compared to maintenance or weight gain. Pre-admission weight change was calculated by subtracting admission, measured weight from reported usual weight and then categorized as weight loss ≥5 lbs or weight maintenance/gain. This categorization was done to maintain consistency between the measurement of the outcome variables between pre-admission weight change and post-discharge weight change to allow for comparability between the stages of hospitalization occurring in the community. Percent weight change during admission was calculated by subtracting discharge weight, or the last measured weight prior to discharge when discharge weight was unavailable, from measured admission weight. Percent weight change during admission was examined as a continuous, numeric variable. Admission BMI was calculated using the patients' actual

weight in kilograms and the estimated height from a knee height measurement and treated as a linear variable.

Food intake gathered from the *nutritionDay Patient Intake Form* was represented using mean intake during the entire stay per patient to capture overall consumption patterns; this variable was then categorized as <75 or ≥75% as prior research has found that patients experienced weight loss when intake was below 75% of their requirements (Kondrup et al., (2002). The responses on *Patient Mealtime and Nutrition Care Survey*, were re-categorized for analysis. Questions were grouped and scored to determine food access 'risk' as described by the authors. Questions representing six domains were clustered as: choice, organizational and environmental barriers, hunger, physical barriers, food quality, and illness. Responses for each question were re-categorized with responses increasing the food access risk represented by 1 and those not indicating food related risk represented by 0. For example, when asked to rate satisfaction with taste of meals provided, original response categories were extremely satisfied, satisfied, dissatisfied, and extremely dissatisfied which were re-categorized as risk equal to dissatisfied and extremely dissatisfied and no risk equal to extremely satisfied and satisfied. Subsequently, responses for questions in each domain were summed and re-categorized to provide a score for the domain, where scores greater than or equal to two indicated risk for that domain (Gulliford, M. Personal communication. 2013). Re-categorization for each of these variables can be seen in Appendix A.

Questions that offered four response categories were recoded to create bivariate variables, allowing for a greater likelihood of determining significance due to these covariates by increasing the number of responses for each option. As well, this strategy

eliminated the need to use dummy variables to represent the various categories for variables that could not legitimately be considered discrete. For example when asked about the appetite following discharge, original response categories were, very good, good, fair, and poor, which were re-categorized as, good (very good or good) and poor, (fair or poor).

5.0 DATA ANALYSIS

Analyses were performed using SPSS 20 (IBM Corporation, USA, 1989, 2011). Descriptive analyses were run first in order to describe the sample using frequencies, distributions, and medians. The sample size determines the number of independent variables that can be modeled, with confidence. For example, approximately 8-10 cases are needed for each variable to be modeled with confidence. A conservative estimate was made that 19 and 9 variables could be modeled for pre-admission and post-discharge, respectively (Peduzzi, Concato, Kemper, Holford, & Feinstein, 1996) while up to 41 variables could be modeled for weight change during admission (Field, 2009). Chi-squares, t-tests, and Spearman's rhos were used to identify which variables were priorities for inclusion in the model. Variables included were associated with the outcome variables at the $p<0.2$ level as well as variables highlighted in the literature or thought to make clinical sense, were chosen for inclusion in initial full models, to the maximum number estimated for inclusion. Bivariate correlations were also used to examine multicollinearity among variables. Significant association between candidate variable were expected with the large sample size therefore in order to reduced the risk of multicollinearity if a significant correlations at the $p<0.001$ then only the variable contributing most to the regression was retained. VIF was also examined to assess multicollinearity in the final admission model. Key covariates of age, gender, hospital type, and admission ward were included in each model as forced covariates in addition to hospital size in the admission and post-discharge analyses in order to account for their influence on weight change as well as potential clustering effects of hospital characteristics.

Pre- and post-hospital self-reported weight loss (≥5 lbs) were examined using logistic regression. Percent weight change during hospital stay was examined using linear regression. Selected variables were included in an initial 'full' regression model with the covariates. Manual backwards removal was used to only include variables with significant predictive value in the final model. Backwards elimination is preferred over forward in regression analyses because of suppressor effects, which requires that one variable be held constant in order for another to have a significant effect. (Field, 2009). Variable removal was done manually in order to ensure the covariates were kept in the model. Selection for removal was based on low B values and insignificant Wald-statistics (linear regression), or t-statistic and the odds-ratios (logistic regression). The removal of each variable was validated through the examination of the change in the R^2 that occurred following its elimination. If the R^2 was reduced by ≥0.2 it was reintroduced to the model on the assumption that using a conservative cut-point would reduce likelihood of excluding significant variables. As a results of these analyses factors independently associated with weight change at various stages of peri-hospitalization were identified.

6.0 Results

[Manuscript draft]

6.1 Abstract

Multivariable modeling was performed using data from the Nutrition Care in Canadian Hospitals Study, identifying factors independently associated with weight change, and specifically weight loss, prior to, during, and following acute hospitalization in older patients (≥65y, n=503). Male gender (OR=1.83, 95% CI 1.23-2.73) and oral nutrition supplement use (OR=2.1, 95% CI 1.31-3.36) were associated with self-reported weight loss (n=445, R^2=0.06). Higher BMI (β=-0.2, p=0.001), occurrence of adverse events (β=-0.15, p=0.008), mean intake <75% of meals during admission (β=-0.19, p=0.001), and antibiotic use during admission (β=-0.11, p=0.049) were significantly associated with weight loss during admission (n=290, R^2=0.14). Post hospital weight loss was associated with a poor self-reported appetite at follow-up (OR=3.82, 95% CI 2.1-6.97), eating with others never or rarely (OR=2.48, 95% CI 1.31-4.69), and having been admitted to a surgical ward (OR=1.86, 95% CI 1.03-3.35) (n=279, R^2=0.16).

Keywords: Weight loss, older adults, peri-hospitalization

6.2 Introduction

Malnutrition in Canadian healthcare institutions is an established concern with existing literature demonstrating prevalences ranging from 20%-50% depending on the diagnosis criteria and study population (Barker et al., 2011; *The Canadian Malnutrition Task Force*, 2011). Undernourished patients are known to consume inadequate intakes of micronutrients, energy and protein; factors such as disease or treatment, menu selection and timing of meals may perpetuate poor food intake during hospitalization (Dupetuis et al., 2003; Thibault et al., 2011). Poor intake, regardless of the cause, promotes nutritional decline and poor recovery, lengthening hospital stay and increasing the risk of mortality (Feldblum et al., 2011). Because aging promotes physiological and pathological changes that promote poor food intake (e.g., taste changes, functional difficulties), weight loss and nutritional decline, the older adult population (≥ 65y) may be more susceptible to acute care malnutrition than younger patients (Chapman, 2011). Increased awareness and treatment of malnutrition in hospitals is required to improve this situation (Corish & Kennedy, 2000; Edington et al., 2000).

Malnutrition is commonly assessed in a variety of ways in acute care research and practice. Generally accepted indicators of nutritional status include Body Mass Index (BMI) and weight loss. It has been suggested that the use of weight loss may be more appropriate for the evaluation of acute nutritional status than BMI as it is clearly manifested in cases of inadequate nutrient and energy intake, while BMI may not shift to indicate these deficiencies (Corish et al., 2000; Kruizenga et al., 2003). Subjective Global Assessment (SGA), validated measure of nutritional status, has also been used in studies of nutritional status in hospital patients (Detsky, 1987; Correia, 2003, Pirlich et al., 2006;

Wyszynski et al., 2003). Yet, since SGA is unable to detect mild malnutrition and lacks the sensitivity required to identify acute nutritional changes, weight loss was chosen as the primary indicator of nutritional change in this study (Barbosa-Silva & Barros, 2006; Sungurtekin et al., 2004).

Existing literature has suggested a variety of factors that can influence the nutritional status of older adults living in the community. The Evans Model is consistent with other literature and identifies five domains specific to this population: social and environmental, physical, mental, individual choice, and economic (Evans et al., 1994, cited in Callen & Wells, 2005). Examples of social and environmental factors include social isolation, eating alone, and the distance of residence from grocery stores (Brownie, 2006; Callen & Wells, 2003; Callen & Wells, 2005; de Castro, 2002, MacIntosh et al., 2000. Physical factors associated with aging such as immobility, tremor, vision loss, poor dentition, and swallowing difficulties influence the ability of individuals to secure, prepare, and consume foods, while the presence of diseases such as gastrointestinal disease, malabsorption syndromes, acute and chronic infections, and hypermetabolism often result in anorexia, micronutrient deficiencies and increased energy requirements (Chen et al. 2001; MacIntosh et al., 2000). Medication use and polypharmacy have also been linked to malnutrition by causing malabsorption of nutrients, gastrointestinal symptoms, and appetite loss, translating to unintentional weight loss (Huffman, 2002; MacIntosh et al., 2000). Mental factors such as dementia, depression, and anxiety have also been found to influence the nutritional status of older adults by negatively influencing consumption habits (Cabrera et al., 2007; Chapman, 2011; Omran & Morley, 2000; Patel & Martin, 2008). Individual choice factors associated with nutritional status

include the use of supplements and vitamins; both have been found to be associated with better nutritional status, although it is not clear how these supplements influence nutritional status (Gazzoti et al., 2003; Sebastian et al., 2007). Finally, economic status influences purchasing power, as those with limited financial means are often forced to forgo the acquisition of nutrient dense foods, particularly if expenses such as utilities, medications, or other necessities take precedence over food (Chen et al. 2001; Donini 2013; MacIntosh et al. 2000; Walker & Beauchene, 1991).

Some factors influencing the nutritional status of older adults in the community also influence their nutritional outcome during hospitalization. These include mental factors, physical impairment, disease and, medication use (Norman et al., 2008; Mudge et al., 2011; Orsitto et al., 2008l; Pirlich et al., 2006). Additional factors specific to the hospitalization experience include factors such as food access and organizational barriers (Allison, 1995; Naithani et al., 2009).

Issues surrounding food access have been categorized as: organizational barriers, such as the suitability of meals times and access to food between meals; physical barriers, such as being able to open packages of provided food and feeding difficulties; and, environmental barriers, such as disruptions by other patients, repetitive noises, or unpleasant scents (Naithani et al., 2009). Additionally, in terms of satisfaction with food quality, past studies have confirmed that the provision of palatable foods encourages intake in older adults (Nieuwenhuizen, 2012).

Finally, increased length of stay is also frequently seen with at risk or malnourished hospitalized patients (Chima et al., 1997; Correia & Waitzberg, 2003; Rasheed & Woods, 2013) due to their impaired recovery. It has been suggested that malnourishment is

exacerbated with an increased length of stay in hospital (Correia & Waitzberg, 2003; Correia, 2003). It can be hypothesized that being in hospital longer results in greater exposure to potentially unappealing foods and barriers to eating, as well as a host of potentially other iatrogenic factors for malnutrition such as isolation and risk of infection; however, more research is required to confirm the independent association of length of stay on continued malnutrition.

While there is extensive literature that has examined factors that influence nutritional status during and post-hospitalization, there are still gaps that need to be addressed. Much of the existing literature is international, likely affecting the generalizability of findings to Canadian hospitals and older adults (Edington, 2000; Pirlich et al., 2006; Waitzberg et al., 2001). Moreover, Canadian studies have usually been conducted in single-sites or regions, influencing the generalizability of results (Finestone, Greene-Finestone, Wilson, & Teasell, 1995; Singh, Watt, Veitch, Cantor & Duerksen, 2006). To date, there is minimal research examining malnutrition across all stages of hospitalization, pre, during and post. In general, studies in older adults have focused on during and post-hospitalization together or in isolation, with the pre-hospitalization period being neglected (Edington et al., 2000; Finestone et al., 1995; Pirlich et al., 2006). As well, most studies to date have only examined or reported few and selected variables that have the potential to influence nutritional status (Edington et al., 2000). The examination of only physical factors influencing food intake for example, will generate different results than studies examining organization and environmental factors. Finally, most studies conducted to date have reported on factors associated with malnutrition across all adult age groups (Correia, 2003; Wyzynski et al., 2003). As aging causes changes in

physiological and social processes, it is likely that factors that impact the nutritional status of younger adults differs from factors impacting older adults. Thus, existing research may not be generalizable to those aged ≥65+ years (Chapman, 2011; Chen et al., 2001).

The overarching goal of this study is to identify independent factors associated with weight change, and specifically weight loss, as an indicator of impaired nutritional status, in older adults throughout their hospitalization (pre-admission, during admission and 30-days post discharge). The current study, using data from Nutrition Care in Canadian Hospitals study—a large, multi-site project examining patients throughout peri-hospitalization—while focusing only on participants ≥65 years, is able to overcome many of the aforementioned limitations of prior work. Additionally, by identifying these factors, it is anticipated that proactive interventions for this vulnerable population can be put into place in order to decrease the prevalence of weight loss in hospitalized elderly.

6.3 Methods

This sub-study was performed using data from the Nutrition Care in Canadian Hospitals Study of the Canadian Malnutrition Task Force (CMTF). The CMTF, a standing committee of the Canadian Nutrition Society (CNS), is a collaboration of clinicians and investigators dedicated to closing the gaps between research and practice in the prevention, detection and treatment of malnutrition to improve nutrition care in Canada (www.Nutritioncareincanada.ca). Ethics clearance was received from the Universities of Guelph and Waterloo for this secondary data analysis (ORE File #

17958). Each hospital involved in data collection also completed an internal ethics review for the collection and analysis of data.

6.3.1 Sample

Data were collected from both academic and community hospitals across Canada. Patients admitted, or transferred, to medical or surgical wards, were eligible to participate if, according to staff, they had an intended hospital stay of more than 2 days. Patients planned to be admitted but who were currently in emergency care were also eligible. Participants had to be 18 years of age or older and able to comprehend the written informed consent. For those unable to give informed consent, such as those experiencing a language barrier, incapacitation and/or cognitive impairment, the translation or signing of the consent form was completed by the patient's power of attorney, or primary family decision maker for care (Canadian Malnutrition Task Force, 2012c). The study protocol excluded patients admitted to a medical day unit, or for observation after an endoscopy procedure or other invasive treatment. Also excluded were patients admitted to obstetric, psychiatry, palliative, and paediatric wards, and those directly admitted to the intensive care unit (Canadian Malnutrition Task Force, 2012c). Enrolment occurred every other week, in large facilities (>200 beds) and every week for smaller facilities (<200 beds). Limits per recruitment week (10-15 patients) were set to ensure feasible follow-through with data collection. A target of 40 and 60 patients was set for small and large hospitals, respectively (Canadian Malnutrition Task Force, 2012c). Study entry dates rotated from Monday to Friday until the quota was reached for the week ensuring that recruitment was quasi-random, covering all days of the week and promoting the attainment of a more

representative sample (Canadian Malnutrition Task Force, 2012c). Participants with edema or ascites (n=36), or who were designated as palliative post recruitment were removed from this analysis (n=7), as were those with altered hydration statuses indicated by IV prescription (n=4), or were considered an outlier for body weight change (≥15% during admission; n=7). A final sample of 490 older adults was available for analysis.

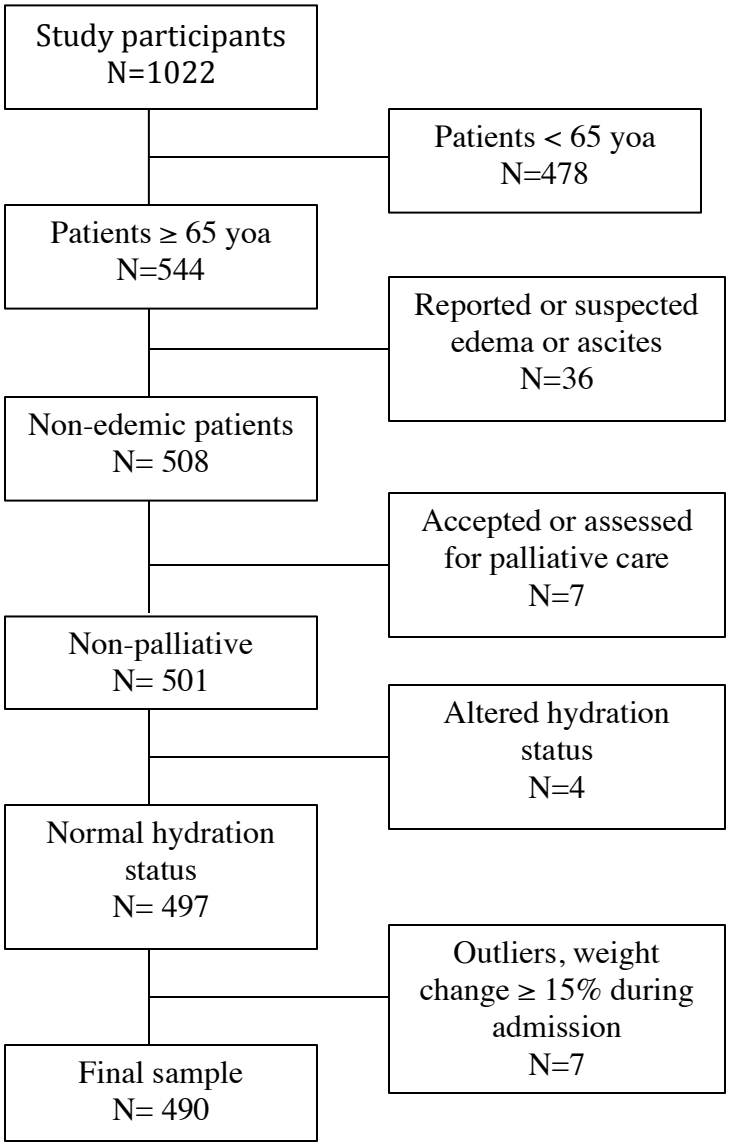

Figure 1: Identification of Sample for Analysis

6.3.2 Overview of data collection and variables for analysis

Only patient level data from the main study was used in this analysis; variables used in multivariate modeling will be briefly described. Variables selected for analysis were based on existing literature on weight change or nutritional status of older adults, as well as clinical judgement. They were further operationalized and categorized as needed for this study. Upon admission, hospital site (including province, type, and size), admission ward (surgical vs. medical), patient demography (age, gender, education level), co-morbidity, present and past cancers, and medication use prior to admission were collected (Canadian Malnutrition Task Force, 2012a). Age in years remained a numeric variable throughout analyses; gender remained categorical, male (1) and female (0); and co-morbidities, represented by the Charlson Comorbidity Index (CCI), remained numeric (higher values indicate increased morbidity). Current, new (diagnosed during admission), and past cancer were categorical variables (yes=1). The number of previous surgeries and admissions in the past five years were examined as numerical variables. Medication use prior to admission was comprised of prescription, non-prescription, and antibiotic use. Antibiotic use was examined as a categorical variable (yes=1), which identifies the presence of infection, while prescription and non-prescription medication use were combined into a new numeric variable for analysis to identify polypharmacy.

SGA and serum c-reactive protein (CRP) were collected at admission and discharge (Canadian Malnutrition Task Force, 2012a). SGA, which uses medical history and physical examination to assess nutritional status, was used to diagnose nutritional status (Detsky et al., 1987). SGA A represented being well-nourished while SGA B and C were amalgamated and represented malnourishment. C-reactive protein was

categorized as normal, ≤ 10 μg/ml (0) or high, >10 μg/ml (1), as described by Black et al. (2004). Knee height was measured and used to calculate body mass index (BMI) on admission and at discharge.

Weight was measured on admission and approximately every two days by the site coordinator during admission and again at discharge using a Seca 952 digital chair scale (Seca gmbh & co., Germany). Patients' measured weight on admission and self-reported usual weight were used to determine pre-admission weight change. Pre-admission weight change was re-categorized as loss ≥5 lbs (1) or weight maintenance/gain (0). This categorization was chosen to match post-discharge weight change categorization, which was collected as self-reported weight loss ≥5 lbs, weight gain ≥5 lbs, no significant change or don't know, and similarly re-categorized for analysis. Percent weight change during admission was calculated using admission weight and discharge weight. In cases where discharge weight was not available, the last available measured weight was used as a proxy.

Additionally, data concerning food related activities of daily living (living, shopping, and cooking) and oral nutritional supplement (ONS) use prior to admission were collected at baseline via self-report of the participant or their proxy (Canadian Malnutrition Task Force, 2012a). Living situation was re-categorized as alone (1) or with others (0) while cooking and shopping were re-categorized as done by primarily by the patient (1) or other (0). ONS use was a categorical variable as use (1) or no use (0).

Food intake during admission was attained from patient self-report using the nutritionDay Patient Intake Form; families who witnessed consumption may have also filled out the form. Portion of the main plate (0%, 25%, 505 75% and whole meal)

consumed for a single meal was recorded. In the first week of admission the nutritionDay Patient Intake Form was completed three times and thereafter twice a week until discharge, except in the case where admission was greater than one month, and then it was completed only once a week until discharge (Canadian Malnutrition Task Force, 2012c). The mean portion of main plate consumed was calculated using all available nutritionDay data and re-categorized as <75% or ≥75% as prior research found that patients experienced weight loss when intake was below 75% of their requirements (Kondrup et al., 2002).

Participant information was tracked throughout admission. Variables included: weight, new diagnoses, ICU admission, surgeries, diet orders, nutrition professional (dietitian, diet technician, and dietetic intern) visits, adverse events (e.g., fall, falls, dysphagia, constipation, delirium etc.), medication (summarized as mean/day) and antibiotic use (described as use or no use), length of stay (days), and mortality. Nutrition professional visits were originally recording by noting the day the visit occurred (Canadian Malnutrition Task Force, 2012a). Re-categorization was done so that each visit day represented one visit. Visits from all nutrition professionals were then summed to create a new numeric variable. Similarly, the occurrences of adverse events were originally represented by the day it occurred as well as the specifics of the event. Though up to two adverse events were recorded, for the purpose of this study adverse events were characterized as having occurred (1) or not (0).

At discharge patients completed a questionnaire to gather data regarding patients' perceptions of food access issues. This questionnaire was adapted from Naithani et al., (2009) and included 38 items. Wording was made more appropriate for use in Canadian

hospitals and some questions were removed for hospitals where there was no menu/food selection (Keller H. Personal communication. 2012). Responses to questions were rated by participants on a Likert-like scale (e.g., never happened to everyday) (Naithani et al., 2009). Questions were grouped and scored to determine risk as described by the authors. Domains included choice, organizational and environmental barriers, hunger, physical barriers, food quality, and conditions that affected food intake (e.g., appetite, pain). Responses for each question were recoded (risk=1 vs no risk= 0) and responses within each domain were summed and re-categorized with scores greater than or equal to two indicating risk for that domain (1 vs 0) (Gulliford, M. Personal communication. 2013).

Participants or family were contacted via telephone 30 days following discharge. Information collected included: if they had been re-hospitalized (1=yes); self-reported weight change; re-categorized as weight loss ≥5 lbs (1) and maintenance or gain (0); appetite, recategorized as fair/poor (1) and good/very good (0), whether or not they were following a special diet (yes=1); if diet was different from pre-admission diet (yes=1); eating more than one meal with someone, recategorized as never/rarely(1) and sometimes/often/almost always (0); who prepares meals, recategorized as patient (1) or other (0); visits to a doctor (yes =1) or dietitian since discharge (yes=1); and, whether or not they had talked to another health professional since discharge (yes=1).

6.3.3 Data analysis

Analyses were performed using SPSS 20 (IBM Corporation, USA, 1989, 2011). Descriptive analyses using frequencies and distributions were used to characterize the sample. Bivariate analyses and clinical judgement were used to identify candidate

variables to include in initial full regression models. Variables included were associated with the outcome variables at the $p<0.2$ level as well as variables highlighted in the literature or thought to make clinical sense. Significant association between candidate variable were expected with the large sample size. Therefore in order to reduced the risk of multicollinearity if a significant correlations at the $p<0.001$ then only the variable contributing most to the regression was retained. VIF was also examined to assess multicollinearity in the final admission model. Key covariates of age, gender, hospital type, and admission ward were included in each model as forced covariates in addition to hospital size in the admission and post-discharge analyses in order to account for their influence on weight change as well as potential clustering effects of hospital characteristics.

Pre- and post-hospital self-reported weight losses (≥5 lbs) were examined using logistic regression. Percent weight change during the hospital stay was examined using linear regression. As sample size determines the number of independent variables that can be modeled with confidence, a conservative estimate was made of 19 and 9 variables for pre-admission and post-discharge models respectively (Peduzzi et al., 1996) (based on proportion losing weight), while 41 variables could be modeled for weight change during admission (Field, 2009).

Candidate variables were forced into the regression models with the covariates and manual backwards removal was used to only include variables with significant predictive value in the final model. Selection for removal was based on low coefficient Beta values and insignificant Wald-statistics (linear regression), t-statistic or the odds-ratios (logistic regression). The removal of each variable was validated through the examination of the

change in the R^2 that occurred following its elimination. If the R^2 was reduced by ≥0.2 it was reintroduced to the model on the assumption that it had noteworthy predictive value; ≥0.2 was selected as a conservative value in order to reduce likelihood of excluding significant variables.

6.4 Results

Table 1 presents the descriptive results of variables across the stages of hospitalization. There were 490 eligible older patients (≥65 years) included in analysis with a mean age of 76.3 years (SD 7.8). Roughly half of the sample was female (50.8%) and approximately one third of patients completed grade school or less (31%); similar proportions completed some or all of high school (37.6%) and some or all of university or college (30.6%). About three quarters of the sample was admitted to a medical ward (71%). Prior to admission, 31.4% of the sample lived alone, 58.6% shopped, and 60.4% cooked for themselves. Approximately two-thirds of participants (67.3%) were discharged home, with 24.7% cooking for themselves, and 18.8% eating meals with someone never or rarely at 30–days post discharge. On admission, 16.5% had cancer and the average Charlson Comorbity Index (CCI) score was 3.42 (SD 3.1); 4.1% of the sample was diagnosed with a new cancer and the average CCI score at discharge was 3.39 (SD 3.1).

On admission, SGA identified 48.6% of participants as malnourished (SGA B or C). At discharge, using the same criteria, 33.1% of participants were malnourished however there was data missing from ≥30% of participants. Additionally, 41% of the 466 of participants for which pre-admission weight change data was available experienced a pre-admission weight loss (≥5 lbs). Over half (58%) of the 416

participants for which admission weight change data was available experienced measured weight loss during their hospital stay with weight change ranging from -14.29 to +14.65% of body weight. Almost a third (30%) of the 321 of participants for which post-discharge weight change data was available reported a weight loss (≥5 lbs) following discharge. Proportions with potential risk factors for weight change at various stages of hospitalization are also noted in Table 1. The average length of stay was 11 ± 12.5 days. Ethnicity was thought to be unhelpful in describing the sample since the majority of patients (82.7%) identified themselves as Canadian, which can be comprised of various ethnicities.

Table 1a: Descriptive analysis of entire sample, preadmission body weight

	Whole sample n=490	Pre-admission weight loss ≥ 5lbs n=193	Pre-admission weight maintenance or gain n=273
Descriptive variable			
Age	76.3 ± 7.8	75.88 ±7.8	76.08 ± 7.6
Gender, female	50.8%	42%	56%
Ward, medical	71%	73.6%	68.1%
Hospital type, academic	58.2%	58.5%	56.4%
Ethnicity, Canadian	82.7%	81.3%	83.5%
Education, Grade school or less, High school (some or completed), University or college (some or completed)	 31% 37.6% 30.6%	32.1%	30.8%
Charlson Comorbidity Index score on admission	3.42 ± 3.1	3.69 ± 3.4	3.25 ± 2.9
High C-Reactive protein level on admission	56.3%	59.6%	53.8%
Current cancer	16.5%	19.7%	15%
Previous cancer	29.2%	30.6%	27.1%
New cancer diagnosis on admission	4.1%	6.2%	2.9%
Oral nutrition supplement use prior to admission	22.7%	29.5%	17.2%

Table 1a: Continued

	Whole sample	Pre-admission weight loss ≥ 5lbs	Pre-admission weight maintenance or gain
Vitamin/mineral supplement use pre-admission	43.9%	38.9%	47.3%
Antibiotic use pre-admission, yes	39.8%	41.5%	37.7%
Medication use pre-admission	15.68 ± 8.2	15.36 ± 8.0	15.75 ± 8.3
Previous surgeries (5y)	0.86 ± 1.1	0.90 ± 1.1	0.84 ± 1.1
Previous admissions (5y)	2.55 ± 3.1	2.71 ± 3.2	2.32 ± 2.8
Live alone at admission	31.4%	31.3%	31.9%
ADL- cooking, patient	60.4%	61.1%	61.2%
ADL- shopping, patient	58.6%	55.4%	63.0%
BMI on admission	28.35 ± 7.9	26.64 ± 8.5	29.56 ±7.1
Malnourished on admission	48.6%	77.2%	27.8%

Table 1b: Descriptive analysis of entire sample, weight change during admission

	Whole sample n=490	Admission weight loss n=240	Admission weight maintenance or gain n=176
Descriptive variable			
Age	76.3 ± 7.8	75.77 ± 7.6	77.16 ± 8.0
Gender, female	50.8%	49.6%	52.3%
Ward, medical	71%	67.1%	76.1%
Hospital type, academic	58.2%	62.9%	52.8%
Hospital size, number of beds	478.98 ± 297.5	492.44 ±301.4	
Management, self-operating	86.5%	91.3%	80.7%
Delivery, tray service	96.3%	97.5%	95.5%
Ethnicity, Canadian	82.7%	83.8%	81.8%
Education, Grade school or less, High school (some or completed), University or college (some or completed)	 31% 37.6% 30.6%	35.8%	27.3%

Table 1b: Continued

	Whole sample	Admission weight loss	Admission weight maintenance or gain
Charlson Comorbidity Index score on admission	3.42 ± 3.1	3.42 ± 3.0	3.22 ± 2.9
High C-Reactive protein level on admission	56.3%	60.4%	51.7%
Current cancer	16.5%	18.3%	13.1%
Previous cancer	29.2%	27.9%	28.4%
New cancer diagnosis on admission	4.1%	4.6%	3.4%
Previous surgeries (5y)	0.86 ± 1.1	0.86 ± 1.1	0.77 ± 1.0
Previous admissions (5y)	2.55 ± 3.1	2.47 ± 2.4	2.65 ± 3.9
Surgeries during admission	0.24 ± 0.5	0.29 ± 0.5	0.20 ± 0.5
Number of nutrition professional visits during admission	0.98 ± 1.7	1.23 ± 1.9	0.90 ± 1.4
NutritionDay average intake <75%	48.8%	55.8%	40.3%
High risk food choice	≥ 30% missing		
High risk organizational and environmental barriers	≥ 30% missing		
High risk for hunger	13.9%	16.7%	12.5%
High risk for physical barriers	28%	28.8%	28.4%
High risk for food quality	18.4%	21.7%	14.8%
High risk for illness	48.2%	50.8%	48.3%
Length of stay (days)	10.77 ± 12.5	12.62 ± 12.9	9.94 ± 13.1
Medication use during admission	13.93 ± 5.9	13.68 ± 5.7	14.58 ± 6.0
Antibiotic use during admission, yes	48.2%	55.8%	39.8%
Adverse events during admission, yes	48.8%	54.6%	48.3%
BMI on admission	28.35 ± 7.9	29.28 ± 7.6	27.06 ± 6.91
Malnourished on admission	48.6%	45.8%	51.1%
Worsening of nutritional status during admission	≥ 30% missing		

Table 1c: Descriptive analysis of entire sample, post discharge weight change

Descriptive variable	Whole sample	Post- discharge weight loss ≥5lbs n=95	Post-discharge weight maintenance or gain n=226
Age	76.3 ± 7.8	76.13 ± 7.7	75.84 ± 7.7
Gender, female	50.8%	51.6%	50.9%
Ward, medical	71%	61.1%	69%
Hospital type, academic	58.2%	54.7%	59.7%
Hospital size, number of beds	478.98 ± 297.5	479.72 ± 300.2	499.07 ± 313.9
Ethnicity, Canadian	82.7%	77.9%	83.6%
Education, Grade school or less, High school (some or completed), University or college (some or completed)	 31% 37.6% 30.6%	28.4%	28.8%
Charlson Comorbidity Index score at discharge	3.42 ± 3.1	3.54 ± 3.5	3.23 ± 3.1
Current cancer	16.5%	20%	16.4%
Previous cancer	29.2%	25.3%	29.2%
New cancer diagnosis on admission	4.1%	4.2%	3.1%
BMI at discharge		28.32 ± 7.7	27.62 ± 6.2
High CRP at discharge	≥ 30% missing		
Malnourished at discharge	≥ 30% missing		
Worsening of nutritional status during admission	≥ 30% missing		
Discharged home		71.6%	75.7%
30 day readmission, yes		21.1%	11.1%
30 day poor appetite		47.4%	23%
Eating alone at 30-days		36.8%	20.4%
Activities of daily living post discharge—cooking, done by patient		29.5%	38.1%
RD visit 30 days		22.1%	11.1%
MD visit 30 days		80%	77.9%
Other health professional 30 days		11.6%	8.0%

Table 2 presents the bivariate associations between independent variables and outcome variables, also displaying the strength and direction of relationships. Variables significantly associated with outcome variables were highlighted. No variables were significantly correlated at r> 0.8 (data not shown).

Table 2: Correlations of covariates and independent variables with weight change during each stage of hospitalization for adults ≥65 y

Variables	Weight loss pre-admission, n=193	Percent weight change during admission, n=369	Weight loss following discharge, n=95
Age	t=0.29	ρ=0.10**	t=-0.30
Gender	X^2=8.96**	t=0.09	X^2=0.01
Hospital site	t=-0.28	ρ=0.12**	t=0.27
Hospital type	X^2=0.211	t=-2.86**	X^2=0.69
Province	t=1.34*	ρ=0.04	t=-0.10
Number of hospital beds		ρ=-1.06**	t=.050
Ward	X^2=3.39*	t=0.71	X^2=2.56*
Food service delivery		t=2.46**	
Food service management		t=-2.28**	
Education	X^2=0.07	t=2.38**	X^2=<0.01
Living situation pre-admission	X^2=0.03		
Person responsible for shopping pre-admission	X^2=1.91*		
Person responsible for cooking pre-admission	X^2=0.14		
Oral nutrition supplement use prior to admission	X^2=9.63 **		
Vitamin/Mineral supplement use prior to admission	X^2= 3.98**		
Antibiotic use prior to admission	t=-1.29*		

Table 2: Continued

	Weight loss pre-admission	Percent weight change during admission	Weight loss following discharge
Medication use prior to admission	t=0.51		
Past surgeries (5y)	t=-0.63	ρ=-0.01	
Past admissions (5y)	t=-1.38*.176	ρ=0.01	
Current cancer	X^2=1.77*,183	t=1.26	X^2=0.59
Past cancer	X^2=0.94	t=0.34	
New cancer upon admission	X^2=2.94* .086	t=1.48*	X^2=0.25
Charlson Comorbidity Index score on admission	t=-1.49*.138	ρ=-0.05	
Charlson Comorbidity score at discharge			t=-0.70
High C-reactive protein level on admission	X^2=1.91*.167	t=1.96*	
Body Mass Index on admission	t=3.99***<.001	ρ=-0.14**	
Body Mass Index at discharge			t=-0.73
Malnourished status on admission		t=0.04	
Malnourished status at discharge			X^2=1.07
Worsening of nutritional status during admission			X^2=2.27*
Mean number of medications during admission		ρ=0.04	
Use of antibiotics during admission		t=2.94**	
Total number of surgeries during admission		ρ=-0.11**	
Total number of nutrition professional visits during admission		ρ=-0.10**	

Table 2: Continued

	Weight loss pre-admission	Percent weight change during admission	Weight loss following discharge
Occurrence of adverse events during admission		t=3.21**	
Mean nutritionDay percent of meal consumed <.75		t=2.14**	
Risk due to food choice during admission		t=-0.24	
Risk due to organizational mealtimes barriers during admission		t=-0.95	
Risk due to hunger during admission		t=-0.06	
Risk due to physical barriers during admission		t=0.26	
Risk due to food quality during admission		t=1.88*	
Risk due to effects of illness		t=1.38	
Length of hospital stay		ρ=-0.21***	
Discharge location			X^2=0.69
Readmission after 30 days post discharge			X^2=5.50**
Appetite at 30 days post discharge			X^2=18.99***
Special diet 30 days post discharge			X^2=0.03
Diet different from pre-admission 30 days post discharge			X^2=0.42
Eating alone never or rarely 30 days post discharge			X^2=9.5**

Table 2: Continued

	Weight loss pre-admission	Percent weight change during admission	Weight loss following discharge
Person responsible for cooking 30 days post discharge			X^2=2.05*
MD visit			X^2=0.69
RD visit			X^2=7.12**
Other health care professional visit			X^2=1.19

* Significant at the 0.2 level
**Significant at the 0.05 level
*** Significant at the <0.001 level

Table 3 presents the results from the pre-admission regression analysis. The final pre-admission model included oral nutrition supplement use (OR=2.1, 95% CI 1.31-3.36) and male gender (OR=1.83, 95% CI 1.23-2.73), which were associated with self-reported weight loss greater than or equal to five pounds (n=445, R^2=0.06). Covariates of age and hospital type were retained in the final model, although neither was significant.

Table 3: Logistic regression examining the factors associated with weight loss greater ≥5 lbs prior to hospital admission in adults ≥65 y (n=445, R^2=0.06)

Variable	Unstandardized β coefficient	Wald (p)	Odds Ratio (OR)	95%CI Of OR
Age	<0.001	<0.001 (p=0.989)	1.00	0.98-1.03
Gender	0.60	8.72 (p=0.003)	1.83	1.23-2.73
Hospital type	-0.03	0.02 (p=0.899)	0.98	0.66-1.44
Ward	-0.40	3.09 (p=0.079)	0.67	0.43-1.05
ONS use prior to admission	0.74	9.49 (p=0.002)	2.10	1.31-3.36

Linear regression was used to identify factors significantly associated with weight change throughout admission. Because it is not well understood whether or not weight change leads to increased hospital stays or if hospital stays lead to weight change, length of stay was excluded from analyses. The exclusion of length of stay as a candidate variable also allowed for the identification of potentially significant factors masked by the effect of length of stay. Table 4 presents the results from admission regression analysis. Hospital type and size, ward, age, and gender were all kept in the model as covariates, although none were significant. Higher BMI on admission (β=-0.2, p=0.001), the occurrence of one or more adverse events (β=-0.15, p=0.008), mean intake of less that 75% of recorded meals during admission (β=-0.19, p=0.001), and the use of antibiotics during admission (β=-0.11, p=0.049) were all associated with weight loss in older patients throughout the admission period (n=290, R^2=0.14).

Table 4: Linear regression examining the factors associated with weight change during hospital admission in adults≥65 y (n=290, R^2=0.14)

Variable	Standardized β coefficient	t	Significance
Hospital type	0.08	0.99	0.322
Number of beds	0.06	0.73	0.467
Ward	-0.01	-0.23	0.818
Age	0.10	1.67	0.097
Gender	0.05	0.90	0.37
BMI on admission	-0.20	-3.45	0.001
Occurrence of adverse events	-0.15	-2.66	0.008
Mean intake <75%	-0.19	-3.23	0.001
Antibiotic use during admission	-0.11	-1.98	0.049

Results of the post-discharge regression are presented in Table 5. Following hospitalization, a poor self-reported appetite (OR=3.82, 95% CI 2.1-6.97), eating with others never or rarely (OR=2.48, 95% CI 1.31-4.69), and having been admitted to a surgical ward (OR=1.86, 95% CI 1.03-3.35), were significantly associated with self-reported weight loss ≥5lbs post discharge. At the 30-day follow-up, none of the covariates were significantly associated with the dependent variable, but as with the other models, all covariates remained in the final model in order to account for potential clustering effects (n=279, R^2=0.16).

Table 5: Logistic regression examining the factors associated with weight loss greater ≥5lbs following discharge from hospital in adults≥65 y (n=279, R^2=0.16)

Variable	Unstandardized β coefficient	Wald (p)	Odds Ratio (OR)	95%CI Of OR
Age	-0.008	0.15 (p=0.697)	0.99	1.00-1.03
Gender	0.07	0.06 (p=0.805)	1.08	0.60-1.93
Hospital type	-0.19	0.21 (p=0.65)	0.83	0.37-1.85
Number of beds	-0.001	2.09 (p=0.149)	0.999	0.998-1.0
Ward	0.62	4.24 (p=0.039)	1.86	1.03-3.35
Poor appetite post discharge	1.34	19.12 (p<0.001)	3.82	2.10-6.97
Eating with others never or rarely post discharge	0.91	7.70 (p=0.006)	2.48	1.31-4.69

6.5 Discussion

It is believed by some researchers that the occurrence of malnutrition in health care prevails despite advances in medical care because nutritional concerns are overlooked or considered of low importance (Barker et al., 2011). In order to improve the nutrition care process, it is essential to identify factors strongly associated with nutritional outcome in order to effectively allocate resources where they will be most beneficial to the patients and their recovery.

The objective of this research was to identify factors independently associated with weight change throughout the stages of hospitalization, specifically for older adults who have potentially increased risk for weight loss (Chapman, 2011), addressing the minimal available research regarding change in nutritional status throughout peri-hospitalization in older adults admitted to Canadian acute facilities. The results of the current study reveal various factors associated with weight change throughout peri-hospitalization, provide a basis for future research topics, and have the potential to guide future nutrition care protocols.

The sample studied had nearly equal proportions of males and females and is almost evenly distributed within education levels. However other factors may influence the generalizability of results and should be kept in mind when comparing findings to those from different institutions, regions, and populations. For example, two thirds of the participants were under the age of 80 (data not shown), potentially underrepresenting the oldest-old adults and thus the effect of age, or factors associated with age (e.g. dementia) on weight change. Recruitment was from only medical and surgical admissions and cognitively well patients were likely preferred in recruitment. Representativeness of the

sample may have been influenced by recruitment methods as site coordinators were unable to approach patients directly for participation. Despite these limitations, this work provides new insights into potential causes and consequences of weight loss in older adult patients.

The final pre-admission model demonstrated significant association between weight loss and male gender as well as oral nutrition supplement use prior to admission. Perissinotto et al. (2002) found that older men in their study had a higher rater of weight loss than women. Although the differences in rates of weight loss were not significant Perissinotto et al. (2002) also found that the mean BMI for women was significantly higher in women than men suggesting that males are at greater risk of undernutrition than females in old age. Contrary to the results of the current study, past intervention research has suggested that the use of oral nutrition supplements (ONS) in older adults has often been associated with improved weight and nutritional status (Lauque et al., 2000; Pivi et al., 2011). This may be explained by the nature of our data collection, and specifically that use of ONS and weight loss were collected at the same time, making it impossible to identify a causal relationship between ONS use and pre-admission weight loss. Also, it is suspected that this association is the result of unwell individuals who had experienced weight loss and were using oral nutrition supplements in order to improve their state, but had yet to recuperate these losses. Although it is suspected that ONS use is the result of weight loss rather than a potential cause, it remained in the model because no other modifiable factors showed significance.

Length of stay has consistently been associated with a decreased nutritional status in much of the literature as with the results of this study (Correia & Waitzberg, 2003;

Chima et al., 1997). However, it is unclear if length of stay increases weight loss, or increased weight loss leads to a greater length of stay and it's potential to mask other significant factors lead for it's exclusion as a candidate variable in the current study. The final model included high admission BMI, the occurrence of adverse events, low food intake, and antibiotic use as factors that significantly influence weight change throughout admission.

Past literature has proposed that high BMI is associated with weight loss during hospitalization, which is consistent with the results of this study (Valentini, 2009). The occurrence of adverse events during admission was also consistent with existing literature. As aforementioned, in the examination of community dwelling older adults, Serra-Prat et al. (2012) identified impaired swallowing efficacy as a risk factor for malnutrition which would be expected to extend to hospitalized older adults. Additionally, adverse events such as falls occurring in hospital may result in minor or severe injury (Oliver, Healey, & Haines, 2010). Sustained injuries may affect the nutritional status of patients (Jensen et al., 2010). Kondrup et al., (2002) examined the incidence of nutrition risk in hospitals and found that weight loss occurred in those consuming less than 75% of their estimated requirements supporting the results of the current study which demonstrated a significant association between weight loss and a self-reported intake of less than 75% of the main plate throughout admission. Antibiotic use is indicative of infection which induces anorexia though reduced intake, affects substrate utilization, promotes tissue catabolism, and increases basal metabolic rate, resulting in weight loss, and is thus not a surprising independent determinant of weight loss in this sample (Macallan, 2009).

Following discharge from hospital, poor reported appetite, never or rarely eating with others, and having been admitted to a surgical ward were associated with a weight loss of ≥5 lbs 30 days post discharge. A reduction in appetite will result in low intake and weight loss; therefore, this association was expected (MacIntosh et al., 2000; Shahar D.R., Schultz, Shahar, A., & Wing, 2001; Shahar, Shai, Vardi, & Fraser, 2003). The association between eating alone and weight loss was also expected as existing literature has suggested that the presence of others during mealtimes significantly influences intake of other adults (de Castro, 1993, Locher, 2005). Finally, the association between having been admitted to a surgical ward and weight loss was expected since surgical patients are at high risk of weight loss post surgery due to the stress and heightened metabolic demands that ensue (Edington & Martyn, 1997). Additional research has demonstrated following surgery patients may be unable or unwilling to eat, or may experience anxiety or depression also reducing food intake and promoting malnutrition which the potential to continue even after discharge from hospital (Edington & Martyn, 1997).

With the exception of gender imposing a significant effect on weight loss prior to hospitalization, and ward imposing significant effects following discharge, none of the other covariates were found to significantly influence weight loss or weight change throughout hospitalization. This is not consistent with prior literature, which has demonstrated that age, gender, admission ward, and certain hospital characteristics, type and size, are all factors associated with nutritional status in elderly patients. Age has been associated with nutritional status and it has been noted that food consumption over the life span declines in a linear fashion, providing some explanation as to why older adults

are more prone to weight loss, lower weight, and malnutrition than their younger counterparts (Morley, 1997; Stephan, 2010, Waitzberg et al., 2001); yet this study was specifically focused on the older adult population and thus the effect of age alone was anticipated to be of minimal significance. Further, other variables with greater explanatory power were modelled in this study. Additionally research has demonstrated conflicting results on the effect of gender on weight change with some showing women to be more at risk and others showing men (Newman et al., 2004). Past research specific to nutritional status and hospital wards has been conflicting. Early research, demonstrated that protein-calorie malnutrition was common in both wards, yet medical patients had better protein status but worse caloric depletion when compared to surgical patients (Bistrain et al., 1976). However, more recent literature has described surgical patients as having superior nutritional status to medical patients, yet it is unclear if this was at admission or during admission (Waitzberg et al., 2001).

Strengths of this study were its inclusion of multiple hospitals and a large sample size, which improves generalizability as well as power to identify associations. Furthermore, an extensive list of variables was tested in this analysis. Despite these strengths, there are also limitations of this study. Loss of participants due to mortality, missing data, or other unknown reasons may conceal other reasons for weight change throughout the continuum of hospitalization, particularly if reasons for loss to follow-up are related to nutritional status, minimal collection psychological data were collected for this investigation.

Final models accounted for a modest amount (6%- 16%) of the variance in weight change/loss throughout the stages of hospitalization. Past research has been able to explain 2-30% of the variance in nutritional status of patients depending on the variables included in the analyses (Barreto Penié , 2005). While certain variables could be highlighted as covariates of weight change at some point throughout the continuum of care, research is required to discriminate between covariates that are the cause of weight loss from those that are related to the effects of weight loss. Also much of the variance in these models remains unexplained. Additional research focused on weight loss and weight change throughout hospitalization is needed in order to explain this conundrum. Nonetheless, the results of this research provide a foundation on which we can begin to understand why malnutrition occurs and effectively allocate resources and ensure optimal recovery for elderly patients.

6.6 Take away points

- Weight loss throughout the continuum of hospitalization in older adults is common and likely has multifactorial causes
- Male gender, oral nutrition supplement use, BMI, adverse events, low food intake, antibiotic use, admission ward, eating with others never or rarely, and poor appetite were found to have a significant association with weight change or weight loss at some point throughout peri-hospitalization
- Future research is needed to increase the understanding between identified relationships of weight change occurring in acutely hospitalized older adults

7.0 DISCUSSION

It is believed by some researchers that the occurrence of malnutrition in health care prevails despite advances in medical care because nutritional concerns are overlooked or considered of low importance (Barker et al. 2011). In order to improve the nutrition care process, it is essential to identify factors strongly associated with nutritional outcome in order to effectively allocate resources where they will be most beneficial to patients and their recovery.

As aging can promote nutritional decline, the objective of this research was to identify factors independently associated with weight change, specifically weight loss, as a measure of nutritional status, throughout the stages of hospitalization in patients aged ≥65y (Chapman, 2011). This work provides new insights into potential causes and consequences of weight loss in older adult patients.

7.1 Sample characteristics

The current study examined a purposive sample of hospitalized older adults nearly equally distributed between genders (50.8% female). Data from 2010 indicate that in Canada, 56% of individuals ≥65 y were female, suggesting that this sample is skewed towards male participants, and thus may not be generalizable to the entire older adult population residing in Canada (Milan & Vézina, 2011). Unfortunately there are few other Canadian studies exclusively focused on an older adult patient population for comparison in terms of generalizability. Of the 152 elderly patients examined by Azad et al. (1999) 56.6% were female, similar to the results of the current study. However the small sample size of Azad et al. (1999) may affect the generalizability of these characteristics to other

Canadian hospitals. About one third of the sample under examination was ≥80y. 20.4 % of the sample from Azad et al. (1999) were ≥80, a lower proportion than the current study. Canadian data from 2012 indicates that 27.5% of the Canadian population is ≥80; this is quite close, but is not surprising that a higher proportion of our sample are over 80 years, due to the known increased health problems in this subgroup. Descriptive analyses also demonstrated that this sample was almost evenly distributed within three education levels. Data from the 2008-2009 show that 30.5% of Canadian older adults have a postsecondary education (Ramage-Morin & Garriguet, 2013). Differences in the categorization of education levels impairs direct comparisons, yet a similar proportion of older adults in general and in this sample had more than a primary school education.

A higher proportion of our sample (31.4%) lived alone as compared to the 2011 Canadian Census (25%) and is consistent with the noted differences in age group admitted to hospital (Statistics Canada, 2011). High proportions (>55%) of our sample required help from others for cooking and shopping, whereas 2008-2009 data have demonstrated that 44% of Canadian older adults have a moderate-severe disability (Ramage-Morin & Garriguet, 2013). While these variables are not directly comparable, it seems that our sample was more frail and dependent than the general Canadian older adult population. It is important to recognize that because comparisons were made to the general Canadian older adult population rather than the Canadian older adult population requiring acute hospitalization, which may account for differences between the sample and population characteristics. Additionally, because recruitment was of only medical and surgical admissions, and since members of the health care team often recruited them, it is anticipated that sample is biased towards less unwell, and cognitively well patients.

7.1.1 Prevalence of impaired nutritional state

In this study 30-58% of participants in the final models experienced weight loss at some point around hospitalization. This coincides with existing literature that has noted the frequency of weight loss and malnutrition during hospitalization. For example, Corish et al. (2000) found that 12% of patients, experienced a weight loss >10% within the 6 months prior to hospitalization while McWhirter & Pennington (1994) described the occurrence of weight loss as 64% of patients of all ages throughout their hospitalization. As the studies by Corish et al. (2000) and McWhirter & Pennington (1994) were conducted with both older and younger adults the weight change specific to older adults cannot be discerned. The presentation of weight loss in so many participants in this study substantiates the need for research into factors associated with weight loss in order to decrease prevalence and improve patient outcome.

7.2 Factors associated with weight loss prior to hospital admission

The final pre-admission regression model highlighted male gender and ONS use prior to admission as factors significantly associated with weight loss ≥5 lbs prior to their admission to an acute care facility. Past research has found an increased rate of weight loss in older men in comparison to older women (Perissinotto et al., 2002). Although the differences in rates of weight loss were not significant, Perissinotto et al. (2002) also found that the mean BMI for women was significantly higher than men, suggesting that males are at greater risk of undernutrition than females in old age. Additionally, studies focused on malnutrition in hospital not specific to older adults have found increased risk

of malnutrition and malnutrition to be more prevalent in men (Barreto Penié, 2005; Wyszynski et al., 2003).

Although it is suspected that ONS use is the result of weight loss rather than a potential cause, it remained in the model because no other modifiable factors showed significance. Past research has suggested that the use of oral nutrition supplements in older adults is associated with improved nutritional status, contrary to the results of the current study. For example, in a study of patients with Alzheimer's Disease, ONS use resulted in significant improvements in weight, BMI, arm circumference, and arm muscle circumference (Pivi et al., 2011). Similarly in a sample of elderly nursing home residents both malnourished and those at risk of malnutrition were more likely to show improvements in body weight with ONS use (Lauque et al., 2000). However, because this study was focused on older patients with acute or exacerbated chronic illnesses requiring hospitalization, greater challenges to regain weight may have been experienced by this sample. There are unfortunately no similar reports of weight loss and ONS use prior to hospitalization in this segment of the population to compare results. Research considering ONS use to date has primarily been intervention-based allowing for the evaluation of the effects of ONS use on nutritional status over a period of time. Since this study relied on self-report recall data at one point in time for information regarding ONS use, a clear cause and effect relationship cannot be discerned. Taking past and current methodology and results into consideration, a probable reasoning for this noted discrepancy is that individuals who were experiencing weight loss were consuming nutrition supplementation in order to improve nutritional status but upon admission had not recovered losses from their usual weight.

Many variables identified in the literature as associated weigh weight change and malnutrition in community-dwelling older adults were not identified in the current study. Reasons for this could be one of many. Firstly, prior research has identified a multitude of social, physical, psychological, economic, and individual choice factors that influence the nutritional status of community dwelling older adults. However, many of the previously significant factors such as polypharmacy, living alone, low-education, and disease were not significantly associated with weight loss in the current study. Additionally, it is suspected that, because previous studies of community dwelling older adults were not specific to the pre-hospital admission period, these studies reflect more medically stable older adults. This study has demonstrated that acutely ill older adults are at risk of weight loss and malnutrition from different factors than their medically stable counterparts and as a result should be treated accordingly. Issues with collected the data upon admission rather than prior to admission may have also influence the validity of the patient data and therefore resulted in unexpected results. A similar problem exists with using usual weight and admission weight to calculate weight change prior to admission. Relying on self-reported usual weight with no specification of the last time the patients was at this usual weight allows for chances of over- or underestimation of weight change occurring prior to admission and does not expose the length of time over which weight changes occurred.

In order to better understand why weight loss occurs in older adults prior to hospital admission more information such as psychological data, consumption habits, and physical barriers should be collected. Depression for example has been found to be associated with weight loss but could not be examined, as it was not collected.

Additionally information surrounding mealtimes and consumption habits were also omitted although information regarding social interactions during mealtimes and appetite may have helped explain the experienced weight changes. Finally, physical barriers influencing intake such as chewing and swallowing capabilities should be examined in future research in an attempt to improve the understanding of weight loss prior to admission. Finally it would be beneficial to confirm usual weight with family members or physicians as well as request a general date for which this weight was applicable in order to ensure the accuracy of the information gathered as well as put weight changes into perspective with the timespan over which they occurred.

7.3 Factors associated with weight change during hospitalization

The final admission model included high admission BMI, the occurrence of adverse events, low food intake, and antibiotic use. Although length of stay has consistently been associated with a decreased nutritional status in much of the literature and also seen in preliminary analyses with these data, it was excluded from the current analysis as it is unclear if length of stay increases weight loss, or increased weight loss leads to a greater length of stay and has the potential to mask other significant factors lead (Correia & Waitzberg, 2003; Chima et al., 1997).

Past literature has suggested that higher BMI in older adults is associated with increased weight loss in nursing home residents (Valentini et al., 2009). Unfortunately there are no known similar hospital-based studies to compare our results. This association is however logical as conservation of body tissues is common in underweight

individuals. Additionally, higher weight older adults may see hospitalization as a good time to lose weight, unaware of the negative consequences.

The occurrence of adverse events during admission was also consistent with existing literature. As aforementioned, in the examination of community dwelling older adults, Serra-Prat et al. (2012) identified impaired swallowing efficacy as a risk factor for malnutrition which would be expected to extend to hospitalized older adults. Additionally, adverse events such as falls occurring in hospital may result in minor or severe injury (Oliver, Healey, & Haines, 2010). Sustained injuries may affect the nutritional status of patients with the potential development acute disease- or injury-related malnutrition, which as aforementioned are caused by acute injury or disease states (Jensen et al., 2010).

Kondrup et al., (2002) examined the incidence of nutrition risk in hospitals and found that weight loss occurred in those consuming less than 75% of their estimated requirements supporting the results of the current study which demonstrated a significant association between weight loss and an intake of less than 75% of meals throughout admission. Antibiotic use is indicative of infection which induces anorexia though reduced intake, affects substrate utilization, promotes tissue catabolism, and increases basal metabolic rate and resulting in weight loss, supporting the association found in the current study (Macallan, 2009).

It is suspected that the use of antibiotics is indicative of infection which induces anorexia though reduced intake, affects substrate utilization, promotes tissue catabolism, and increases basal metabolic rate and resulting in weight loss (Macallan, 2009). It is suspected that weight loss in our sample was partially attributed to infection, of which

antibiotic use is a proxy (Macallan, 2009). Infection induces anorexia though reduced intake, affects substrate utilization, promotes tissue catabolism, and increases basal metabolic rate (Macallan, 2009). As such, antibiotics prescribed to combat infection may further deteriorate nutritional status. For example in a study of polypharmacy by Veehof, Stewart, Meyboom-de Jong, & Haaijer-Ruskamp (1999) antibiotics were responsible for adverse gastrointestinal complications such as nausea, diarrhea, and stomach pains which may cause further declines in the nutritional status of patients.

Consistent with the pre-admission analysis it is expected that by targeting the ill older adult demographic, many factors generally assumed influence weight change lose their significance. For example hospital type have been in this study as only older adults were included removing the variance of age between difference hospital types which existing literature has proposed to explain the increased rates of malnutrition in community hospitals where patients are also significantly older (Pirlich et al., 2006).

Past research has identified many factors influencing the nutritional status of patients during hospitalization including social, physical, mental, food-related, and organizational. Since few social and mental health factors were represented with the during admission data collection, it is not surprising that these factors were not included in the final model. Physical, food-related, and organizational factors were more comprehensively examined, which may explain why their independent effects were detected in the regression models. Ideally future research information regarding the psychological health of patients as well as social interaction in hospital will be collected in order to examine potential factors that were overlooked in this study. Additionally, to date the majority of research examining malnutrition in the hospital setting has been

conducted in both young and older adults. Because older adults are at increased risk of weight loss and malnutrition it is likely that the factors associated with weight loss in this population are different than their younger counterparts. In the future more research should be conducted with the older adults exclusively in order to better understand weight change in this population.

7.4 Factors associated with weight loss following hospitalization

Minimal research on weight loss post hospitalization and its potential causes exists and as such, this study meets an important gap, identifying possible strategies for promoting nutritional health post hospitalization. Thirty-days following discharge from hospital, poor reported appetite, eating with others never or rarely, and having been admitted to a surgical ward were significantly associated with a weight loss of five pounds or greater. A reduction in appetite, energy intake and expenditure is typical ill older adults and typically the decline in intake is greater than the decline in expenditure, which results in weight loss (MacIntosh et al., 2000). The relationship between poor appetite and weight loss was anticipated, having already been observed in prior studies (MacIntosh et al., 2000) For example, in the examination of eating patterns of older adults, it was found that poor appetite was associated with a decline in energy intake in women whereas poorer health status, which may influence factors such as appetite, was predictive of low energy intake in men (Shahar et al., 2003). This association was also observed in a study of widowed older adults where greater weight loss was associated with low appetite (Shahar et al., 2001).

The current study also demonstrated that eating with others never or rarely 30-days following discharge from hospital was significantly associated with self-reported weight loss greater than or equal to five pounds in these older patients. This result is also consistent with existing literature that suggests that the presence of others during mealtimes significantly improves food intake in older adults (Locher, 2005). For example de Castro (1993) found that eating with others resulted in the increased food intake due to social facilitation. Comparably, more recent research specific to older adults who had newly experienced the exacerbation of a chronic illness or an acute condition, confirms that increased caloric intake occurs in older adults when they eat with others as compared to when eating unaccompanied (Locher, 2005).

Lastly, the relationship between having been admitted to a surgical ward and weight loss following discharge seen in the current was expected based on existing literature. Surgical patients, regardless of type of surgery, are at high risk of weight loss post surgery due to the stress and inflammatory processes that ensue providing an explanation for the association between having been admitted to a surgical ward and weight loss following discharge in this study (Edington & Martyn, 1997). Furthermore following surgery patients may be unable or unwilling to eat, or may experience anxiety or depression which can reduce food intake and promote malnutrition even after discharge from hospital (Edington & Martyn, 1997). The effects of surgery post discharge on nutritional status has been previously identified; in one study, 11% of patients were malnourished 6 weeks following surgery (Edington & Martyn, 1997), further supporting the association observed in the current study.

Not only is there less available literature specific to the post hospitalization period in general but, as with the admission period analysis examining only older patients may have resulted in discrepancies between the current study and existing literature of the post-hospitalization period. Additionally, in comparison to the pre-admission and admission periods, little data was collected in the post-discharge follow-up. It is suspected that a better understanding of weight loss following discharge would be possible in future research if more variables were examined. For example, as with pre-admission data, psychological factors such as depression, and physical barriers, such as chewing and swallowing difficulties, were not collected although past research has demonstrated their ability to influence nutritional status. Additionally, medication/antibiotic use were not examined, and this study was unable to determine if use was associated with weight loss following discharge. Benefit may also come from collecting CCI at 30-days in case of new diagnoses following discharge. Although occurrence of readmission was examined, adverse events following discharge should also be examined, as certain adverse events such as constipation may not require hospitalization.

7.5 Covariates

With the exception of gender imposing a significant effect on weight change prior to admission and surgical ward being significantly associated with weight loss following discharge, no covariates were found to significantly be associated with weight loss or weight change throughout hospitalization. This is conflicting with existing literature, which has demonstrated that age, and hospital characteristics, type and size, are all

factors associated with nutritional status in elderly patients (Bistrain et al 1976; Edington & Martyn, 1997; Morely, 1997; Newman et al., 2001; Waitzberg 2001).

It is suspected that certain factors generally expected to influence weight change throughout hospitalization such as age, were insignificant in the current study due to the effect of illness overpowering their influence. This idea was also presented in a study by Russell et al. (2007) who found that the prevalence of malnutrition in older adults was only 25% greater than the prevalence in younger adults; in a community sample the prevalence of malnutrition would be several folds greater in older adults than younger adults, demonstrating that conditions for which hospitalization is required may subdue the influence of other commonly identified variables (Russell et al., 2007). It is also suspected that by honing in on older patients, certain factors specific to this group would be identified as key covariates as compared to younger patients.

7.6 Limitations

Despite having a relatively large sample size from multiple acute care facilities all over Canada, the current study had some limitations. These specifically include the: potentially biased sample; loss to follow-up and missing data; limited exploration of psychological factors at all stages of hospitalization and social support during hospitalization; measures of food intake during admission; and reliance on cross-sectional and self-report data for prior to and post hospitalization data collections.

As discussed in 6.1 the sample under study may not have been an accurate representation of all older adults admitted to acute care hospitals included in the chosen hospital sites or in Canada overall. Thus, conclusions need to be tempered with the

understanding that findings may not be appropriate for generalization to other older adult patients in Canada. Comparisons to hospital surveys within the CMTF data collection will confirm representativeness of the study sample at least for hospitals included. Further comparisons to Canadian Institutes of Health Information or other resources are required to demonstrate generalizability beyond sample hospitals. Despite this limitation, this is one of the largest studies conducted to date, using multiple sites that were diverse for data collection.

Loss to follow up and missing data was also a concern in the current study. While the original sample size of 490 participants provides sufficient numbers for multivariate analyses, the loss of participants due to mortality or other unknown reasons may conceal other reasons for weight change throughout the continuum of hospitalization, particularly if reasons for lack of follow-up were related to nutritional status. Outside of death, causes for lack of complete data collection were not included in the data set available for analysis. One of the primary dependent variables, change in body weight during admission, required use of last body weight for 98 cases. This was done based on the assumption that acute hospitalization periods were typically short and only minimal changes in weight between last measured weight and actual discharge weight were possible. Yet the accuracy of this assumption cannot be verified.

Additionally, missing data on some variables decreased the number of participants that could be included in models. For example, only 445 cases were included in the final pre-admission logistic regression and only 290 in the final admission linear regression from the original sample of 490 elderly patients. Additionally, based on the fullest data point at discharge, 35 participants dropped out prior to the post discharge follow up.

These dropouts, in addition to missing data, meant that only 279 cases were examined in the final in the post-discharge logistic regression from the original sample. As well, certain variables were excluded from analyses because too many cases (≥30%) were missing; this typically occurred as new variables were added to the data collection in phase 2, after the first 6 hospitals had completed their data collection. For factors such as pre-admission diet and CRP at discharge over 30% of participant data was missing in the original data set thereby excluding it from analyses. Despite missing data and some loss to follow-up, this study was still able to maintain a relatively large sample size from distinct hospital sites and contributes to the limited amount literature specific to weight loss in older adults throughout stages of hospitalization.

Another limiting factor was the loss of participants due to missing data which influenced the regression models by limiting the number of variables that could be modeled. Not only did this mean that potentially significant factors were removed because the model was unable to support their inclusion, but certain variables were operationalized in a less than ideal manner to allow for inclusion. As aforementioned, hospital site was included as a linear variable as the models were unable to support 17 dummy variables required to include each hospital site and the 7 to include province as a categorical variables. The same issue arose with special diets prior to and following admission. Participants may have been following one of many diets at these times however, being unable to accommodate the number of dummy variables required the re-categorization of this variable as to whether or not the patient followed a diet.

Additionally, minimal psychological data were collected for this investigation, as the main study was not focused on older adults. Past research has demonstrated a strong

association between nutritional status and psychological factors such as depression, dementia, anxiety etc. in older adults (Cabrera et al., 2007; Chapman, 2011. Nykanen et al., 2012; Omran & Morley, 2000; Roque, 2013). As aforementioned, although not explicitly excluded, recruitment procedures in most hospitals lead to few older adults with cognitive impairment likely being included. Depression, the only psychological variable collected, which was not significantly associated with weight loss during hospitalization ($t=0.7$, $p=0.48$). This variable was not examined prior to or following hospitalization, where it may have been of relevance for older patients. Lacking additional information, the effects of psychological factors on weight change in the current sample are unknown.

Various questions regarding activities of daily living (living, cooking, shopping situations etc.) were collected prior to and following acute hospitalization allowing for the examination of the effects of social support on nutritional status (Canadian Malnutrition Task Force, 2012a). However, no questions were aimed at gauging social interactions at meals during hospitalization. As past research has found an association between social interaction and nutritional status in hospital, the final admission regression model may have benefited from the examination of this factor (Wright et al., 2006). Yet, most acute care hospitals in Canada do not have dining rooms for patients. While family bringing in food may indicate eating with family in hospital, this question on the patient food access survey was combined with other items.

Overall, although this study overlooked certain potentially significant factors, the large number and variety of variables that were examined still allow for a comprehensive

analysis that considered a combination of factors previously identified as associated with weight change during hospitalization or in older adults.

Also limiting was the use of the NutritionDay questionnaire to assess intake throughout admission. The average percent of meal consumed during hospitalization and patient meal access factors, with the exception of food quality, were not significantly associated with weight change during hospitalization. Generally one would assume that decreased food consumption, inadequate meal choice, organizational and environmental factors, food access, and hunger, would be associated with a decrease in weight. As described in the methods section, the *nutritionDay Patient Intake Form* was not administered everyday or at every meal, thus not representing a patient's consumption throughout their entire admission period and it was based self-report which is potentially prone to error. This is especially possible in the current study as cognitive declines associated with aging may influence recall ability. Furthermore, the Patient Mealtime Access information was collected at discharge, which has the potential to result in recall bias influencing responses.

Another limitation of the current study was that all of the pre-admission and post-discharge patient information was collected at one point in time and based on recall and self-report. Data collection at one point in time is unable to infer causation, and unable to distinguish cause and effect from simple associations, making it challenging to fully explain results (Mann, 2003). For example the unexpected result of ONS use being related to weight loss prior to admission cannot be fully explained nor can a cause and effect relationship be assumed. As such this study is limited. The use of self-report data for certain variables is also a challenge in this study. Past research has shown a trend

towards underreporting of weight (Gorber S. C., Tremblay, Moher, & Gorber B., 2007). There is the potential that inaccuracies of the self-reported pre-admission usual weight and post-discharge weight changes may have influenced findings.

8.0 IMPLICATIONS

The results of the current study have demonstrated the prevalence of weight loss in older patients and the potentially multifactorial nature of why this outcome occurs. Results of this research can be used as a foundation to guide future research to better understand malnutrition in older adults throughout hospitalization and to ensure nutrition care is able to maintain nutritional status before malnutrition occurs.

8.1 Future research

Although the current study was able to consider a large number of factors potentially associated with weight change, much of the variance in weight change for older adults who are hospitalized remains unexplained. Future research should be aimed at identifying additional factors associated with weight change throughout all stages of hospitalization in order to account for more variance. In particular there is a lack of information regarding the pre- and post-hospitalization periods. Upon admission more thorough examinations of patient history including eating habits, mental health concerns, environmental barriers, and social supports should be collected in order to better understand why weight loss occurs although the same issues of self-report remain. Similarly follow-up interviews following discharge from hospital should also be more comprehensive and include actual weight, mental health concerns, environmental barriers. Future research on admission weight change should examine factors specific to older adults that were excluded from the current study in order to address some of the current study's research gaps. Specifically, greater consideration of social, psychological and environmental factors during hospitalization is required.

Particular difficulty exists in collecting data prior to admission as reliance on self-reported, recalled information is needed especially in the older adults population where cognitive decline may influence recall ability. Future research may benefit from the use of contact with family physicians, children, or spouse to ensure the accuracy of data provided by the patients.

Additionally more research should build on the results of the current study, further exploring the associations that were identified and attempting to detect causal relationships. Certain variables associated with weight loss, such as ONS use prior to admission require further investigation to explain these relationships. For example, a cross sectional examination of self-reported ONS use to weight change trends may help further explain the association seen in the current study.

While more research is indicated, the results of the current study provide a foundation on which future studies should be based through the identification relationships that need clarification and documentation of areas that need to be examined before malnutrition in older patients admitted to acute care can be fully understood.

8.2 In practice

Although the current study was unable to account for all variance in weight change throughout peri-hospitalization results can be used in practice to better identify older patients at risk of malnutrition and intervene before nutritional declines occur. 58% of participants lost weight during admission suggesting that insufficient screening and re-screening is occurring and that nutrition interventions are not occurring or are occurring too late in admission to benefit patients. Additionally with 41% of participants having

lost weight prior to admission and 30% having lost weight after discharge there may be a need for increased monitoring of older patients in the community as well as for the development of programs aimed at addressing factors, such as eating alone, which are associated with weight loss in this population.

Factors identified in the current study may be beneficial in identifying where efforts should be focused. For example, because increased antibiotic use was associated with weight loss prior to and during hospitalization older patients prescribed multiple antibiotics should receive regular nutritional assessment and monitoring to address their increased risk. Regular monitoring of weight is also indicated in order to provide early interventions such as oral nutrition supplement use before extreme weight loss occurs. Additionally, other factors related to consumption such as also be beneficial to examine in order to prevent weight loss from occurring.

Nutrition screening in Canadian hospitals should be mandatory in order to ensure patients are receiving consultations before malnutrition develops or worsens. Referral to dietitians or other nutrition professionals may benefit all older patients including those with normal and high BMIs ($\geq 22 kg/m^2$). Although not classified as underweight by BMI classifications criteria of the Nutrition Screening Initiative, the current study has demonstrated that these older patients have an increased likelihood of weight loss and therefore may require interventions aimed at weight maintenance.

Prior to discharge from hospital patients or caregivers should be educated on the risks of weight loss following hospitalization. Encouraging eating with others as well as promoting energy dense meals or the use of oral nutrition supplements, particularly for patients indicating poor appetite, will help lessen the likelihood of weight loss following

discharge. Furthermore, following discharge older adults should also be referred to dietitians or other health care professions for monitoring of nutritional status and implementation of proper interventions such as ONS or Meals on Wheels initiated as needed. Finally regular follow-ups with physicians or other health care professionals may help monitor any disease conditions contributing to weight loss and curb post-hospital weight loss and impaired nutritional status.

9.0 CONCLUSIONS

Literature to date which has examined hospital malnutrition has primarily been conducted outside of Canada, has considered older adults with their less nutritionally at risk younger counterparts, and has often foregone the examination of the pre- and post-hospitalization periods. Additionally, with the exception of a few large-scale studies, much of the existing literature have focused on a few specific factors related to weight loss rather than taking a more comprehensive approach to understanding the epidemiology of hospital malnutrition.

The objective of this study was to identify factors independently associated with weight change throughout the stages of hospitalization in a sample of older adults which was achieved by examining the three proposed research questions using a comprehensive set of variables provided by the CMTF.

While certain variables could be highlighted as covariates of weight change at some stage throughout hospitalization, more research is required to discriminate between covariates that are the cause of weight loss from those that are related to the effects of weight loss. Also much of the variance in these models remains unexplained. Additional research focused on weight loss and weight change throughout hospitalization is needed in order to explain this conundrum as well as to improve the nutritional health of these vulnerable patients.

Overall, despite it's limitations, the results from the current study provide a foundation on which researchers and clinicians can begin to understand why weight loss occurs elderly patients admitted to Canadian hospitals and in the future enable the prioritization of nutrition interventions and ensure optimal recovery

APPENDIX A

[OPERATIONALIZATION OF VARIABLES FOR ANALYSIS]

Variable	Original	New
Dependent Variables		
Weight change prior to admission	N/A	New categorized variable *Usual weight - Admission weight* 0=weight maintenance or gain 1=weight loss ≥ 5lbs
Percent measured weight change during admission	Numeric	New numeric variable *(Discharge weight* – Admission weight)/admission weight x100* **For participants missing discharge weight last follow-up weight measurement was used as a proxy for discharge weight*
Weight change following admission	1 = Yes, gain of more than 5 lbs 2 = Yes, loss of more than 5 lbs 3 = No, weight has stayed within a few lbs 4 = Don't know	Recategorized 0= weight maintenance or gain 1= weight loss ≥ 5lbs
Covariates		
Age	Numeric	No changes made
Gender	0=Female 1=Male	No changes made
Hospital type	1=Academic 2=Community	No changes made
Hospital size	Numeric, number of beds	No changes made
Admission ward	Numeric	Recategorized by CMTF 1= medical 2=surgical
Food service management	1=Self-operating 2=Contract	No changes made

Variable	Original	New
Food serviced delivery	1=Room service 2=Tray	No changes made
Independent variables		
Education	1=Grade school or less 2=High school (some or completed) 3=University or college (some or completed)	Recategorized as 1= Grade school or less 0=Higher school (some or completed) and University or college (some or completed)
Current cancer	1=Yes 0=No	No changes made
Previous cancer	1=Yes 0=No	No changes made
New cancer	1=Breast 2=Prostate 3=Colorectal 4=Lung 5=Bladder 6=Non-Hodgkin Lymphoma 7=Skin melanoma 8=Renal 9=Other	Recategorized into categorical variable 1= yes 0=no
Oral nutrition supplement use prior to admission	1=Yes 0=No	No changes made
Antibiotic use prior to admission	Numeric	Recategorized 1=yes 0=no
Medication use prior to admission	Numeric	New numeric variable *(Total prescribed meds at admission + Number of PRN at admission)*
Previous surgeries (5 years)	Numeric	No changes made
Previous acute care admissions (5 years)	Numeric	No changes made

Variable	Original	New
Living situation prior to admission	1=Lives alone 2=Lives with others 3=Supportive housing/residential (services available but none required e.g. seniors apt building) 4=Retirement home/assisted living {where 1 or more meals are provided, medication oversight, no nursing care} 5=Nursing home (nursing care required for ADL) 6=Other	1= alone 2= other
Person primarily responsible for cooking	1=Patient 2=Spouse 3=Adult child 4=Other family 5=Neighbour 6=Friend 7=Community support services (i.e. Meals on Wheels, congregate dining, grocery service, homemaking support)	1= patient 2= other
Person primarily responsible for grocery shopping	1=Patient 2=Spouse 3=Adult child 4=Other family 5=Neighbour 6=Friend 7=Community support services (i.e. Meals on Wheels, congregate dining, grocery service, homemaking support)	1= patient 2= other
Surgeries during admission	Day of surgery up to 3 surgeries	New variable, total number of surgeries during admission. *Day of surgery recoded as 1 surgery and then summed.*

Variable	Original	New
Medication use during admission	Number of medications at each follow up	New variable, mean number of medications throughout admission
Antibiotic use during admission	Number of antibiotics at each follow up	New variable, antibiotic use during admission 0=no 1=yes
Nutrition professional visits during admission	Day of dietitian, diet technician, dietetic intern visit	New variable, total number of nutrition professional visits during admission *Day of visit recoded as 1 surgery and then summed.*
Adverse events	Up to 2 adverse events recorded	New variable, occurrence of adverse events during admission 0=no 1=yes
NutritionDay intake	Percent of meal consumed recorded periodically throughout admission	New variable, mean percent of meal consumed during admission recoded as 0= ≥75% 1= <75%
CCI on admission	Numeric	No changes made
CCI at discharge	Numeric	No changes made
BMI on admission	Numeric	No changes made
BMI at discharge	Numeric	No changes made
Nutritional status on admission	1=SGA A 2=SGA B 3=SGA C	Recategorized 0= well nourished (SGA A) 1=malnourished (SGA B/C)
Nutritional status at discharge	1=SGA A 2=SGA B 3=SGA C	Recategorized 0= well nourished (SGA A) 1=malnourished (SGA B/C)

Variable	Original	New
SGA change	N/A	New variable = SGA on admission – SGA at discharge 0= improvement or no change in nutritional status (positive value/ 0) 1= worsening of nutritional status (negative value)
Choice	A. I understand how to complete the menu selection sheet. 1 = Agree strongly 2 = Agree 3= Disagree 4= Disagree strongly 9= non-selective menu	Recategorization (below) based on methods used by Naithani et al. (2009) (Naithani et al. personal communication. 2013) *Variables are recoded and summed. Total ≥ 2 is indicative of nutritional risk and consequently recoded again as:* 0=low risk 1=high risk 1=0 2=0 3=1 4=1 9=1

Variable	Original	New
	B. I have been able to choose foods that I like or prefer. 1 = Agree strongly 2 = Agree 3= Disagree 4= Disagree strongly 9= non-selective menu C. Choosing the right food is difficult because there isn't enough information on the menu sheet. 1 = Agree strongly 2 = Agree 3= Disagree 4= Disagree strongly 9= non-selective menu D. Meals are served at times that suit me. 1 = Agree strongly 2 = Agree 3= Disagree 4= Disagree strongly	 1=0 2=0 3=1 4=1 9=1 1=1 2=1 3=0 4=0 9=1 1=0 2=0 3=1 4=1
Organization and environmental mealtime satisfaction		Recategorization (below) based on methods used by Naithani et al. (2009) (Naithani et al. personal communication. 2013) *Variables are recoded and summed. Total ≥ 2 is indicative of nutritional risk and consequently recoded again as:* 0=low risk 1=high risk

Variable	Original	New
	A. When the food arrives, I always want what I've ordered. 1 = Every meal 2 = Some meals, not every meal 3 = A few meals 4 = Never happened 9= non-selective menu B. I did not receive the food that I ordered. 1 = Every meal 2 = Some meals, not every meal 3 = A few meals 4 = Never happened C. When I was eating I was disturbed. For example, by activities, noises or unpleasant smells. 1 = Every meal 2 = Some meals, not every meal 3 = A few meals 4 = Never happened D. My mealtimes were interrupted by the hospital staff wanting to speak to me or give me treatment. 1 = Every meal 2 = Some meals, not every meal 3 = A few meals 4 = Never happened	 1=0 2=1 3=1 4=1 9=1 1=1 2=1 3=1 4=0 1=1 2=1 3=1 4=0 1=1 2=1 3=1 4=0

Variable	Original	New
	E. I missed my meals because I was not available when they were served. 1 = Every meal 2 = Some meals, not every meal 3 = A few meals 4 = Never happened F. I missed meals because I had to avoid food for tests. 1 = Every meal 2 = Some meals, not every meal 3 = A few meals 4 = Never happened G. When I missed my meals, I was given hospital food by staff. 1 = Every meal 2 = Some meals, not every meal 3 = A few meals 4 = Never happened 5 = Didn't miss a meal H. When I needed help, I got the help I needed to eat my meals. 1 = Every meal 2 = Some meals, not every meal 3 = A few meals 4 = Never happened 5 = I didn't need any help	 1=1 2=1 3=1 4=0 1=1 2=1 3=1 4=0 1=0 2=1 3=1 4=1 5=0 1=0 2=1 3=1 4=1 5=0

Variable	Original	New
Hunger during hospitalization		Recategorization (below) based on methods used by Naithani et al. (2009) (Naithani et al. personal communication. 2013) *Variables are recoded and summed. Total ≥ 2 is indicative of nutritional risk and consequently recoded again as:* 0=low risk 1=high risk
	A. My visitors bring in food for me because I am hungry. 1 = Every day 2 = Some days, not every day 3 = A few days 4 = Never happened B. I get hungry because the time between meals is too long. 1 = Every day 2 = Some days, not every day 3 = A few days 4 = Never happened C. I felt hungry but I could not ask staff for food. 1 = Every day 2 = Some days, not every day 3 = A few days 4 = Never happened	 1=1 2=1 3=1 4=0 1=1 2=1 3=1 4=0 1=1 2=1 3=1 4=0

Variable	Original	New
	D. I felt hungry and wanted something to eat but no food was available from the hospital 1 = Every day 2 = Some days, not every day 3 = A few days 4 = Never happened	 1=1 2=1 3=1 4=0
Physical barriers associated with mealtimes	 A. Being in an uncomfortable position to eat 1 = Every meal 2 = Some meals, not every meal 3 = A few meals 4 = Never happened B. Difficulty reaching my food 1 = Every meal 2 = Some meals, not every meal 3 = A few meals 4 = Never happened	Recategorization (below) based on methods used by Naithani et al. (2009) (Naithani et al. personal communication. 2013) *Variables are recoded and summed. Total ≥ 2 is indicative of nutritional risk and consequently recoded again as:* 0=low risk 1=high risk 1=1 2=1 3=1 4=0 1=1 2=1 3=1 4=0

Variable	Original	New
	C. Difficulty cutting up my food	
	1 = Every meal	1=1
	2 = Some meals, not every meal	2=1
	3 = A few meals	3=1
	4 = Never happened	4=0
	D. Difficultly opening packets / unwrapping food	
	1 = Every meal	1=1
	2 = Some meals, not every meal	2=1
	3 = A few meals	3=1
	4 = Never happened	4=0
	E. Difficulty feeding myself	
	1 = Every meal	1=1
	2 = Some meals, not every meal	2=1
	3 = A few meals	3=1
	4 = Never happened	4=0
	F. Not enough time to eat all the food that I wanted to eat	
	1 = Every meal	1=1
	2 = Some meals, not every meal	2=1
	3 = A few meals	3=1
	4 = Never happened	4=0

Variable	Original	New
	G. I need help to eat my meals 1 = Every meal 2 = Some meals, not every meal 3 = A few meals 4 = Never happened	1=1 2=1 3=1 4=0
Food quality	Taste 1 = Extremely satisfied 2 = Satisfied 3 = Dissatisfied 4 = Extremely dissatisfied Appearance 1 = Extremely satisfied 2 = Satisfied 3 = Dissatisfied 4 = Extremely dissatisfied Smell 1 = Extremely satisfied 2 = Satisfied 3 = Dissatisfied 4 = Extremely dissatisfied Portion size 1 = Extremely satisfied 2 = Satisfied 3 = Dissatisfied 4 = Extremely dissatisfied Temperature of food 1 = Extremely satisfied 2 = Satisfied 3 = Dissatisfied 4 = Extremely dissatisfied	 1=0 2=0 3=1 4=1 1=0 2=0 3=1 4=1 1=0 2=0 3=1 4=1 1=0 2=0 3=1 4=1

Variable	Original	New
The influence of illness on mealtimes		Recategorization (below) based on methods used by Naithani et al. (2009) (Naithani et al. personal communication. 2013) *Variables are recoded and summed. Total ≥ 2 is indicative of nutritional risk and consequently recoded again as:* 0=low risk 1=high risk
	Sickness	
	1 = Every meal	1=1
	2 = Some meals, not every meal	2=1
	3 = A few meals	3=1
	4 = Never happened	4=0
	Pain	
	1 = Every meal	1=1
	2 = Some meals, not every meal	2=1
	3 = A few meals	3=1
	4 = Never happened	4=0
	Tired	
	1 = Every meal	1=1
	2 = Some meals, not every meal	2=1
	3 = A few meals	3=1
	4 = Never happened	4=0

Variable	Original	New
	Worry 1 = Every meal 2 = Some meals, not every meal 3 = A few meals 4 = Never happened Depressed 1 = Every meal 2 = Some meals, not every meal 3 = A few meals 4 = Never happened Breathing difficulties 1 = Every meal 2 = Some meals, not every meal 3 = A few meals 4 = Never happened Chewing or swallowing difficulties 1 = Every meal 2 = Some meals, not every meal 3 = A few meals 4 = Never happened	 1=1 2=1 3=1 4=0 1=1 2=1 3=1 4=0 1=1 2=1 3=1 4=0 1=1 2=1 3=1 4=0
Discharge location	Home = 1 Someone else's home = 2 supportive housing/residential care = 3 Retirement home/assisted living = 4 Nursing home = 5 Other = 6	Recategorized 1=home 2=other
30 day readmission	Yes = 1 No = 0	No changes made

Variable	Original	New
Appetite 30 days following discharge	1 = Very good 2 = Good 3 = Fair 4 = Poor	0= good/very good 1=fair/poor
Special diet following discharge	1 = Yes 0 = No	No changes made
Diet changes from pre-admission	1 = Yes 0 = No	No changes made
Eating more than one meal with someone following discharge	1 = Never or rarely 2 = Sometimes 3 = Often 4 = Almost always	0=sometimes/often/almost always 1=never or rarely
Person primarily responsible for meal preparation following discharge	1 = I do 2 = I share my cooking with someone else 3 = Some else cooks most of my meals	1=self 2=someone else
MD visit following discharge for diet advice	1 = yes 2 = no	No changes made
RD visit following discharge for diet advice	1 = yes 2 = no	No changes made
Other health care professional visit following discharge for diet advice	1 = yes 2 = no	No changes made

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