THE IMPACT OF PARTICIPATION IN MEALS ON WHEELS AND MORE (MOWAM) IN AUSTIN, TX, ON DIETARY INTAKE AND HEALTH STATUS

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Seanna M. Marceaux, B.A., B.S., R.D., L.D.

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Committee Members Approved:

_____
B.J. Friedman, Chair

_____
Sylvia Crixell

_____
Melissa Delgado

Approved:

_____
J. Michael Willoughby
Dean of the Graduate College

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TABLE OF CONTENTS

Page

LIST OF TABLES

Table **Page**

CHAPTER I

REVIEW OF THE LITERATURE

Central to the 1965 United States Older Americans Act, the Elderly Nutrition Program (ENP), was established to reduce hunger, food insecurity, and social isolation in homebound older adults. The ENP encompasses two essential components, Home Delivered Meals (HDM) and Congregate Meals. The overall goal of HDM programs is to improve health and wellbeing of recipients by preventing malnutrition, thereby avoiding a downward spiral that might lead to premature institutionalization (Colello, 2010; Sieber, 2006).

The importance of HDM is continuing to grow. From 1980 to 2002, participation in the ENP grew 290%, and will continue to increase along with the population of older adults in the US, which is expected to double by 2030 (Department of Human Health Services [DHHS], 2010; & U.S. Census Bureau, 2010; O'Shaughnessy, 2004; Centers for Disease Control and Prevention [CDC], 2003). In Texas, the elderly population is also expected to increase, especially in central Texas. From 2000 to 2005, the elderly population in the Austin-San Marcos area grew at a greater rate than in all other metropolitan areas in Texas. In fact, by 2040, the Austin-San Marcos area is expected to grow by over 300%, experiencing the largest percentage growth of adults 60 years and older in Texas (Texas Department on Aging, 2003). According to a Brookings Institute

study (Frey, 2011), of all the metropolitan areas in the country, Austin has the second fastest growing 65 and older population and the number one fastest growing 55-64 years old population. Therefore, HDM programs will be increasingly important in fostering health and potentially reducing health care costs among the elderly.

In 2008, HDM programs provided 146.4 million meals to approximately 910,000 homebound older adults nationwide (Colello, 2010), costing $216,831,000 in 2012 (Administration on Aging [AoA], 2012). Funding for HDM is provided through the Administration on Aging (AoA), which awards funding to state agencies based on each state's population share of adults over 60 years of age. Funds are then disseminated to local Area Agencies on Aging who administer HDM programs within their areas of the state (Colello, 2010). Funding is also based on compliance with the most current Dietary Guidelines for Americans. Meals must also meet Dietary Reference Intakes (DRI) for older adults at levels based on the number of meals served daily. Meals must meet 33% of the DRI for one meal per day served and 66% if two meals per day are served (Colello, 2010).

In Austin, Texas, the HDM program is Meals on Wheels and More (MOWAM). When MOWAM was established in 1972, 29 participants were served during the first year. Like most HDM programs, MOWAM has grown considerably, and currently provides approximately 900,000 meals to 3,000 homebound clients each year. This program is important because Texas ranks fourth in food insecurity among seniors according to the latest Meals on Wheels Association of America Report on Senior Hunger in the United States (Ziliak & Gundersen, 2009). Therefore, with an expanding population of elderly and increasing budgetary constraints, MOWAM will have to

determine methods to identify those at greatest risk for poor nutrition status and/or malnutrition as well as ensure that the services provided are improving nutritional intake and health status.

With advanced age, there are several risk factors that play a role in the health of older adults. For example, physiological alterations naturally occur that impact sensory detection, oral health, digestion, and absorption of nutrients. In addition, internal signaling processes that regulate appetite and food intake are also deregulated. The high prevalence of chronic disease and multiple medications negatively affects dietary intake and nutrition status. Older adults also experience psychological, social, environmental, and lifestyle factors that place them at high risk for poor dietary intake and malnutrition. These risk factors lead to inadequate dietary intake and overtime result in poor nutrition status and malnutrition, health related disability, the development and/or exacerbation of chronic diseases and premature institutionalization, all of which results in increased health care costs. HDM participants represent one of the most vulnerable subsets of the older adult population as they exhibit many of these risk factors and have a higher prevalence of inadequate dietary intake and poor nutrition status compared to the older adult population as a whole.

Factors Impacting Nutrient Intake in Older Adults

Older adults sometimes need food assistance because they are faced with factors such as physiological, psychological, and social that negatively affects their health. In addition to the usual physiological consequences of aging, termed “senescence” or “natural” aging, psychological and social factors also interfere with their ability to secure

food and prepare healthful meals. Combined, these factors experienced by older adults can greatly influence health and dietary intake.

Physiological factors. As adults age, many physiological changes occur that greatly influence dietary intake and nutrition status. For example, alterations to the gastrointestinal tract include changes in sensory function, oral health, digestion, and absorption. The internal signaling processes that rely on hormones and neurotransmitters to regulate appetite and food intake and monitor energy homeostasis become altered with age, as well.

***Organ system alterations*.** Older adults who experience functional sensory impairment affecting taste, smell, hearing, and/or sight are susceptible to malnutrition (Chen, Schiling, & Lyder, 2001). The senses of taste and olfaction are intertwined. Disease, polypharmacy and age-related functional decline in the olfactory epithelium are primary factors contributing to loss of smell (Brownie, 2006; Hickson, 2006). Adults 65-80 and those over 80 years of age experience a 50% and 75% decline in flavor detection, or dysgeusia, respectively (Brownie, 2006). With advanced age, the ability to detect different taste modalities declines. In fact, an older adult with at least one chronic disease and taking more than three medications requires substantially more salt and sugar (up to 11 times and 3 times as much, respectively) to distinguish these tastes in foods compared to younger adults ” (Hickson, 2006).

Although the cause of diminished taste is not fully understood, researchers have proposed that dysgeusia may be due to a decrease in the number of taste buds or papilla on the tongue, or to a change in the function of cell receptors responsible for the sensation of taste (Brownie, 2006; Hickson, 2006). Smell and taste function to promote

anticipatory changes that physiologically and metabolically prepare the human digestive tract for digestion, absorption, and metabolism (Power & Schulkin, 2008; Hickson, 2006). These senses, components of the cephalic phase response to eating, influence the quality of dietary intake, can negatively influence appetite and enjoyment of food, and may result in poor food choices and decreased energy and nutrient intake.

Many older adults may also experience changes in oral health, such as loss of teeth (edentulism), ill-fitting dentures, and dry mouth (xerostomia). These conditions result in discomfort while chewing and swallowing. Of adults 65 and older, 54% have no natural teeth (Federal Interagency Forum on Aging Related Statistics, 2010). According to the National Diet and Nutrition Survey for people aged 65 years and older, when compared to those with natural teeth, edenate people reported having more difficulty chewing and eating a variety of foods and were more likely to experience xerostomia, which negatively impacted energy and nutrient intake (Hickson, 2006). Age-related changes of the esophagus and/or diseases of the central nervous system (CNS) may result in difficulty swallowing (dysphasia) and altered motility of the esophagus, both of which can lead to reduced food intake (Brownie, 2006; Hickson, 2006). In short, adults with oral health complications are at a greater risk of malnutrition (Chen et al., 2001). Instead of enjoying mealtime as a flavorful and pain-free experience, older adults report diminished appetite, avoiding foods or making poor choices, all of which can negatively impact nutrition status among the elderly.

Impaired absorption of nutrients is another physiological change associated with aging that can affect nutritional health. After the age of 50, the stomach tends to produce less hydrochloric acid (HCl), which is necessary to hydrolyze nutrients from bound

molecules such as proteins and to otherwise facilitate adequate digestion and absorption. Further, approximately 20 to 50% of the elderly population is also affected by chronic inflammation of the stomach mucosal lining, known as atrophic gastritis (Brownie, 2006). Over time, gastritis reduces the number of functioning parietal cells, causing a decrease in gastric production of Intrinsic Factor (IF), pepsin, and HCl. These symptoms combine to negatively affect the absorption of several pH-dependent nutrients, including vitamin B12, folate, iron, calcium, and beta-carotene (Allen, 2010; Brownie, 2006; Meyyazhagan & Palmer, 2002). Based on the high prevalence of atrophic gastritis, the Institute of Medicine recommends that individuals aged 51 and older consume vitamin B12 as a supplement or in fortified foods. Supplemental vitamin B12 is not bound to protein, and can thus be absorbed even when stomach acid levels are low. For adults experiencing loss of intrinsic factor, vitamin B12 must be obtained from higher doses administered by mouth or via injection. Impaired absorption of nutrients due to natural physiological changes experienced in advanced age places older adults at risk for malnutrition.

Aging also affects the metabolic processing of some nutrients. This is particularly true of vitamin D, which can be consumed from a few foods or formed in the skin upon exposure to the sun. Not only is older skin less efficient at producing the subcutaneous vitamin D precursor, but older adults may also spend less time in the sun, particularly if they are disabled. Furthermore, the older kidney may become less efficient at converting vitamin D to its biologically active form, 1, 25-dihydroxy-vitamin D (Sharkey, 2008).

Hydration status may also be affected by aging. Impaired renal function and diminished thirst perception, conditions that are found even in healthy older adults,

increase the risk for dehydration. Other contributors to dehydration include the fear of incontinence, which may cause avoidance of liquids and the use of diuretics, commonly prescribed for hypertension, which effectively eliminates fluids from the body, also place older adults at risk. Finally, cognitive dysfunction may also result in loss of thirst awareness increasing risk of dehydration (Meyyazhagan & Palmer, 2002).

Chronic disease and polypharmacy. According to the Centers for Disease Control and Prevention (CDC), 7 in 10 deaths each year are attributable to chronic diseases (CDC, 2009). In adults 65 years of age and older, approximately 80% have at least one chronic disease and 50% have more than one (Perry, 2011; Houston et al., 2009). Many acute and chronic diseases predispose older adults to poor nutrition status and increase their risk for malnutrition. Indeed, disease alone can affect consumption, digestion, absorption, and nutrient utilization (Meyyazhagan & Palmer, 2002; Wakimoto & Block, 2001; Weimer, 1997). In fact, the majority of chronic diseases that older adults have affect these processes (Brownie, 2006).

Multiple medications, prescriptions, and over-the-counter (OTC) drugs is very common. Although adults over 65 years of age account for approximately 15% of the population, they purchase one-third of all prescription drugs and 40% of all OTC medications (Ballentine, 2008; Fulton & Allen, 2005). More than half take a minimum of one medication and many take three to five prescription drugs (Fulton & Allen, 2005). The definition of polypharmacy varies among experts. Definitions include the simultaneous use of two or more medications for 240 days or more, to up to six or more medications (Munger, 2010; Fulton & Allen, 2005). Others define polypharmacy as the use of prescribed medications that are unnecessary for treatment, or at least one

potentially inappropriate medication prescribed in combination therapy (Munger, 2010; Fulton & Allen, 2005).

For many chronic illnesses, such as cardiovascular diseases, diabetes, and chronic obstructive pulmonary disease, aggressive combination drug therapy is prescribed to improve outcomes for patients (Perry, 2011; Munger, 2010; Ballentine, 2008). However, polypharmacy increases the likelihood of adverse drug reactions and interactions (Fulton & Allen, 2005) and is a significant cause of hospital admissions, morbidity and mortality (Ballentine, 2008). The risk of having an adverse drug event is only 13% when two medications are taken, however with the use of five or seven or more medications, the risk increases to 58% and 82%, respectively (Fulton & Allen, 2005). Research has also shown that taking three or more medications daily is associated with severe levels of disability (Sharkey & Haines, 2002).

Taking several medications can exacerbate symptoms already experienced with advanced age such as diminished taste, smell, and appetite, delayed gastric emptying, xerostomia, nausea, vomiting, and diarrhea. These symptoms have negative impact on dietary intake and food choice. Many medications interfere with nutrient absorption, utilization, excretion, and can also deplete the body's mineral stores (Sharkey, 2008; Brownie, 2006; Hickson, 2006; Krondl, Lau, Coleman, & Stocker, 2003; McCormack, 1997). In summary, although polypharmacy may be necessary to treat or manage chronic conditions, they pose a great risk to the elderly population in regards to their nutrition status and health.

Anorexia of aging. While body weight generally increases after the age of 30, this process gradually reverses around the age of 70 (McDonald & Ruhe, 2010). Called

the ‘anorexia of aging’, older adults tend to exhibit poor appetite and rapid satiation when they do eat leading to diminished energy and nutrient intake (McDonald & Ruhe, 2010; Hickson, 2006; Chapman, MacIntosh, Morley, & Horowitz, 2002; Meyyazhagan & Palmer, 2002). Prolonged anorexia, a key indicator of malnutrition among older adults, leads to weight loss and has shown to be an independent predictor of mortality (Morley, 2007; Chen et al., 2001). It is generally accepted that weight loss after the age of 70 is not caused by an increase in energy expenditure since people are often less active as they age (McDonald & Ruhe, 2010; Miller & Wolfe, 2008). Instead, factors associated with weight loss include reduced appetite, chewing or swallowing difficulties, chronic health conditions, acute illness, polypharmacy, neuropsychological conditions such as dementia or depression, limited income, and reduced social activity (Stajkovic, Aitken & Holroyd-Leduc, 2011; Miller & Wolfe, 2010). Depression and polypharmacy are major causes of anorexia-induced weight loss (Morley, 2007).

There is also evidence that normal energy homeostatic mechanisms become altered with advanced age (McDonald & Ruhe, 2010). Anorexia has been shown to be an independent predictor of mortality-induced weight loss (Morley, 2007). Research involving cohort, cross-sectional, and longitudinal data has shown that calorie and nutrient intake decline with age (Wakimoto & Block, 2001). When comparing the caloric intake of both men and women in their 20s to those in their 80s, energy intake was shown to be reduced by 1000 to 1200 and 600-800 kcalories in men and women, respectively (Wakimoto & Block, 2001). Diminished energy intake is coupled with inadequate nutrient intake, which becomes problematic since nutrient requirements remain the same

or even increase throughout the lifespan (Keller, 2007; Wakimoto & Block, 2001; McCormack, 1997).

Mechanisms responsible for this diminished appetite are unclear but several theories have been proposed. In a review, Hickson (2006) reported differences in the ability to regulate food intake between the young and old, in addition to the alteration of peptide hormones involved in hunger and satiety. For example, stomach capacity is also reduced among the elderly contributing to early satiety (Hickson, 2006). Secretion of cholecystokinin, a hormone responsible for satiety, is greater in the aged, resulting in decreased gastric emptying and early satiety. Conversely, ghrelin secretion, a hormone that stimulates appetite, decreases with age (McDonald & Ruhe, 2010; Morley, 2007; Hickson, 2006; Huffman, 2002). New research demonstrates that other appetite regulating hormones such as peptide-YY and glucagon-like-peptide become altered with age possibly promoting “Anorexia of Aging” as well (Hickson, 2006).

Appetite and weight regulation may also be influenced by increased secretion of inflammatory cytokines and changes in the function of the CNS. Aging influences the up-regulation of several molecules such as catecholamines and glucocorticoids, which leads to increased levels of cytokines, Tumor necrosis factor- alpha (TNF-α) and Interleukin (IL) 1 and 6. These cytokines are also induced during chronic low grade inflammation, injury, and infection, which are often experienced with increased age. Cytokines are known to cause anorexia and increase the catabolism of lean muscle mass (Hickson, 2006). In the CNS, changes in opioid receptors and neurotransmitters may lead to decreased food intake and the ability to regulate weight. Opioids, produced naturally in the brain, are thought to increase food intake. Loss of opioid receptors and reduced

endogenous opioid concentrations are associated with advanced age. Therefore, older adults may be less sensitive to the action of opioids, making them less hungry (Hickson, 2006). Many neurotransmitters have been shown to impact regulation in food intake such as neuropeptide Y and Gamma-Amino Butyric Acid (GABA), which are found in areas of the hypothalamus most associated with food intake and weight regulation. Research supports that weight loss in advanced age is reflective of the decline in hypothalamic function (McDonald & Ruhe, 2010; Hickson, 2006).

Weight loss among the elderly can be divided into three types: wasting, cachexia, and sarcopenia. Wasting is attributed to inadequate dietary intake (Anorexia of Aging) and can be attributed to physiological, such as dementia and depression, and social conditions such as poverty and physical inabilities to shop or prepare food (Hickson, 2006). Cachexia, a condition that results in loss of weight, muscle, and appetite, and sarcopenia, which is characterized by the loss of muscle mass, represent the main causes of lean body mass loss associated with aging (Morley, 2007; Hickson, 2006).

Problematic weight loss is defined as 5% loss of body weight within one month or 10% over a period of 6 months or longer (Stajkovic et al., 2001). Research has shown that in the elderly, a 5% loss in body weight in one year increases morbidity and has been shown to be an independent predictor of mortality (Stajkovic et al., 2011; Alibhai, Greenwood, & Payette, 2005). Weight loss is also considered fundamental to the development of frailty (Morley, 2007). Those who lose 5% of body weight within one month are more than 4 times more likely to die within one year (Stajkovic et al., 2011; Huffman, 2002). The loss of at least 5 kg or more within one year increases the likelihood of institutionalization by 170% (Payette, Coulombe, Boutier, & Gray-Donald, 2000).

According to NHANES II (National Health and Nutrition Examination Survey), weight loss of 5% or more in older women increased their risk of disability (Meyyazhagan & Palmer, 2002). Unintentional weight loss is also linked with negative outcomes such as protein-energy malnutrition, decreased immunity along with high infection rates, poor wound healing and decubitus ulcers, functional decline, disruption in cognition and greater use of acute and long term care facilities (Stajkovic et al., 2011; Morley, 2007). Evidence suggests that somewhere between 13% and 20% of elderly experience a 5% weight loss (≥ 5 kilograms) over a 5 to 10 year period (Stajkovic et al., 2011; Alibhai et al., 2005). In addition, data from the NHANES I Epidemiologic Follow-up Study showed that more than 50% of Americans between 65-74 years of age lost at least 5% of their previous weight over a 10-year period with 26% and 14% of women and men, respectively, losing at least 15% of their previous weight during this period (Meyyazhagan & Palmer, 2002). In summary, although weight loss has been shown to be prevalent among the older adult population, weight loss of 5 to 10% within one year should not be considered a normal process of aging (Huffman, 2002).

***Body composition changes*.** Changes in body composition occur as a result of malnutrition and aging (Hickson, 2006). Skeletal muscle is the main reserve for protein, with 50-75% of the body's amino acid stores located in skeletal muscle (Genaro & Martini, 2010). Maintaining muscle is vital for metabolic and physical functions, strength, mobility, and in supporting the body's response to stress. Even in healthy adults, a loss of 10% of LBM has been shown to diminish immunity, increase infection, and has been linked with increased mortality (Hickson, 2006). Loss of muscle mass and subsequent decreased muscle strength have also been associated with functional disability

and impaired mobility independent of other effects such as chronic disease, depression, cognitive impairment and other age related factors (Sharkey, 2008). Muscle wasting in older adults reduces their protein reserves leading to the body's poor response to serious illness and stress (Miller & Wolfe, 2010).

LBM including muscle, organ tissue, skin, and bone declines with age in healthy individuals beginning around the age of 40 or 50. Between the ages of 25 and 75, LBM decreases by 19% and 12 % in men and women, respectively (Meyyazhagan & Palmer, 2002). The loss in LBM occurs much earlier than the usual changes in fat mass and may be more pronounced in older adults who are ill (Hickson, 2006; Brownie, 2006). Unlike LBM, fat mass has been shown to increase until individuals reach the ages of 70-75, then stabilize and/or decline thereafter (Morley, 2007; Hickson, 2006).

As previously mentioned, cachexia and sarcopenia represent the main causes of LBM loss associated with aging (Morley, 2007; Hickson, 2006). Cachexia leads to increased metabolic rate and protein catabolism initiated by an acute response (Hickson, 2006). Chronic disease states such as rheumatoid arthritis and congestive heart failure, and infections and decubitus ulcers frequently result in cachexia (Hickson, 2006).

Similar to cachexia, sarcopenia is characterized by the loss of muscle mass. The prevalence of sarcopenia in community dwelling older adults has been estimated to be approximately 15% in adults younger than 70, but up to 50% in those 80 and older (Houston, Nicklas, & Zizza, 2009; Miller & Wolfe, 2008; Morley, 2007). Sarcopenia leads to functional decline, fractures (Alibhai et al., 2005), and increased disability and mortality (Morley, 2007; Iannuzzi-Sucich, Prestwood, & Kenny, 2002). The etiology of sarcopenia is multifactorial. When weight loss occurs in the elderly, bone and muscle

mass are lost in addition to fat mass. Functionally important body cell mass (muscle, viscera, immune system, collage, bone) is affected to a greater extent in individuals 70 years or older than in youth in their 20s (Hickson, 2006). Other factors contribute to age related loss of LBM unrelated to weight loss. Levels of testosterone, anabolic steroids such as dehydroepiandosterone (DHEA), and other growth factors decrease with age and have been associated with muscle loss. Mechanogrowth factor, a variant of insulin growth factor (IGF-1) responsible for muscle repair and maintenance of muscle function, has been shown to decrease with advanced age. In contrast, cortisol, a glucocorticoid that stimulates the protein catabolism and the release of free amino acids from muscle tissue for gluconeogenesis in response to inflammatory stress actually increases with age.

In addition, inflammatory cytokines TNFα, IL-1, and IL-6 have also been shown to be involved with all three types of weight loss, wasting, cachexia, and sarcopenia (Stajkkovic et al., 2011; Hickson, 2006). Increased cytokine levels occur with infection, injury, and long term inflammation (e.g., chronic disease) (Hickson, 2006). In fact, IL-6 has been touted as the "'geriatric" cytokine due to its relationship to muscle loss, functional decline, and mortality (Morley, 2007). TNFα, IL-1, and IL-6 may also be involved in muscle catabolism by inhibiting muscle cell differentiation during the normal process of muscle fiber regeneration (Hickson, 2006). Cytokines may further promote sarcopenia by inhibiting muscle anabolism, inducing insulin resistance, and playing a role in cellular apoptosis (Miller & Wolfe, 2008).

The CNS has also been implicated in playing a role in the development of sarcopenia. In fact, some researchers believe that changes in CNS function are fundamental to the development of sarcopenia, as age-related loss of neurons in the spinal

cord results in muscle atrophy (Hickson, 2006). Taken together, low calorie intake and other physiological changes associated with advancing age promote loss of LBM and place the elderly at high nutrition risk (Morley, 2007).

"Sarcopenic obesity", a relatively new term, refers to a condition in which a decrease in LBM is accompanied by an increase in adiposity. Both sarcopenia and obesity have been independently associated with diminished muscle strength and lead to disability. However, compared to either sarcopenia or obesity, sarcopenic obesity is more strongly associated with functional impairment in older adults, adding a 2.5 to 3-fold increase in risk for disability. Central adiposity is negatively associated with muscle strength as it stimulates elevated cytokine production, which promotes muscle catabolism. Therefore, obesity in the elderly exacerbates the development of sarcopenia increasing risk of disability and malnutrition in this population (Miller & Wolfe, 2008).

Paradox of obesity and anorexia of aging. Overweight and obesity is defined by calculating an individual's Body Mass Index (BMI) (defined as weight in kilograms divided by height in meters squared). BMI categories include $\leq$18.5 kg/m^2 as underweight, 18.5-24.9 kg/m^2 as normal, 25.0-29.9 kg/m^2 as overweight, and $\geq$ 30 kg/m^2 as obese (CDC, 2011). Among adults $\geq$ 60 years of age, approximately 77% of men and 74% of women are overweight and 37% of men and 42% of women are obese with 16% of men and 30% of women having a BMI $\geq$ 35 (Flegal, Carrol, Kit, & Ogden, 2012). Overweight and obesity among older adults have been associated with increased risk for chronic metabolic changes such as cardiovascular disease, hypertension, dyslipidemia, diabetes, arthritis and some cancers (Houston et al., 2009; Oreopoulos, Kalantar-Zadeh, Sharma, & Fonarow, 2009). Many studies have also shown that BMI is inversely related

to physical function in older adults (Oreopoulos et al., 2009). For example, there is a significant association among older adults between a BMI $\geq$ 35 kg/m^2 and poor lower extremity physical performance resulting in a greater severity of disability and functional impairment (Sharkey, 2008; Miller & Wolfe, 2008; Sharkey, Brand, Giuliani, Zohoori, & Haines, 2004a; Sharkey, Giuliani, Haines, Branch, Busby-Whitehead, & Zohoori, 2003).

Several experts argue that the current target body weights are not appropriate for older persons (Oreopoulos et al., 2009; Miller & Wolfe, 2008; Dolan, Kraemer, Browner, Ensrud, & Kelsey, 2007; Janssen, 2007; Sanchez-Garcia et al., 2007; Zamboni et al., 2005) and that BMI may not be appropriate in identifying risk in older adults due to usual changes in body composition and stature. At the same BMI, older adults have more adipose tissue than young adults since LBM declines and adiposity increases. Therefore the standard BMI cut off points defining overweight and obesity may underestimate body fat in the elderly (Miller & Wolfe, 2008; Zamboni et al., 2005). Another factor associated with aging that affects the use if BMI in assessing overweight is the change in stature that sometimes accompanies aging. Demineralization of the skeletal system results in vertebral compressions and impacts measured height, which is estimated to decrease at 0.5-1.5 cm per decade from 30 to 70 years of age equating to a 3 cm and 5 cm decrease for men and women, respectively (Miller et al., 2009; Oreopoulos et al., 2009; Sanchez-Garcia et al., 2007; Zamboni et al., 2005). After the age of 80, height decreases even more, up to 5 cm for men and 8 cm for women (Zamboni et al., 2005). In addition, skeletal modification also impacts the bones of the extremities, which can lead to inaccurate height measurements when using alternative measurements for bed-bound individuals (e.g., length of the ulna or knee height). With only slight changes in weight,

this alone may result in the derivation of a false BMI calculation of 1.5 and 2.5 kg/m^2 in men and women, respectively (Oreopoulos et al., 2009; Zamboni et al., 2005). Thus, both the height and weight of the BMI calculation become skewed due to common processes accompanying aging.

While most evidence suggests that overweight and obesity is associated with increased risk for mortality, this is not always the case. The 'obesity paradox' refers to a situation in which high BMI is not associated with increased health risk. Studies have shown that BMI may overestimate health risks in the elderly, specifically for those within the overweight category (Miller & Wolfe, 2008). Evidence suggests that health risks associated with excess weight appear to be lower in the elderly compared to middle-aged adults (Houston et al., 2009). For older adults, more deaths are associated with being underweight (Miller & Wolfe, 2008), and studies have found that being overweight was not associated with increased mortality rates (Zamboni et al., 2005). Oreopoulos et al (2009) conducted a review of published research on obesity in older adults from 1966-2009. They reported an optimum BMI for older adults being between 25-35 kg/m^2, with most studies linking a BMI of 27-30 kg/m^2 with the lowest mortality risk in this population. Other researchers have suggested BMI categories ranging from 25.0-29.9 kg/m^2 as being the desirable BMI range (Sanchez-Garcia et al., 2007). Miller et al. (2009) compared BMI of $\leq$ 22 kg/m^2 with the risk of falls, fractures, and all-cause mortality in the elderly. Those with BMI less than 22 kg/m^2 were 38% more likely to suffer a fracture and 52% were more likely to die after controlling for potential confounders. This study recommends BMIs of between 20 to 22 kg/m^2 as the threshold for underweight rather than $\leq$ 18.5 kg/m^2. Janssen (2007) investigated the morbidity and mortality risk

associated with BMI in approximately 5,000 men and women 65 years of age and older. Risk for diseases such as heart disease, stroke, cancer, osteoporosis, was no different between those in the overweight and normal categories. Although there was a slightly increased risk for arthritis, physical disability, and diabetes risk in the overweight group, all-cause mortality risk was 11% lower in the overweight group compared to the normal weight group. The relationship of decreased risk with elevated BMI was most apparent in adults 75 years of age and older. Further research is needed to determine if cut off points should be modified for the elderly population in effort to better estimate health risk in this population (Oreopoulos et al., 2009).

A better indicator of adiposity in the elderly may be distribution of fat. Visceral fat, indicated by measuring waist circumference, increases to a greater extent than subcutaneous fat with age (Miller et al., 2009; Oreopoulos et al., 2009; Miller & Wolfe, 2008; Hickson, 2006). Since abdominal obesity is associated with increased morbidity and mortality, it may be better to use waist circumference in addition to BMI to estimate health risk in the elderly (Houston et al., 2009; Zamboni et al., 2005).

Experts have proposed several hypotheses in an effort to explain the ‘obesity paradox’ in the elderly. One hypothesis is the ‘survival effect ’or‘survival biases. While overweight and obese individuals are more likely to die at an earlier age, overweight or obese individuals who live into old age may have protective characteristics that mitigate the negative health consequences of excess body fat (Oreopoulos et al., 2009; Houston et al., 2009; Janssen, 2007). Others theorize that, for those who become obese in old age, the adverse effects of obesity may not have sufficient time to manifest (Oreopoulos et al., 2009). Furthermore, both lean mass and fat mass serve as important nutrient reserves, but

unlike muscle, fat can provide energy to vital organs without having to generate energy to maintain itself (Morley, 2007; Janssen, 2007). Since older adults are more susceptible to accelerated weight loss as a result of illness and stress (Miller & Wolfe, 2008), fat tissue offers a protective effect, preventing protein-energy malnutrition during these times (Oreopoulos et al., 2009; Janssen, 2007). Finally, increased BMI may provide other health benefits in later years, such as protection from osteoporotic fractures, since high BMI is associated with increased bone mineral density.

Weight loss recommendations have not been established for overweight and obese older adults because the results of studies addressing the effect of weight loss in this population are discordant (Houston et al., 2009; Zamboni et al., 2005). For example, the benefits of weight reduction on cardiovascular risk factors, glucose tolerance, metabolic syndrome, inflammatory markers, pulmonary disease and osteoarthritis has been documented for obese older adults (Oreopoulos et al., 2009; Miller & Wolfe, 2008; Zamboni et al., 2005). However, weight loss in this population is also associated with declines in bone mineral density and lean body mass, which increase frailty and fracture risk (Oreopoulos et al., 2009; Houston et al., 2009). In addition, “both intentional and unintentional weight loss is predictive of increased all-cause mortality” (Houston et al., 2009; Miller & Wolfe, 2008). More studies are needed to determine if weight loss in the overweight and obese elderly is appropriate.

Psychological, social, environmental and lifestyle factors. Many psychological, social, lifestyle and environmental barriers to food intake are heightened with advanced age. Psychological factors include depression, bereavement, and cognitive decline. While living alone, isolation, minority status, limited income, food insecurity, reduced physical

mobility, lack of transportation, and poor proximity to grocery stores represent social, lifestyle and environmental factors. Combined, these factors are often experienced by the elderly and negatively impact dietary intake.

Psychological conditions have been shown to increase nutrition risk and weight loss (Hickson, 2006; Meyyazhagan & Palmer, 2002). Of elders living in the community, 5 to 15% experience sadness or clinical depression, which decrease appetite and digestion, and lead to weight loss and diminished well-being (Wellman, Weddle, Dranz, & Brain, 1997). In one study of 145 homebound men and women elders, more than half reported feeling lonely (Payette H, Gray-Donald, Cyr, & Boutier, 1995). The degree of loneliness has been shown to be inversely related to dietary adequacy (Krondl, Coleman, & Lau, 2008). For instance, widows have been shown to be at a higher nutrition risk than women living alone, suggesting that bereavement adversely affects eating behaviors (Krondl et al., 2008; Hickson, 2006).

Cognitive impairment, such as confusion or memory loss, is experienced by one out of five older adults and can impact their ability to remember if or when they have eaten (Meyyazhagan & Palmer, 2002; Wellman et al., 1997). Dementia is a common cause of undernutrition by impairing desire or ability to eat, and, weight loss in community-dwelling older adults may be an early sign of the onset of dementia (Hickson, 2006; Meyyazhagan & Palmer, 2002). Alzheimer's disease also impacts taste and smell, as well as chewing and swallowing ability. Research has shown that within eight years following an Alzheimer's diagnosis, approximately half of those afflicted lose the ability to feed themselves (Hickson, 2006). Other psychological factors such as anxiety or stress

have also been shown to impact changes in eating behaviors among the elderly (Hickson, 2006).

As adults age, increased nutrition risk is associated with disrupted lifestyle and social factors (Krondl et al., 2008). Living alone, ethnic minority status, limited income, food insecurity, and physical immobility have been associated with high nutrition risk and inadequate nutrient intake in older adults (Krondl et al., 2008; Keller, 2007; Sharkey, 2004a). It has been estimated that 20% of adults 65 to 79 years of age and 32% of adults 80 years or older eat alone (Salva & Pera, 2001). According to the National Diet and Nutrition Survey for those 65 and older, those living alone consumed fewer calories than those living with others (Hickson, 2006). Individuals living alone tend to eat less and often choose easy-to-prepare foods that are limited in nutrient content placing them at risk for deficiencies (Salva & Pera, 2001). In contrast, being married is associated with protection against nutrition risk (Krondl et al., 2008).

Studies show that older ethnic minorities are at an increased risk for malnutrition compared to their white counterparts (Krondl et al., 2008; Sharkey 2004a). For example, homebound Mexican Americans have been shown to be at greater nutrition risk independent of poverty status (Sharkey 2004b). Appropriate intake of energy and essential nutrients has also been found to be lower among black and Hispanic elderly (Weimer, 1997). Moreover it has been documented that older adults of minority status are at higher risk because they are often unaware of ENP nutrition programs (Klesges et al., 2001). This disparity will have a disproportionate effect because the population of older minorities is expected to increase by 271% compared to only 81% for whites (Krondl et al., 2008).

Low socioeconomic status and food insecurity are also predictors of nutrition risk (Krondl et al., 2008; Keller, 2006; Sharkey, 2004a; Weimer, 1997; White, 1994). According to the USDA Economic Research Service, food security is defined as "access by all members at all times to enough food for an active, healthy life" (United States Department of Agriculture Economic Research Services, 2009). Nationally, food insecurity has been a consistent problem among elderly Americans (Lee & Frongillo, 2001). Obviously, the less money individuals have, the less they have to spend on food, which may affect their ability to obtain an adequate diet. Among the elderly, these factors are compounded since older adults tend to spend less money on food compared to other age groups and often live on fixed incomes (Krondl et al., 2008). Elderly living on low incomes are more likely than those of higher incomes to report not getting enough to eat and skipping meals due to lack of food availability, and are often faced with the difficult choice between buying medications or buying food (Duerr, 2006; Weimer, 1997; Wellman et al., 1997). Elderly living on the lowest incomes have substantially lower nutrient intake than the elderly population as a whole (Sharkey, 2008; Hickson, 2006; Sharkey, 2003b; Weimer, 1997). Even after controlling for other socioeconomic conditions, NHANES III data revealed that food insecurity was negatively associated with nutrient intake in the elderly (Lee & Frongillo, 2001). Similarly, a national study based on the 1989-1991 Continuing Survey of Food Intake by Individuals showed that food-insecure elders consumed only 58% of the recommended intake of several essential nutrients (Rose & Oliveira, 1997).

Physical disability presents barriers to food access and intake for the elderly and homebound adults. According to NHANES III data, 4% of adults 60 to 90 years of age

had limited mobility and were unable to prepare meals (Meyyazhagan & Palmer, 2002). Among those 80 years and older, 17% were unable to walk and 23% were unable to prepare their meals (Meyyazhagan & Palmer, 2002). Other estimates have shown that only about half of elderly under 70 years of age and approximately 20% of those over 80 years of age can shop independently (Salva & Pera, 2001).

Compared to the US elderly population as a whole, ENP participants are more than twice as likely to live alone, have more than two times the number of physical disabilities, with almost half having incomes below the federal poverty level (Colello, 2010; Ponza et al., 1996). Studies have shown that between 60 to 90% of the HDM population has increased nutrition risk (Keller and McKenzie, 2003; Lokken, Byrd, & Hope, 2002; Coulston, Craig, & Voss, 1996). National surveys of home-delivered meal programs have revealed that 16% of participants reported occasions of food insecurity within the past six months, such as having no food or no money to buy food, or having to choose between buying medications or food (Duerr, 2006; Klesges et al., 2001). Nearly 50% of home delivered meal participants report saving part of their home-delivered meal to be consumed at a later time (Duerr, 2006). In a national pilot survey administered by the AoA, 66% of respondents reported that the HDM provided “half or more of their daily food intake” (AoA, 2004). In Texas, almost 58% of HDM recipients in the Lower Rio Grande Valley were deemed food insecure and exhibited higher risk of nutrition health risk factors. This independent association remained significant even after controlling for demographic factors (Sharkey, 2004a).

Suffering from physical limitations, disease, and isolation, often leads to diminished motivation to shop, cook and consume food (Krondl et al., 2003). Many

homebound elders also experience increased physical limitations affecting their ability to perform Activities of Daily Living (ADLs) such as bathing, toileting, dressing, eating and Instrumental Activities of Daily Living (IADLs), including meal preparation, shopping, managing medications and transportation. One study of 239 homebound men and women elders showed that as many as 76% of the sample were functionally dependent in at least one ADL and 95% in at least one IADL (Millen et al., 2001). In another evaluation of HDM recipients, 77% demonstrated a need for assistance with more than one ADL or IADL. Almost two-thirds of recipients had difficulty shopping for food and nearly half were unable to prepare meals (Duerr, 2006). Similarly, Sharkey et al. (2004) found that over 90% of HDM recipients had physical limitations preventing them from shopping, cooking or feeding themselves. In over 1,000 HDM participants, limited income, eating alone, polypharmacy, shopping and food preparation difficulty, and unintentional weight loss were associated with increased disability of ADLs (Sharkey, 2002).

Combined, these multi-faceted factors heighten the risk of poor health among the elderly. Psychological, social, environmental and lifestyle factors predispose older adults to poor dietary intake, poor nutrition status or malnutrition. Elders who are homebound are more profoundly impacted by these factors.

Consequences of Inadequate Intake and Poor Dietary Status

Inadequate dietary intake overtime leads to malnutrition, which has been associated with the development of chronic diseases, decreased immunity, increased hospital costs, functional disability, premature institutionalization, diminished quality of life and mortality (Sharkey, 2008; Keller, 2007; Brownie, 2006; Meyyazhagan & Palmer, 2002; Chen et al., 2001). Malnutrition, “is defined as a state of being poorly nourished”

(Hickson, 2006), includes both undernutrition and overnutrition. In regard to undernourishment, malnutrition prevalence rates among hospitalized and community-dwelling elderly have been estimated to be 29-61% and 5-10%, respectively (Hickson, 2006; Brownie, 2006).

Chronic disease. As previously mentioned, chronic disease contributes to poor nutrition status and risk for malnutrition by affecting consumption, absorption and nutrient utilization. Conversely, poor dietary intake can contribute to or exacerbate the development of chronic disease. Although body composition changes occur naturally with advanced age, sarcopenia is partly due to inadequate intake of protein and energy. Greater risk for osteoporosis is found among undernourished older adults, which often result in hip fractures and other devastating consequences (Klesges et al., 2001). Bone density begins to decline between 30-40 years of age resulting in a risk for osteoporotic fractures of 40-50% and 13-22% for women and men, respectively (Genaro & Martini, 2010; Chernoff, 2004). For postmenopausal women, the rate of bone loss increases by 1% annually (Genaro & Martini, 2010). An osteoporotic patient has a 40% lifetime fracture risk in the spine, hip, or wrist. Hip and spinal fractures require hospitalization and are associated with a higher risk of other complications such as pneumonia, resulting in a mortality risk of up to 20% within one year (Rachner, Khosla, & Hofbauer, 2011). Similar to sarcopenia, osteoporosis is also associated with increased risk of falling and fractures and potentially results in loss of independence and increased morbidity (Genaro & Martini, 2010).

Metabolic syndrome (MetSyn) has been defined by the National Cholesterol Education Program Adult Treatment Panel III as the presence of three out of five of the

following: abdominal obesity, hypertriglyceridemia, decreased high density lipoprotein cholesterol, hypertension and high fasting blood glucose (Ervin, 2009). The majority of the five risk factors are linked to dietary intake. For example, hypertension is associated with higher sodium and lower potassium intake. Hypertriglyceridemia is associated with excess abdominal adipose tissue and refined carbohydrate consumption. Glucose intolerance and abdominal obesity are associated with long-term consumption of low nutrient, energy dense foods and refined carbohydrates. In recent analyses of NHANES 2003-2006, approximately 34% of US adults met the criteria for MetSyn (Ervin, 2009). MetSyn prevalence increases with age. Men and women 60 years of age and older were four times and six times as likely, respectively, to meet MetSyn criteria compared with younger age groups (Ervin, 2009). MetSyn results in an increased risk for developing type 2 diabetes and cardiovascular diseases and has been shown to be a significant predictor of coronary heart disease (Ford, Giles, & Dietz, 2003; Alexander, Landsman, Teutsch, & Haffner, 2003; Meyyazhagan & Palmer, 2002). Individuals 70 years and older with MetSyn have a significantly higher risk of cardiac events including myocardial infarction, heart failure and cardiovascular mortality (Butler et al., 2006).

As age increases, there is a concurrent increase in the incidence of hypertension (HTN), or high blood pressure. Ninety percent of those over 55 years are at risk for developing this condition. Even though adults over 65 years of age represent less than 15% of the total population in the US, more than 40% of this age group has diagnosed hypertension (Munger, 2010). Hypertension and diabetes often occur together; approximately 75% of individuals with diabetes also have hypertension. This combination is associated with several debilitating complications such as retinopathy,

nephropathy, peripheral vascular disease, coronary heart disease, and stroke (Munger, 2010). Lifestyle factors including adequate fruit and vegetable intake, healthy protein and omega 3 fat sources, along with reduced sodium intake help to manage or prevent the development of HTN.

Health-related physical disability. Functional disability is defined as any impairment in an individual's basic ability to perform the physical ADLs or IADLs of daily living. Poor dietary intake has been associated with functional disability and increased mortality (Meyyazhagan & Palmer, 2002). As stated earlier, weight loss of 5% or more over 6 months place older adults at an increased risk for disability (Meyyazhagan & Palmer, 2002). Poor intake of calcium, vitamin D, magnesium, and phosphorus, nutrients important in maintaining the musculoskeletal system has also been shown to accelerate disability as evidenced by reduced lower extremity performance, which includes balance, mobility, and strength (Sharkey et al., 2004a; Sharkey et al., 2003). Even after controlling for extent of disability at baseline, musculoskeletal nutrient intake was directly linked with lower extremity performance, and therefore indirectly associated with severity of disability (Sharkey et al., 2004a). Micronutrient deficiencies, such as serum A, D, E, B6, B12, cartotenoids, folate, Zn, and Se, have also been shown to be independently associated with diminished functional status among disabled older women. Those with more deficiencies have greater risk (Semba et al., 2006). Self-reported functional limitations have also been independently associated with nutrition-related risk factors such as weight loss/gain, depression, polypharmacy, decreased appetite, poor oral health, poverty, and eating alone (Sharkey, 2008). The development of physical disability

can also be initiated by chronic disease, also influenced by dietary intake (Sharkey, 2008).

Institutionalization and health care costs. Up to 60% of our nation's total health care budget is spent on older adults (Sharkey, 2008). Annual spending on healthcare in general has continued to climb, as evidenced by an increase of $1.4 trillion/year to $2.2 trillion/year in 2001 and 2007, respectively, with a projected increase to $4.3 trillion/year by 2017 (Ariza, Vimalandanda, & Rosenzweig, 2010). Medicare spending has increased concurrently and is expected to increase from $523 billion in 2010 to $845 billion by 2019, reflecting the projected increase in Medicare recipients from 47 million to 80 billion (Henry J. Kaiser Family Foundation, 2010).

Two-thirds of general and acute hospital beds are occupied by adults aged 65 and older, and longer hospital stays are more common among adults 75 years of age and older (Hickson, 2006). According to the CDC, more than 75% of health care costs are attributable to chronic disease conditions (CDC, 2009). In 2007, the direct and indirect cost of diabetes was estimated to equal $174 billion, of which 56% were attributed to people 65 years of age and older. The estimated total cardiovascular disease costs in 2010 were $444 billion (CDC, 2009). Annual medical costs associated with osteoporosis are currently estimated to range from $14 to $20 billion (Becker, Kilgore, & Morrisey, 2010).

Poor nutrition status may be a factor in promoting premature institutionalization, prolonged hospital stays, increased hospital costs, and early hospital readmission (Sharkey, 2008; Hickson, 2006; Meyyazhagan & Palmer, 2002; Lee & Frongillo, 2001). Malnutrition results in increased medical costs due to its association with more

complications, prolonged hospital stays and more frequent hospital readmissions, resulting in up to $2,000-$10,000 higher costs per admission (Hickson, 2006; Wellman et al., 1997). Protein-energy malnutrition has been independently associated with non-elective hospital readmission (Sullivan, 1992). Although risk factors for institutionalization include older age, poverty, poor health status, living alone and limited physical ability, the major cause may be unintentional weight loss due to poor dietary intake (Payette et al., 2000). For example, in a cohort of almost 300 elderly, weight loss of 5 kg or more was significantly associated with being institutionalized, even after controlling for health, disease, functional status and other social variables (Payette et al., 2000). Not only does premature institutionalization negatively affect quality of life and well-being of older adults, it also leads to increased health care costs and nursing home expenses. These costs have substantially increased over decades and are expected to continue to rise in the future. According to the 2009 MetLife Market Survey of Nursing Home, Assisted Living, Adult Day Services, and Home Care Costs, the average annual cost of a private room or semi-private room in US nursing homes is $79,935 and $72,270, respectively (MetLife Mature Market Institute, 2009). In Dallas/Ft. Worth, Houston, and Austin, the cost for a private room in a nursing home ranged from $66,000 to over $78,000 per year, and assisted living expenses ranged from over $36,000 to over $39,000, with care in Austin being the most costly (MetLife Mature Market Institute, 2009). Reducing the need for a nursing home private room or assisted living needs in Austin, TX would save $66,248 and $39,252 per person per year, respectively.

Dietary Components of Concern

In general, older adults consume fewer calories and fewer nutrients than younger adults. For example, the caloric intake of both men and women in their 80s is 1000 to 1200 kcals lower in men and 600-800 in women than those in their 20s (Wakimoto & Block, 2001). In a dietary assessment of 498 adults between 60 and 80 years of age, Lipid Research Clinics Program Prevalence Study found levels of intake below the DRI for calcium, potassium, folic acid, vitamin A and vitamin C (Anderson et al., 2009). According to the USDA 1989-92 Continuing Survey of Food Intake of Individuals (CSFII), 1/3 of over 1500 adults 60 years of age and older consumed below the Recommended Daily Allowance (RDA) for energy, protein, fat, vitamin E, C, niacin, B6, Calcium, Magnesium, iron, zinc, (Weimer, 1998). Another nationwide survey of over 450 adults 65 years of age and older reported that more than 40% of both men and women consumed less than 2/3 RDA for A, E, calcium, zinc for men and energy, E, calcium, zinc for women, with adults older than 74 years of age having the most deficient intake (Ryan, Craig, & Finn, 1992). Similarly, in an evaluation of over 2,650 elderly 65-85 years of age, prevalence for inadequate intake was highest for zinc, calcium, vitamin E, and B6 (Cid-Ruzafa, Caulfield, Barron, & West, 1999). Although general energy and nutrient intake tend to be inadequate in older adults, specific nutrients of concern include protein, calcium, vitamin D, B12, and folic acid.

Protein. Sufficient protein intake is essential for older adults to maintain their immune system and to keep vital tissue and organs healthy. In addition, protein is needed to preserve lean muscle mass to prevent sarcopenia (Genaro & Martini, 2010). Some loss of skeletal muscle mass is part of biological senescence, with muscle being lost at a rate

of 3-8% every 10 years after the age of 30 and accelerating with advanced age (Genaro & Martini, 2010). The increased rate of muscle deterioration is largely attributed to deficient protein intake and physical inactivity, both modifiable risk factors. Recently, data from the Health, Aging, and Body Composition (Health ABC) study demonstrated that dietary protein intake was associated with significant changes in muscle mass in older independent living adults, even after adjusting for fat mass (Houston et al., 2008).

Research has shown that most older adults consume less than the RDA of 0.8g/kg (Houston et al., 2008). Dasgupta et al. (2005) investigated the protein intake of HDM participants using three random 24-hour dietary recalls and found that half did not meet the RDA requirements for protein. According to the data derived from NHANES 2003-2004, approximately 7 to 9% of women 50 years and older consumed protein below the Estimated Average Requirement (EAR) (Fulgoni, 2008). However, this study probably underestimated protein inadequacy among this group since adequate intake was calculated using the EAR, which is 0.6g/kg/day, less than the RDA of 0.8g/kg/day. Poor dietary intake of protein is partly attributed to lower consumption of meat, poultry, and fish, which are more costly and more difficult to chew and digest (Chernoff, 2004). There may be a deficit in knowledge about alternative protein containing foods as well.

Many researchers recommend that the current RDA for protein of 0.8g/kg/day should be increased in order to meet nitrogen equilibrium in this population (Genaro & Martini, 2010; Chernoff, 2004). Proposed increases include at least 1.0 -1.14 g/kg/day to solely maintain LBM, with higher amounts needed for wound healing, bed sores, infection or rebuilding tissue loss (Kim, Wilson, & Lee, 2010; Chernoff, 2004; Meyyazhagan & Palmer, 2002; Campbell, 2001). Higher protein intake is necessary to

negate metabolic changes in protein metabolism. When compared with younger adults, older adults have demonstrated increased proteolysis when in a fasting state, in addition to an impaired ability to halt catabolism after food intake resumes (Kim et al., 2010). Protein synthesis (protein anabolism) in muscle tissue becomes less efficient in the elderly, as well, and may be attributed to decreased sensitivity to the essential amino acid leucine (Kim et al., 2010). Therefore, deteriorating lean muscle mass may be attributable to metabolic changes that occur with advanced age as well as inadequate intake.

There is also evidence that protein deficiency affects bone metabolism and bone mass density (BMD), thereby increasing risk of osteoporosis (Genaro & Martini, 2010). Recent cross-sectional and longitudinal studies have illustrated that dietary protein may elevate bone markers and improve bone density (Jesudason & Clifton, 2011). Evidence suggests that protein is critical for the maintenance of BMD in postmenopausal women and in older men. In addition to protein, adequate intake of calcium, fruits, and vegetables has been shown to be equally important promoting positive bone health (Jesudason & Clifton, 2011).

Calcium and vitamin D. Calcium and vitamin D are necessary for a host of bodily processes. Calcium is crucial for muscle contraction, expansion and contraction of blood vessels, hormone and enzyme secretion, and nervous system signal transmission (National Institutes of Health [NIH], 2011a). A minute amount of circulating calcium is needed to conduct these functions. The remaining calcium is stored in bone, where bone remodeling occurs continuously. Remodeling consists of resorption, the release of calcium from bone to circulation, and deposition, the storage of calcium in bone. Adequate calcium intake (along with hormones) is necessary to maintain calcium

deposition. However, as adults age, the rate of bone calcium resorption surpasses calcium deposition due to decreased estrogen levels and inadequate dietary intake, augumenting the risk for osteoporosis (NIH, 2011a).

Commonly known food sources of calcium include dairy products such as milk, cheese, and yogurt. However, there are also plant-based sources of calcium including dark leafy greens (collard, mustard, kale, spinach) in addition to fortified foods such as calcium fortified orange juice, milk alternatives (soy, almond, rice milks) and some cereal products. The Institutes of Medicine (IOM) recently released updated recommendations for daily calcium intake. For adults 50 years and older, the RDA for calcium is 1200 mg/day, which can be achieved daily by consuming two servings of dairy or fortified milk alternative, one serving of dark leafy greens, and a fortified food product (Institutes of Medicine [IOM], 2010).

Vitamin D is required for adequate intestinal absorption of calcium and for maintenance of bone remodeling (NIH, 20011b). In addition to bone health, vitamin D may also impact muscle strength, with deficiency leading to muscle weakness (Sharkey, 2008). Emerging evidence indicates a link between vitamin D status and cardiovascular disease, multiple sclerosis, and diabetes (Ascherio, Munder, & Simon, 2010; Mascitelli, Goldstein, & Pezzetta, 2010). With aging, vitamin D levels in the body tend to decline (Morley, 2007). Deficiency in vitamin D can be caused by several factors such as inadequate dietary consumption due to limited food sources, limited sun exposure, and gastrointestinal and renal diseases (Meyyazhagan & Palmer, 2002).

Very few foods supply sufficient vitamin D. These include egg yolk, some fish, and fortified foods such as milk and some cereals (NIH, 2011b). Older adults tend to

consume fewer fortified dairy foods due to lactose intolerance and may not be aware of other fortified food sources. Adequate sunlight exposure also provides a source of vitamin D by catalyzing subcutaneous synthesis of cholecalciferol. Conversion of cholecalciferol to active 1,25 dihydroxy D_3 is performed in the liver and kidney. Functional decline of the liver and kidney with aging will diminish active vitamin D production. In addition, homebound older adults may lack exposure to sunlight due to physical or mental limitations in getting outside, exacerbating the risk for deficiency (Gloth, Gundberg, & Hollis, 1995).

Research has shown that vitamin D deficiency is common in older individuals. In the United States and Europe, vitamin D deficiency affects 40% to 100% of independent elderly men and women (Holick, 2007). Approximately 50% of nursing home residents and 57% of hospital inpatients have vitamin D deficiency (Greenspan & Resnick, 2005).

The IOM also updated recommendations for vitamin D intake to 600 IU for adults between the ages of 50-70 and 800 IU/day for adults 71 years of age and older. In contrast to calcium, it is more difficult to obtain adequate daily vitamin D levels without the consumption of fortified foods, adequate sunlight, and/or supplementation (IOM, 2010).

Vitamin B12 and folate. Vitamin B12 is necessary for neurological function and homeostatic metabolic pathways. The RDA for B12 is 2.4 µg/day (IOM, 2001). Food sources include animal products such as meat, poultry, fish, dairy, and eggs, in addition to fortified foods. Folate from food is converted to folic acid, which is involved in several metabolic pathways responsible for DNA synthesis, amino acid metabolism and homeostasis of the body. The RDA for folate is 400 µg/day achieved by consuming, dark

leafy greens, citrus, legumes, and fortified enriched grains (mandated by FDA in 1998) (Bailey, 2004; IOM, 2001).

Deficiency in vitamin B12 can lead to irreversible neurological damage, megaloblastic anemia, and vascular disease (Chatthanawaree, 2010). Inadequate blood folic acid levels are associated with cognitive dysfunction, atherosclerosis and megaloblastic anemia, but also certain cancers (Pfeiffer et al., 2007). Both vitamin B12 and folic acid are involved in the methionine cycle, which results in the metabolism of homocysteine to methionine (Stover, 2004; Rampersaud, Kauwell, & Bailey, 2003). Deficiency in these two vitamins leads to hyperhomocysteinemia, a biochemical abnormality associated with cardiovascular disease risk, potential risk for developing dementia, and possibly increased risk of bone loss (Carlsson, 2006; Andres et al., 2004; Stover, 2004; Rampersaud et al., 2003). Hyperhomocysteinemia, a significant risk factor for atherosclerosis, has shown to increase cardiovascular disease risk by promoting platelet dysfunction and coagulation in arteries (Carlsson, 2006).

High circulating levels of homocysteine have been associated with cerebral microangiopathy and microvascular brain lesions, which are correlates of vascular dementia (Stranger et al., 2009). In addition, hyperhomocysteinemia and low B12 and folic acid levels are risk factors for mild cognitive impairment, dementia, and irreversible cognitive and memory dysfunction (Stranger et al., 2009; Stover, 2004). B12 and folate are involved in the synthesis of S-adenosylmethionine (SAM), which is necessary for neurotransmitter, phospholipid, and myelin methylation in the brain (Rampersaud et al., 2003). SAM is also necessary for brain synthesis of dopamine, norepinephrine and serotonin. Therefore, deficiency in these vitamins may also be linked with depression

(Stranger et al., 2009). As a consequence of hyperhomocysteinemia, vascular disease may result in brain ischemia or stroke, diminishing cognitive function (Rampersaud et al., 2003). Finally, since folic acid is involved in methylation of DNA, inadequate intake potentially disrupts the DNA repair system causing pro-carcinogenic effects and is associated with increased risk of certain cancers (Stover, 2004; Rampersaud et al., 2003).

Older adults are at an increased risk of malabsorption of B12 and folic acid due to physiological changes to the gastrointestinal tract. The digestion and absorption of B12 is a multi-step process involving gastric secretion of hydrochloric acid, Intrinsic Factor (IF), and pepsin. B12 is hydrolyzed from its binding protein by hydrochloric acid and pepsin and then binds to R-protein in the stomach. This complex travels to the small intestine where pancreatic enzymes hydrolyze B12 from R-protein making it available to bind to, a step necessary for absorption (Allen, 2010; Andres et al., 2004). Similarly, digestion of folate requires hydrochloric acid and specific enzymes to hydrolyze the polyglutamate form of folate to the monoglutamate form that is absorbed.

There are several reasons why older adults are at an increased risk of for developing B12 deficiency. Beginning at age 60, risk of deficiency or depletion is mainly due to malabsorption of B12 (Allen, 2010) combined with inadequate intake. Studies report that approximately 50% of the elderly in the United States may have inadequate intake of B12, especially if they are malnourished or patients in institutions or psychiatric hospitals (Andres et al., 2004). Among the elderly, prevalence of low serum B12 concentrations has been reported to range from 0.6% to 46% (Chatthanawaree, 2010).

It is estimated that 20-50% of older adults have atrophic gastritis, a primary cause for B12 and folate malabsorption (Brownie, 2006; Carlsson, 2006; Andres et al., 2004).

With atrophic gastritis, hydrochloric acid, pepsin, and IF production is reduced, negatively impacting absorption of B12 and folate. Another common cause of B12 deficiency is pernicious anemia, with prevalence rates estimated to affect 20-50% of the elderly. Pernicious anemia is an autoimmune disease that damages the gastric mucosa resulting in reduced production and secretion of gastric acid and IF, thereby impairing absorption of both B12 and folate. Additionally, chronic use of medications such as antacids, proton pump inhibitors, H2-receptor antagonists, methotrexate, and metformin, has also been attributed to malabsorption (Andres et al., 2004; Rampersaud et al., 2003).

Homebound elderly are at even greater risk for nutrient deficiencies due to inadequate consumption. Substantially inadequate intake of protein, energy, and several essential nutrients required for daily living have been documented throughout the literature for *homebound* older adults in general (Millen et al., 2001; Ritchie et al., 1997; Gloth et al., 1996; Payette et al., 1995). Millen et al. (2001) evaluated dietary intake in 239 homebound subjects and found that fiber, vitamin D, calcium, and magnesium were the most likely nutrients to be consumed in inadequate amounts, with less than 20% of subjects meeting dietary standards. In another study of *homebound* elders, prevalence of intake below the RDA was documented for folate (50%), B12 (53%), and niacin (57%). The nutrients with the highest prevalence of inadequate intake were magnesium (80%), calcium (80%), vitamin D (83%), and zinc (90%) (Gloth et al., 1996). Evaluations of macronutrient intake in *homebound* elders (carbohydrate, fat, and protein) have also documented intake below recommendations (Ritchie et al., 1997; Payette et al., 1995). As a result, *homebound* elderly represent a particularly high risk population for development of nutrient deficiencies.

Nutrition Impact of Home Delivered Meal Programs

HDM programs, a component of ENP, strive to reduce hunger and food insecurity and to improve the health and well-being of *homebound* older adults. Since it is so important to increase the availability of nutrient dense foods and increase nutrient intake of *homebound* elders, the daily meal served under this program must meet the USDA Dietary Guidelines for Americans and provide one-third of current Dietary Reference Intakes (DRIs) (Colello, 2010); many HDM programs provide meals containing 40-50% of the RDA for required nutrients (Duerr, 2006; Ponza 1996).

Several studies have investigated nutrient intake in HDM recipients (Dasgupta, Sharkey, & Guoyao, 2005; Sharkey et al., 2003; Sharkey, 2003; Krondl et al., 2003; Sharkey, Branch, Zohoori, Giuliani, Busby-Whitehead, Haines, 2002; Lokken et al., 2002; MacLellan, 1997; Herndon, 1995; Stevens, Grivetti, & McDonald, 1992; Bunker, Stansfield, & Blayton, 1986; Lipschitz, Mitchell, & Steele, 1985; Davies, Purves, & Holdsworth, 1981). Data collection methods included 24-hour recalls, 7-day food records, and diet histories. These studies reported total nutrient intake which included those provided by the HDM.

A few studies examined changes in nutrient intake as a result of provision of HDM. Some compared recipients versus non-recipients, or compared intake on delivery days versus non-delivery days (Frongillo & Wolfe; 2010; Roy & Payette, 2006; AoA, 2004; Millen et al., 2002; Steele & Bryan, 1986).

Two studies compared nutrient intake of participants versus non-participants. Millen et al. (2002) compared a nationally representative sample of ENP participants (both congregate meal recipients and HDM recipients, N=1,858) with a closely matched

sample of non-participants living in the same zip codes (N= 841). ENP participants received 30-50% of their total daily food intake from one of the ENP programs. In addition, ENP participants met or exceeded the daily recommendation for most of the selected nutrients of study and consumed higher levels of calories and all 16 nutrients of study including protein, vitamins A, C, D, E, thiamin, riboflavin, niacin, vitamin B6, folate, B12, calcium, iron, magnesium, zinc, and phosphorus when compared to non-participants (up to 31% more in some cases). In fact, ENP participants' consumption of all 16 nutrients except for vitamin B12 and iron was significantly higher than intake of non-participants. In contrast, Steele and Bryan (1986) compared 32 HDM recipients to 22 non-recipients who were on the HDM wait list. They found that both groups had similar intake in the majority of the nutrients, with the non-recipients consuming significantly more carbohydrates, thiamin, and iron. Surprisingly, the only nutrient that was consumed in greater amounts by HDM recipients was calcium.

Other studies compared nutrient intake of HDM recipients on delivery days versus non-delivery days. Using a nationally representative sample of approximately 4,000 HDM participants, the AoA compared the consumption of nutrient dense foods on meal delivery days versus non-meal delivery days such as weekends using the Performance Outcomes Measures Project survey (AoA, 2004). Results showed that the delivered meals contributed substantially to recipients' consumption of nutrient-dense foods when compared to non-meal delivery days. For example, on non-meal delivery days, only 38% of participants consumed any fruit, and only 34% consumed any vegetables. In contrast, on meal delivery days, substantially more participants consumed

produce, with 99% consuming one serving of fruit and 94% consuming at least one serving of a vegetable (AoA, 2004).

Roy and Payette (2006) assessed baseline nutrient intake to intake after 8 weeks of 31 new enrollees in a HDM program who did not continue services in the program with 20 enrollees who remained in the program. Two consecutive 24-hour dietary recalls were conducted at baseline followed by 5 non-consecutive 24-hour dietary recalls at follow up. Intake of energy, protein, carbohydrate, fat, vitamin A, thiamin, riboflavin, niacin, vitamins B6, B12, C, D, E, folate, calcium, iron, and magnesium were evaluated. There were no significant differences in energy and nutrient intake between the two groups at baseline, but at 8 weeks, the participating group consumed significantly more calories and more of all nutrients except for vitamin A, riboflavin, and vitamin B12 compared to those who withdrew from the study. Statistically significant increases were observed among participant in energy ($p<0.05$), protein ($p<0.03$), fat ($p<0.03$), and thiamin ($p<0.03$) compared to those who withdrew. However, despite the receipt of HDM, the participants consumed inadequate amounts of B6, vitamin E, folate and magnesium at 8 weeks.

A more recent study investigated the impact of HDM on participants' dietary patterns and nutrient intake in upstate New York. Comparison included three non-randomized groups: 1) HDM meal group, 2) HDM no-meal group (subjects who were enrolled in the HDM program with the follow up 24 hour dietary recall conducted on a non-meal delivery day), and 3) Non-HDM group (subjects receiving community based long term care services only). At baseline, 171 HDM subjects and 41 non-HDM subjects completed a 24-hour dietary recall. Researchers conducted follow up at 6 (N=100) and 12

months (N=69) after baseline. At baseline, mean nutrient intakes did not differ between the three groups. The intake of nutrient-dense foods and specific nutrients among the HDM meal group significantly improved at 6 and 12 months compared to the HDM no-meal group (Frongillo & Wolfe, 2010). In addition, the HDM group significantly increased their consumption of nutrient-dense foods, fruits and vegetables, calories, protein and micronutrients such as beta-carotene, vitamins E, A, D, C, niacin, thiamin, riboflavin, B6, B12, folate, phosphorus, iron, calcium, zinc and magnesium compared to the HDM no-meal group. Compared to the no-HDM group, the HDM meal group also had significantly greater intake of vegetables, vitamins A, B6, B12, D, E, calcium, magnesium, and phosphorus (Frongillo & Wolfe, 2010).

Thus, although several studies have evaluated nutrient intake in HDM participants, their methodology did not compare intake to a baseline measure. The few studies that have been conducted comparing intake to a baseline measure show that HDM improves nutrient intake of participants. However, more research is needed since there are limited studies evaluating the nutrient intake of the same individuals at baseline (before meals) compared to follow up (after meals).

Nutrition Status and Malnutrition Prevalence in Older Adults

Malnourished older adults are at an increased risk for functional decline, hospitalization and mortality (Sieber, 2006). Research has shown that prolonged poor dietary intake is linked with malnutrition, decreased immunity, increased hospital costs, functional disability, premature institutionalization, and mortality (Sharkey, 2008). Although the prevalence of malnutrition found among community dwelling older adults is only 5 to 10% (Brownie, 2006), HDM participants are at greater nutrition risk due to

the physiological, psychological, and social risk factors already described (Sharkey, 2008). Studies have shown that the prevalence of increased nutrition risk in HDM recipients ranges between 60-90% (Keller & McKenzie, 2003; Lokken et al., 2002; Coulston et al., 1996). While there is no single diagnostic test that accurately flags malnutrition, there are strong indicators of poor nutrition status, including significant weight change over a specified period of time, reduced body circumferences, and/or biochemical parameters associated with wasting, such as low albumin (Keller, 2007).

Nutrition screening is used to assess HDM participant's overall nutrition health in order to identify those in greater need of further nutrition intervention and services. The routine use of a nutrition screening process is standard practice for most HDM programs.

Nutrition Screening Instruments

The Nutrition Screening Initiative (NSI) Checklist. The most commonly used tool is the Nutrition Screening Initiative "DETERMINE your Health Checklist" (NSI Checklist). While the NSI Checklist assesses risk factors associated with poor nutrition status in the elderly (e.g., having limited money for food purchases or taking more than three prescriptive medications per day), it does not accurately flag malnourishment (Phillips, Foley, Barnard, Isenring, & Miller, 2010; Sinnett et al., 2010; Quigley, Hermann, & Warde, 2008; Charlton, Kolbe-Alexander, & Nel, 2007; Marshal, Stumbo, Warren, & Xie, 2001; MacLellan & Van Til, 1998; Sayhoun, Jacques, Dallal, & Russel, 1997; Coulston et al., 1996; Guigoz, Vellas, & Garry, 1996). The NSI Checklist (Appendix) was originally developed to promote public awareness of risk factors that can eventually lead to poor nutrition status among older adults (White et al., 1992). It was

meant to be followed by two further levels of screening and assessment to include anthropometrics and biochemical data, etc. (White et al., 1992).

Several researchers have identified problems with the NSI Checklist, concluding that it overestimates nutrition risk and that it has a low specificity (i.e., the percentage of subjects of no nutrition risk who are correctly diagnosed). Coulston et al (1996) assessed the efficacy of the NSI Checklist by also assessing clinical data often to assess nutrition status, including anthropometrics, dietary intake, and biochemical markers such as serum albumin. These researchers found that the NSI Checklist overestimated poor nutrition status compared to the assessment data. For example, the NSI Checklist identified 98% of subjects as being at nutrition risk compared to 75% identified using the clinical assessment data (Coulston et al., 1996). Posner et al. (1993) evaluated the ability of the NSI Checklist to predict dietary intake and perceived health status in 749 subjects. The NSI Checklist demonstrated only a 38% precision rate for identifying subjects who consumed <75% of the RDA, but was better able to predict perceived health status in approximately half of the subjects. Other studies have concluded that the NSI Checklist may be more appropriately used as an educational tool, or used in conjunction with further dietary screening tools (Quigley et al., 2008; Marshal et al., 2001; Sayhoun et al., 1997; Guigoz et al., 1996; Melnik, Helferd, Dirmery, & Wales, 1994). Recently, Sinnett et al. (2010) further concluded that modifications to the NSI Checklist are necessary to improve this tool as a means of measuring nutrition risk. In summary, the NSI Checklist has not proven to be useful in identifying those who are malnourished due to its low precision rate and high number of false positives. Therefore, the NSI Checklist should not

be utilized as a sole means of evaluating nutrition status among HDM participants (Phillips et al., 2010; Charlton et al., 2007).

Mini Nutritional Assessment (MNA). The MNA (Appendix) is another nutrition status assessment tool developed in the early 1990s. It includes 18 questions pertaining to food intake, weight loss, hydration, medication use and psychological stress (bereavement, etc.) and neuropsychological problems (depression and dementia). In addition, anthropometric measurements such mid-arm and calf circumferences, and height, weight and calculated BMI are incorporated. MNA correlates well with serum albumin levels, a primary biochemical marker for nutrition status (Feldblum et al., 2007; Nelms 2007; Sieber, 2006). Serum albumin has been shown to be a sensitive biochemical marker for protein-energy malnutrition (PEM), with levels less than 3.5 g/dL indicating PEM (Nelms, Sucher, Long, 2007; Chernoff, 2006). Unlike the NSI Checklist, the MNA has undergone extensive validity testing. During its development, the MNA was validated by three successive studies that included over 600 elderly individuals from France and New Mexico (Guigoz, Vellas, & Garry, 1994). These studies were conducted by comparing results of the MNA to clinical status evaluations conducted by two physicians trained in nutrition assessment. Parameters included comprehensive nutrition assessments, anthropometric measures, dietary intake, and biochemical markers including albumin (Guigoz et al., 1996). The MNA matched the physicians' assessments in 92% of subjects, and in 98% of subjects when using biochemical parameters. In the second study, the MNA was able to identify identical clinical nutrition status for 89% of the subjects without biochemical data, and for 88% when incorporating biochemical data. These results suggest that the MNA can correctly identify nutrition status in the elderly without

the use of further assessment data including biochemical parameters (Guigoz et al., 1996). Based on these validation studies, the MNA is now considered the gold standard for malnutrition screening in the elderly (Sieber, 2006).

MNA Short Form Version 1. To provide a quick screening tool, in 2001 the MNA was shortened to the MNA-Short Form (MNA-SF V1), which requires answers to only 6 items with the highest sensitivity and greatest overall accuracy, and assessment of BMI (Rubenstein, Harker, Salva, Guigoz, & Vellas, 2001). In contrast, the full MNA includes 18 questions and requires several anthropometric measures (i.e. height, weight, calculated BMI, mid-arm circumference, and calf circumferences). The MNA-SF V1 was validated against the same data used for validation studies of the full MNA. The correlation between the full MNA and the MNA-SF V1 was strong ($r = .945$, <0.001), with sensitivity and specificity being 97.9% and 100%, respectively, and an overall diagnostic accuracy of 96.5% (Rubenstein et al., 2001). Both the MNA-SF V1 and the full MNA correlated adequately with serum albumin levels ($r = .679$, $r = .699$, respectively). When Rubenstein et al. (Rubenstein et al., 2001) used the MNA-SF V1 to assess nutrition risk, only two subjects who had low serum albumin levels were not identified.

Since its validation, several researchers have evaluated the usefulness of the MNA-SF V1. Wikby et al. (2008) tested the sensitivity (measures that proportion of actual positives, which are correctly identified), specificity (measures the proportion of negatives which are correctly identified) and diagnostic predictability of the MNA-SF V1 against the full MNA in 127 community dwelling elders in Sweden. Researchers found an 87% agreement between scores obtained using the MNA-SF V1 and the full MNA,

with high sensitivity (89%), high specificity (82%), and high positive predictability (92%) (proportion of subjects with positive tests who are correctly diagnosed). Thus, the MNA-SF V1 has high diagnostic accuracy relative to clinical nutrition status and strongly correlated with the full MNA with respect to its ability to predict low serum albumin levels among subjects. Similarly, in their investigation of malnutrition prevalence in over 22,000 community dwelling Spaniards, Cuervo et al. (2008) found that the MNA-SF V1 correlated highly with the Full MNA ($r = .85$, $p<0.001$) with sensitivity of 85.2%. Sensitivity was defined as the proportion of 'undernourished' or 'at risk' subjects who were classified as 'undernourished' by the MNA-SF V1 who had been correctly identified in these categories by full MNA. Specificity for the 'well nourished' classification by MNA-SF V1 compared to the full MNA, was 88.9%. Combined, these results suggest that the MNA-SF V1 is an appropriate screening tool to independently evaluate nutrition status among the elderly.

Other studies have also found that the MNA-SF V1 correlates well with serum albumin levels. Kuzuya et al. (2005) evaluated both the full MNA and the MNA-SF V1 in 226 Japanese elderly in various settings including geriatric outpatient clinics, hospitals, nursing homes, and home care patients. As with previous studies (cite), scores obtained using the MNA-SF V1 were strongly correlated with those obtained using the full MNA ($r=.88$, $p<.0001$). Although the authors stipulated that the BMI cut-off points were not appropriate for the Japanese elderly population, the full MNA nevertheless correlated well with serum albumin levels ($r=0.60$) with 81% sensitivity and 86% specificity. Since the MNA-SF V1 was significantly correlated with the full MNA and the full MNA demonstrated good correlation with albumin, the authors infer that the MNA-SF V1 may

also correlate well with albumin (Kuzuya et al., 2005). In an Italian study of 275 patients in an acute medical ward, the MNA-SF V1 was used experimentally to assess functional decline (Salvi et al., 2007). After twelve months, researchers found that the MNA-SF V1 correctly identified patients with lower serum albumin, increased disability, and who required longer lengths of stay. The researchers reported that the MNA-SF V1 classifications were independent risk factors for patients with acute medical problems (Salvi et al., 2007). In another study of over 2,300 Turkish elderly living in the community, Ulger et al. (2010) investigated the prevalence of malnutrition risk and associated factors. They used the MNA-SF V1 along with a comprehensive geriatric assessment system including evaluation of functionality, biochemical measures, and comorbidities. Results showed that among other factors, serum albumin was independently associated with the malnutrition risk classification provided by the MNA-SF V1 (Ulger et al., 2010).

Therefore, based on the fact that the MNA-SF V1 demonstrates high sensitivity, specificity, and positive predictive value, several researchers have adopted the MNA-SF V1 to evaluate the nutrition status of the elderly. (Bilotta, Bergamaschini, Arienti, Spreafico, & Vergani, 2010; Serra-Prat, Palomera, Roca, & Puig-Domingo, 2010; Ghisla et al., 2007).

MNA Short Form Version 2. The MNA-SF V1 has been modified further. The MNA-SF V2 (Appendix) includes the same 6 questions used in the MNA-SF V1, but offers the healthcare provider a choice of measuring calf circumference or calculating BMI. Also, this version designates three diagnostic categories rather than two. These modifications were incorporated to 1) allow the instrument to be used in bed-bound

clients for whom height and weight data cannot be gathered, and 2) better classify an individual's nutrition risk. In 2009, Kaiser et al. validated the MNA-SF V2 against the Full MNA and demonstrated that calf circumference correlates well with serum albumin and BMI, and that the MNS-SF V2 correctly classified nutrition risk in 91.7% of the study population (Kaiser et al., 2009). Soon thereafter, Charlton et al. (2010) recently assessed the usefulness of the MNA-SF V2 compared to the full MNA in rehabilitated older patients in Australia. Compared to the full MNA, the sensitivity of the MNA-SF V2 was 89.3% with a specificity of 44%. In this study, 56% of subjects classified as well-nourished using the full MNA were identified as being at risk or malnourished using the MNA-SF V2. Clearly, further evaluation of the MNA-SF V2 is needed to determine if it is an appropriate tool to identify nutrition risk.

Nutrition Screening in Home Delivered Meal Programs

The majority of studies investigating the nutrition status of HDM recipients have used the NSI Checklist screening tool (Sharkey, 2004a; Sharkey & Haines, 2002; Lokken et al., 2002; Coulston et al., 1996; Herndon, 1995; Melnik et al., 1994). While the primary objective of many studies was to determine the nutrition risk or nutrition health of elderly enrolled in a HDM program (Lokken et al., 2002; Coulston et al., 1996; Herndon, 1995), some researchers examined relationships between nutrition risk indicators and the severity of disability, eligibility for HDM, or other risk factors (Sharkey, 2004; Sharkey & Haines, 2002; Melnik et al., 1994). Very few have measured nutrition status in HDM participants before and after an intervention to determine whether the intervention resulted in a change in nutrition health.

While some researchers have used the full MNA to screen participants before and after an intervention, only a few have evaluated whether participation in HDM programs affected *nutrition status* of the participants. Kretser et al (2003) compared the effects of two different meal models for HDM using the full MNA to measure change in nutrition status of HDM participants by comparing a control group (N=101) who received the traditional meal model of one meal per day, 5 days a week, to the experimental group (N=102) who received 3 meals plus 2 snacks daily for 7 days a week. Nutrition status of both groups was evaluated using the full MNA at baseline, 3 months, and 6 months after the intervention. The full MNA was able to measure change in nutrition status in both groups, with the nutrition status of the experimental group improving the most.

Suda et al (2001) also measured change in nutrition status in HDM participants using the full MNA. Nutrition status was compared between HDM participants who received meals plus additional education on health and nutrition (N=42) to a control group who only received meals (N=39). Nutrition status was similar between both groups at baseline, but at follow-up, the nutrition status of the experimental group significantly improved compared to the control group. Again, the MNA was able to measure change in nutrition status. These two studies demonstrate the ability of the MNA to successfully measure change in nutrition status following an intervention in a HDM program.

The only study found to assess nutrition status of HDM recipients over time was Keller (2006). This study used the SCREEN (Seniors in the Community: Risk Evaluation for Eating and Nutrition) questionnaire to assess nutrition risk among the population. Subjects were recruited from agencies providing services to the elderly, and included those receiving formal meal service such as HDM (28%), those receiving meals in social

settings, such as congregate meals (42%) and subjects not enrolled in a meal program (30%). Individual nutrition status of 263 subjects was compared between baseline and after 18 months. The goal was to determine if formal meal assistance prevents further declines in nutrition status. At baseline, 41% of subjects were identified at high nutrition risk and 26% were at moderate risk. At follow up, participation in formal meal programs was shown to be independently associated with better nutrition risk scores and prevention of further declines in nutrition risk.

A validated, evidence-based nutrition screening tool is needed for ENP-funded programs to be able to accurately identify those in need of HDM services and to target limited resources more effectively. Although the NSI Checklist identifies risk factors associated with poor nutrition status, it was not designed directly assess malnourishment. The MNA-SF V2 should be considered for use by programs since they have been shown to better identify the malnourished, and are easy to use in a community setting. In addition, the MNA-SF V2 needs to be further evaluated and has yet to be to evaluate nutrition status change among participants in HDM programs. Finally, more research is needed to determine if the provision of HDM actually improves individuals' nutrition status.

Rationale for Research

Since the homebound elderly population in Austin is dependent on MOWAM as the sole provider of HDM to alleviate hunger and food insecurity and protect their health, it is imperative that the impact of MOWAM be evaluated. According to the latest Meals on Wheels Association of America Report on Senior Hunger in the United States, Texas ranks fourth in food insecurity among seniors (Ziliak & Gundersen, 2009). Older adults

over the age of 60 comprise roughly 14% of the current population in Texas, with minorities and those who fall below the poverty level comprising of 32% and 12%, respectively (Ziliak & Gundersen, 2009). In Texas, the Austin-San Marcos metropolitan area is expected to experience the largest projected growth of adults over 60. Therefore, it is vital to address the need for food assistance and the nutrition health of these individuals. MOWAM of Austin, TX serves over 2,000 homebound individuals each day. More than half live alone and approximately 90% live below 200% of the federal poverty line. To date, there has not been a formal evaluation of the effect that this HDM program has on nutrition status among its participants. This evaluation is necessary in order to address programmatic improvements that might be needed to improve the nutritional health of its participants. Therefore, the purpose of this project is to determine if nutrition status of MOWAM participants improves, if nutrient intake changes, and if nutrient intake affects nutrition status. MOWAM has recently elected to use the MNA-SF V2 in conjunction with the NSI Checklist for nutrition screening of recipients. For this pilot, we propose to administer both the NSI Checklist and the MNA-SF V2 (as per usual) along with a validated food frequency questionnaire to a subset of clients at baseline and after 3 months of receipt of MOWAM meals in order to determine if the data produced by any of these instruments change from pre-test to post-test. Based on the literature to date, we predict that the results of the NSI Checklist will minimally change. We anticipate that the results of the MNA-SF V2 and food frequency questionnaire will reveal positive changes in nutrition risk/malnourishment and dietary intake.

Objectives/Specific Aims

The aims of this study are to determine whether we can detect measurable differences in nutrition risk/dietary intake of participants in MOWAM at baseline and after 3 months of participating in the program using: (1) a Block Food Frequency Questionnaire (FFQ); (2) the Nutrition Screening Initiative (NSI) "DETERMINE your Health Checklist; and (3) the Mini Nutritional Assessment Short Form Version 2 (MNA-SF V2).

Based on previous research, we hypothesize that:

1. After 3 months of participation in MOWAM, participants will consume more of the following nutrients: protein, beta carotene, thiamin, riboflavin, niacin, B6, B12, folate, vitamins C, D, E, calcium, iron, potassium, magnesium, zinc, fiber and less sodium, as evidenced by estimated nutrient intake analyses provided by the pre and post FFQ.
2. After 3 months of participation in MOWAM, participants will consume more of the following nutrient-dense food groups: Dairy, Protein-rich foods (legumes, fish, and lean meats), Fruits, Vegetables, and less Foods of Minimal Nutritional Value (FMNV) as measured by servings of Fats, Oils, Sugar, and Sodas provided in the FFQ analysis.
3. After 3 months of participating in MOWAM, nutrition status will improve as measured by the MNA-SF V2.
4. After 3 months of participating in MOWAM, nutrition status will improve as measured by the NSI Checklist.

5. The MNA-SF V2 will be a more sensitive indicator of measured change in nutrition status as evidenced by the MNA-SF V2 demonstrating more nutrition status category changes than the NSI Checklist from baseline to 3 months.

To our knowledge, this will be the first study to 1) compare nutrient intake from baseline (before meals) to follow up (after meals) using the same subjects, and 2) use the MNA-SF V2 to assess change in nutrition status among HDM participants. The results of the proposed research will provide preliminary data that will demonstrate whether the program effectively contributes to dietary nutrient intake of its participants. In addition, if the MNA-SF V2 is more effective than the NSI Checklist, it may be used to target the limited resources of local HDM programs to those in most need. Other HDM programs nationwide could also use the MNA-SF V2 to better identify malnourished elderly. Results reflecting improved nutrition status as a result of HDM can also be used to justify continued and/or increased funding for HDM programs across the nation in effort to increase the longevity and quality of life of homebound elderly.

CHAPTER II

MANUSCRIPT

Introduction

Home Delivered Meal (HDM) programs were established in 1978 as part of the US Elderly Nutrition Program (ENP) to reduce hunger and food insecurity in homebound older adults (Colello, 2010). Additionally, according to the Administration on Aging (AoA), the HDM program is often the first in-home community service provided to an older adult, and may generate crucial additional services, such as nutritional assessment, screening and health referrals (AoA, 2012). Since ENP's inception, HDM programs have experienced marked growth. For example, from 1990 to 2008, the number of HDM meals served to older adults across the US increased by 44%. In 2008, 146.4 million meals were delivered to approximately 910,000 participants (Colello, 2010). The number of older adults needing HDM services will increase along with growth of the older US adult population, which is predicted to double between 2000 and 2030 (DHHS, 2010; & U.S. Census Bureau, 2010; CDC, 2003).

Given the pending challenges, it is paramount that HDM programs are able to quickly and accurately assess nutrition status, both to identify individuals at the greatest risk for malnourishment and to evaluate whether participation in the program improves diet and health. Nutrition assessment is typically conducted using a screening tool.

Optimally, a screening tool is easy to implement in the home setting, requires minimal expertise by HDM staff, and accurately informs the program. While several screening tools have been developed, the tool most commonly used in HDM programs, the Nutrition Screening Initiative "DETERMINE your Health Checklist" (NSI Checklist), inaccurately identifies the extent of malnourishment, overestimates nutritional risk, and has not been effectively validated in older adults (Phillips, Foley, Barnard, Isenring, & Miller, 2010; Sinnett et al., 2010; Quigley, Hermann, & Warde, 2008; Charlton, Kolbe-Alexander, & Nel, 2007; Marshal, Stumbo, Warren, & Xie, 2001; MacLellan & Van Til, 1998; Coulston, Craig, & Voss, 1996). An alternative tool, the Mini Nutritional Assessment (MNA) has been extensively tested for reliability and validity and is accepted as the only screening tool specific to those 65 years of age and older (Green & Watson, 2006; Sieber, 2006; Guigoz et al., 1996). However, the length and complexity of the original, full length MNA has made it difficult to administer in the field. A short form of the MNA, the MNA-SF, was developed and validated against the MNA as a quick screening tool that can be easily used in community settings (Rubenstein et al., 2001). A recent modification of the MNA-SF includes only five questions and a single anthropometric measure – either body mass index or calf circumference (Kaiser et al., 2009). As a validated screening instrument that is easy to implement in a community setting, the MNA-SF may be more appropriate than the NSI Checklist to assess nutrition status of applicants and participants. At present, no studies have compared the NSI Checklist, which is commonly in use despite numerous shortcomings, and the MNA-SF in an HDM program.

Another important way to evaluate HDM programs is to directly assess their impact on nutrition. While many studies have reported nutrient intake of individuals participating in HDM programs, most have assessed intake by comparing to dietary standards, without employing a baseline assessment or control (Dasgupta et al., 2005; Krondl et al., 2003; Sharkey et al., 2003; Sharkey, 2003; Sharkey et al., 2002; Lokken et al., 2002). Some researchers have compared nutrient intake of participants to that of non-participating controls (Frongillo & Wolfe 2010; Roy & Payette, 2006; Millen, Ohls, Ponza, McCool, 2002), or compared nutrient intake of participants on meal delivery days to their intake on non-delivery days (Frongillo & Wolfe 2010; AoA, 2004). To our knowledge, no studies have used a pre-test/posttest design to compare overall nutrient intake of HDM clients while receiving meals to their intake before participating in the program (Sharkey, 2004a; Sharkey & Haines, 2002; Lokken et al., 2002; Melnik, Coulston et al., 1996; Herndon, 1995; Helferd, Firmer, & Wales, 1994).

Meals on Wheels and More (MOWAM), the HDM program in Austin, TX, currently serves approximately 3,000 people per year. Since the population of adults over the age of 55 is growing more rapidly in Austin than in any other metropolitan region in the nation (Frey, 2011), it is crucial for MOWAM to evaluate its program to maximize efficiency. To date, like many HDM programs, MOWAM has been using the NSI Checklist to screen applicants at baseline and again after a year of participation. Unfortunately, applicants have most often been classified as “high risk” by the NSI Checklist, preventing MOWAM staff from identifying which applicants are at greatest risk. Recently, the director of nutrition services at MOWAM began using the MNA-SF along with the NSI Checklist. The purpose of this study was to determine: (1) which

assessment tool, the NSI Checklist or the MNA-SF, provided the most reliable data for nutritional screening among MOWAM participants; (2) whether participation in the program for a period of 3 months improved the nutrition status of participants according to both screening tools; and (3) whether overall dietary intake of clients improved after participation in the program for 3 months.

Methods

Design. This study used a quasi-experimental design. New MOWAM clients who volunteered to participate were followed for 3 months. A one-group pretest-posttest was used to assess nutrient status and food and nutrient intake. This study was approved by the Texas State University-San Marcos Institutional Review Board (IRB) and was compliant with all IRB guidelines.

Procedures. Researchers accompanied HDM staff to the first home visit of MOWAM applicants who had been previously screened for eligibility via telephone. Clients over the age of 65 and free of cognitive impairment were invited to participate in the study after they completed the usual intake assessments, including the NSI Checklist and MNA-SF nutrition status screening tools. After obtaining informed consent, researchers administered the Block Brief 2000 food frequency questionnaire (FFQ) to a total of 47 newly enrolled subjects. Approximately three months after meal service began, researchers collected posttest data from 40 subjects during follow-up home visits. Approximately two months later, an exploratory post-hoc survey was administered by telephone to subject participants.

Instruments. The 10-item Nutrition Screening Instrument Checklist (NSI Checklist) was used to assess nutrition status. NSI Checklist questions ask for yes/no

answers about the presence of illness or conditions that change the kind and/or amount of food eaten, frequency of fruit, vegetable, and milk consumption, intake of less than two meals/day, presence of tooth or mouth problems that interfere with eating, difficulty buying food due to lack of money, alcohol and prescription drug use, eating alone, unintentional weight loss or gain, and physical disabilities affecting shopping, cooking and self-feeding (White et al., 1992). Points for responses to each question were totaled to indicate "good", "moderate-risk" or "high-risk" nutrition status. Reliability of the NSI Checklist in this sample was assessed at pre-test and post-test, with Cronbach's alpha values of .176 and .355, respectively. Cronbach's alpha for a larger sample of MOWAM participants (n = 933) was .166. Pearson's correlation revealed that nutrition status per the NSI Checklist at follow-up was significantly correlated to status at baseline, $N = 40$, $r = .40$, $p < .05$.

The Mini Nutrition Assessment Short-Form (MNA-SF), a 5-item questionnaire that includes a calf circumference measurement, was used to assess nutrition status. Multiple-choice questions in the MNA-SF address food intake, weight loss, presence of acute disease, and psychological stress over the past three months, and also ask about mobility and depression. Given that the original MNA-SF questions were originally developed by medical professionals and included technical jargon, this study employed a simplified script as per the Nestle Nutrition Institute's MNA-SF Guide. Points from question responses and the calf circumference measurement were summed to categorize nutrition status as "normal", "at risk for malnutrition", or "malnourished". The MNA-SF has been previously validated for adults 65 years of age and older (Kaiser et al., 2009). Reliability of the MNA-SF was assessed at baseline and follow-up, with Cronbach's

alpha values of .422 and .044, respectively. Cronbach's alpha for a larger sample of MOWAM participants (n = 933) was .488. Pearson's correlation revealed that nutrition status per the MNA at follow-up was significantly correlated to status at baseline, $N = 40$, $r = .34$, $p < .05$.

The 92-question Block Brief 2000 Food Frequency Questionnaire (FFQ) was used to estimate food and nutrient intake. *Nutrition Quest* analyzed response forms and provided intake data for 28 nutrients and food groups. Food groups included dairy, protein-rich foods (dairy, meat and legumes), fruits, vegetables, fats, oils, sweets and sodas.

An exploratory post-hoc survey was administered by phone approximately 2 months after follow-up data collection. To assess whether eating practices were affected by participation, clients were asked if they liked the HDM meals, how much of the meals they usually ate, and whether the amount of food they usually consumed had changed. They were also asked whether the amount of food they were receiving from other sources had changed, and whether the amount of money they were spending on food had changed.

Statistical analysis. All statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS, version 20.0, 2011). Subjects' intake of nutrients and food groups before and after receiving HDM meals were compared using paired sample t-tests. Nutrition status as determined using the NSI Checklist and MNA-SF were compared using chi-square analysis. Effect size was determined using Cramer's V. Cramer's V $\geq$ .35 denoted large effect size for crosstabs larger than 2X2; Cramer's V $\geq$ .50 denoted large effect size for smaller crosstabs (Cohen, 1988).

Results

Subjects. Of the 47 subjects who completed baseline data collection, 7 dropped out due to hospitalization, discontinuation of meal service, or unwillingness to continue. Data from the remaining 40 subjects who completed the follow up assessment were included in analyses (see Table 1). The sample was predominantly female (77.5%) and 40.0% were white, 37.5% African American, 20.0% Hispanic, and 2.5% Native American. Participants ranged in age from 65 to 96, with a mean age of 75.28 ± 6.60. Household monthly income ranged from $606 to $5907, with a mean income of $1466 ± 962.40. Over half of the subjects lived alone.

Nutrition status. A chi-square test revealed a pre/post significant difference in nutrition status as determined by the NSI Checklist (X^2 (2, N = 40) = 7.435, $p < .05$), with a medium effect size (crosstab 2X3, Cramer's V = .431). There was also a pre/post significant difference in nutrition status as determined by the MNA-SF (X^2 (4, N = 40) = 14.723, $p < .01$), with a large effect size (crosstab 3X3, Cramer's V = .429; see Table 2). According to the NSI Checklist, 77.5% (n = 31) of the total sample was in the "high risk" category at baseline and 25 were in this category at follow-up. In contrast, per the MNA-SF, the nutrition status of 32.5% (n = 13) of the total sample was classified as "malnourished" at baseline, while only 3 were in the malnourished category at follow-up. According to the NSI Checklist, no participants were classified as "good" at baseline, and 2 were so categorized at follow-up. According to the MNA-SF, 20% (n = 8) of the total sample was classified as "normal" at baseline and 47.5% (n = 19) was normal at follow-up.

Relationships between instrument items and nutrition status are included in Table 3. In the larger sample (n = 933), 9 of 10 items in the NSI Checklist were significantly correlated with nutrition status, but only one item, not having enough money for food, was strongly correlated with status. While all items in the MNA-SF were significantly correlated with nutrition status, 3 items, including recent decline in food intake, unintended weight loss, and calf circumference, were strongly correlated with nutrition status.

Nutrient and food group intake. Mean differences in food and nutrient intake are reported in Table 4. Between baseline and follow-up, significant decreases were found in intakes of vitamin D (M = 87.90 IU, SD = 208.78), t(39)= 2.66, $p < 0.05$, total fat (M = 14.30 g, SD = 38.61), t(39) = 2.35, $p < .05$, saturated fat (M = 5.52 g, SD = 12.85), t(39) = 2.72, $p < .05$, monounsaturated fat (M = 6.30, SD = 15.78), t(39) = 2.51, $p < .05$, percent calories from fat (M = 2.70, SD = 6.83), t(39) = 2.47, $p < .05$, and percent calories from sweets/desserts (M = 4.50, SD = 12.18), t(39) = 2.35, $p < .05$. Significant increases were found in intakes of beta-carotene (M = -1131.45 µg, SD = 2817.75), t(36) = -2.44, $p < .05$, and percent calories from protein (M = -1.40, SD = 3.42), t(39) = -2.51, $p < .05$. Partial correlations conducted to control for age, household size, and income on intake of each nutrient and food group revealed no influence.

Post-hoc survey. Thirty participants completed the post hoc survey. Others could not be reached due to discontinued phone service (n = 2), no answer after multiple calls (n = 3), deceased (n = 4), or admitted to a nursing home (n = 1). The majority of respondents reported liking the meals (n = 28) and consuming all (n = 25) or most (n = 4) of the meals. Most (n = 18) reported spending less on food while receiving meals. Some

reported reduced or discontinued food assistance from family or friends (n = 6), and eating out less often (n = 5). Seven reported skipping meals less often and 13 reported eating less fast food since receiving meals. Of the 7 participants with low follow-up intake of protein (≤ 56 g/d for men and ≤ 46 g/d for women) and/or kcalories (≤ 2000 kcal for men and ≤ 1600 kcal for women), all reported liking the meals and consuming the entire meal (United States Department of Agriculture Center for Nutrition Policy and Promotion, 2011). Of those who died after follow-up, all had adequate intake of protein and kcalories at baseline and 2 had decreased intake of protein and kcalories at follow-up.

Discussion

To our knowledge, this is the first study to compare the practical use of the NSI Checklist and the MNA-SF in a HDM program. We were prompted to investigate these tools because the NSI Checklist, mandated for many HDM programs, had routinely categorized most MOWAM applicants as high risk, making it difficult for us to evaluate applications. When administered to 933 MOWAM clients, the alpha coefficients for the NSI Checklist and the MNA-SF were well below the accepted .7 cut-off for reliability, which was not surprising since reliability scores are generally lower when scales include few items (e.g. less than 10) (Palent, 2010; Urdan, 2010). Upon further investigation using Pearson's correlation, pre- and posttest nutrition status determined by both instruments was significantly correlated, providing some measure of confidence in the results. According to the NSI Checklist, most (31) of the 40 subjects were at high risk at baseline and also after 3 months of participating in MOWAM (25). These results are in line with the tendency of this instrument to overestimate nutritional risk and provide low specificity (Coulston et al., 1996). Given these results, the NSI Checklist may indeed be

more effective as an awareness/education tool instead of as a diagnostic tool for use in HDM programs (Sayhoun et al., 1997).

The MNA-SF more evenly distributed clients into risk categories at baseline and revealed a greater degree of improvement following participation in the program. Specifically, there were 13 in the malnourished category at baseline and only 3 classified as malnourished at follow-up. These results are more useful to MOWAM staff, especially since research more strongly supports the full MNA and MNA-SF. Specifically, the full MNA has been validated among older adults and has exhibited high sensitivity (Guigoz et al., 1996; Guigoz, Vellas, & Garry, 1994), and the MNA-SF has similarly generated results with high specificity and sensitivity and diagnostic accuracy (Kaiser et al., 2009; Cuervo et al., 2008; Wikby et al., 2008; Rubenstein et al., 2001).

Previous studies have compared the NSI Checklist to the full MNA, but not to the MNA-SF. De Groot, Beck, Schroll, and Staveren (1998) concluded that neither the NSI Checklist nor the MNA was useful when used in a healthy older adult population and suggested the need for further studies. More recently, Charlton, Kolbe-Alexander, and Nel (2007) found that the full MNA was more appropriate for use in identifying nutrition risk in the elderly because they found a significant and positive association between the full MNA and anthropometric measures. Their results suggested that the NSI Checklist had low specificity, in that it did not correctly identify those who were not at risk, and also overestimated nutrition risk.

Results of this study suggest that the quality of the diet of participants improved after receiving meals. The decrease in fat and sweets and increase in percent kcalories from protein may reflect less reliance on fast foods and packaged foods. Indeed, in the

post hoc survey, participants reported consuming fewer foods from other sources. It is important that family members be informed that meal recipients may need continued food assistance support.

There were several strengths of this study. Importantly, this study represents a union of practice and research, much needed among HDM programs. This may be the first HDM assessment to compare pre- and posttest dietary intake among the same subjects. Other studies have looked at the contribution of HDM meals to nutrient intake using 24-hour recalls, 7-day food records, and diet histories, including the delivered meal, but have not compared intake to baseline status prior to beginning meal services (Dasgupta et al., 2005; Krondl et al., 2003; Sharkey et al., 2003; Sharkey, 2003; Sharkey et al., 2002; Lokken et al., 2002; MacLellan, 1997; Herndon, 1995; Stevens, Grivetti, & McDonald, 1992; Bunker, Stansfield, & Blayton, 1986; Lipshitz, Mitchell, & Steele, 1985; Davies, Purves, & Holdsworth, 1981). An additional strength is the administration of the post hoc survey to assist researchers with evaluation of the results.

This study is not without limitations. Due to cost constraints, there were no objective measures of nutrition status to correlate to the changes in nutrition status. Another limitation was the use of a food frequency questionnaire in lieu of 24 hour recalls to assess dietary intake (Millen et al., 2002; Roy & Payette, 2006; Frongillo & Wolfe, 2010). While the Block Brief FFQ was chosen to make it easier to administer to homebound clients (compared to using several 24 hour recalls), results of food frequency questionnaires may be less accurate due to fatigue and differences in usual portion size of older adults (Shahar et al., 2003).

In conclusion, results of this study suggest that the MNA-SF was more useful than the NSI Checklist when assessing nutrition status in homebound applicants to MOWAM. The MNA-SF takes very little time to administer and briefly trained HDM staff were comfortable taking the calf circumference measurement. Given the limited resources available to HDM agencies, the MNA-SF may be more effective at identifying those at greatest nutrition risk so they can be given priority for HDM services.

TABLE 1: Demographic Characteristics of Meals on Wheels and More Participants (*N*=40)

	n	%
Gender		
Male	9	22.5
Female	31	77.5
Age		
65-74	19	47.5
75-84	20	50
85-94	0	0
95-100	1	2.5
Ethnicity		
White	16	40
Hispanic	8	20
Black/African American	15	37.5
Native American	1	2.5
Household Size		
1	23	57.5
2	10	25
3	3	7.5
4	2	5
5	2	5
Monthly Income		
<$1,000	13	32.5
$1,000-$2,000	20	50
$2,000-$3,000	5	12.5
$3,000-$4,000	1	2.5
$4,000-$5,000	0	0
$5,000-$6,000	1	2.5

TABLE 2: Chi-square Analysis of Nutrition Status Change using the MNA-SF and NSI Checklist Screening Instruments Prior to and 3 Months after Participation in Meals on Wheels and More (*N*=40)

		MNA-SF[1]					NSI Checklist[2]		
		Follow-up					Follow-up		
		Malnourished	At risk	Normal			High Risk	Moderate Risk	Good
Baseline Status	**n**	**n (%)**	**n (%)**	**n (%)**	**Baseline Status**	**n**	**n (%)**	**n (%)**	**n (%)**
Malnourished	13	3 (23)	4 (30.8)	6 (46.2)	High Risk	31	25 (80.6)	5 (16.2)	1 (3.2)
At risk	19	0 (0)	13 (68.4)	6 (31.6)	Moderate risk	9	3 (33.3)	5 (55.6)	1 (11.1)
Normal	8	0 (0)	1 (12.5)	7 (87.5)	Good	0	-	-	-
Total	40	3 (7.5)	18 (45)	19 (47.5)	Total	40	28 (70)	10 (25)	2 (5)

At baseline, Cronbach's alpha (6 items) = 0.422; Inter-item Correlation Mean = 1.438 (.850 to 2.400); at follow-up, Cronbach's alpha = 0.044; Inter-item Correlation Mean = 1.817 (1.300 to 2.550); Overall change: (X^2 (4, N=40) = 14.723, p< .01).

At baseline, Cronbach's alpha (10 items) = 0.176; Inter-item Correlation Mean = .976 (.300 to 1.700); at follow-up, Cronbach's alpha = 0.355; Inter-item Correlation Mean = .869 (.250 to 2.00); Overall change: (X^2 (2, N=40) = 7.435, p< .05).

TABLE 3: Relationship between Instrument Items and Nutrition Status for MNA-SF and NSI Checklist among Meals on Wheels and More Participants Based on Pearson Correlation

	Nutrition Status		
	Baseline	Follow-up	MOWAM
	N=40	*N*=40	n=933
MNA – SF	(r)	(r)	(r)
Food intake declined over past 3 m	.54***	.43**	.53***
Weight loss during last 3 m	.78***	.44**	.65***
Mobility	ns	.48**	.36***
Psychological stress/acute disease past 3 m	.51**	ns	.46***
Neurological problems	.47**	.38*	.48***
Calf circumference measurement low	ns	.38*	.54***
Follow-up status	.34*	ns	ns
NSI Checklist			
Illness make me change amount of food I eat	.43**	ns	.33***
Eat < 2 meals/d	ns	ns	.42***
Eat few fruits/vegetable/milk products	ns	ns	.38***
Drink 3+ alcoholic beverages/d	ns	ns	ns
Tooth/mouth problems	ns	.41**	.44***
Money for food limited	.44**	.52**	.59***
Eat alone	ns	ns	.21***
3+ drugs/ medications/d	ns	.46**	.20***
Unintentional 10 LB. weight change in 6 m	.40*	ns	.39***
Inability shop/prepare food	ns	ns	.11**
Follow-up status	.40*	ns	ns

Significance: *$p < .05$ **$p < .01$ ***$p < .001$, ns = not significant.

TABLE 4: Nutrient and Food Intake Differences at Baseline and 3 months after Participation in Meals on Wheels and More (*N* = 40)

	Mean Difference	SD	*p* value	% (*n*) of participants met/exceed RDA	
Nutrients				Baseline	Follow Up
Kcalories	234.96	872.42	0.099	****47.5% (19)	****40% (16)
Protein	3.09	26.65	0.468	82.5% (33)	72.5% (29)
Fat	14.30	38.61	* 0.024	ND	ND
Saturated fat	5.52	12.85	* 0.010	ND	ND
Monounsaturated fat	6.30	15.78	* 0.016	ND	ND
Polyunsaturated fat	1.67	9.32	0.264	ND	ND
Carbohydrate	24.30	124.49	0.255	75% (30)	72.5% (29)
Calcium	111.70	439.85	0.116	20% (8)	15% (6)
Phosphorus	110.70	496.34	0.166	85% (34)	82.5% (33)
Sodium	294.50	991.60	0.068	***87.5% (35)	***80% (32)
Potassium	-3.95	982.22	0.980	***7.5% (3)	***10% (4)
Iron	0.62	6.23	0.535	77.5% (31)	67.5% (27)
Magnesium	17.02	134.98	0.430	30% (12)	30% (12)
Zinc	0.86	4.80	0.262	57.5% (23)	55% (22)
Thiamin	0.074	0.55	0.395	70% (28)	62.5% (25)
Riboflavin	0.20	0.70	0.082	82.5% (33)	80% (32)
Niacin	0.92	8.23	0.485	67.5% (27)	47.5% (19)
Vitamin B12	1.60	6.36	0.111	87.5% (35)	85% (34)
Vitamin B6	-0.025	0.72	0.829	62.5% (25)	52.5% (21)
Folate	12.98	181.19	0.653	37.5% (15)	35% (14)
Vitamin A (IU)	-2342.80	10993.79	0.186	100% (40)	97.5% (39)
Vitamin C	-9.91	66.74	0.353	65% (26)	67.5% (27)
Vitamin E	1.19	5.47	0.178	10% (4)	10% (4)
Vitamin D	87.90	208.78	* 0.011	17.5% (7)	12.5% (5)
Vitamin K	-22.42	195.78	0.473	***65% (26)	***62.5% (25)
Beta Carotene	-1131.45	2817.75	* 0.020		
Fiber	-0.68	10.61	0.688	***20% (8)	***32.5% (13)
% kcal fat	2.70	6.83	* 0.018		
% kcal protein	-1.40	3.42	* 0.016		
% kcal carbohydrate	-1.25	7.80	0.319		
% kcal sweets	4.50	12.18	* 0.024		

TABLE 4 - Continued

	Mean Difference	SD	*p* value	% (*n*) of participants met/exceed RDA
Food				
Vegetable servings	-0.40	3.38	0.458	
Fruit frequency	-0.11	0.85	0.397	
Protein servings	0.02	0.92	0.895	
Dairy servings	0.24	1.44	0.305	
Fat servings	3.80	1.46	0.105	

* $p < 0.05$; df = 39
** Beta Carotene significant results after outliers removed (df = 36, $N = 37$)
*** Adequate Intakes (AI) as no EAR/RDA has been established for nutrient
**** Kcalorie values determined by Dietary Guidelines for Americans 2012 for sedentary men (<2000)/ women (< 1600) 51+
Fruit frequency = Daily frequency of fruits & fruit juices
Protein servings = Daily servings of meat, fish, poultry, beans, eggs
Fat servings = Daily servings of fats & oils, sweets, sodas

APPENDIX

NUTRITION SCREENING INSTRUMENTS

Nutrition Screening Initiative “DETERMINE your Health Checklist” (NSI Checklist)

Mini Nutritional Assessment (MNA)

MNA-SF Version 2 (MNA-SF V2)

Consent Form to Participate in Research

MNA-SF Interview Script

MNA-SF Guide

Block Brief 2000 Food Frequency Questionnaire

Post Hoc Survey

Determine Your Nutritional Health

The Warning Signs of poor nutritional health are often overlooked. Use this checklist to find out if you or someone you know is at nutritional risk.

Read the statements below. Circle the number in the yes column for those that apply to you or someone you know. For each yes answer, score the number in the box. Total your nutritional score.

	Yes
I have an illness or condition that made me change the kind and/or amount of food I eat.	2
I eat fewer than 2 meals per day.	3
I eat few fruits or vegetables, or milk products.	2
I have 3 or more drinks of beer, liquor, or wine almost everyday.	2
I have tooth or mouth problems that make it hard for me to eat.	2
I don't always have enough money to buy the food I need.	4
I eat alone most of the time.	1
I take 3 or more different prescribed or over-the-counter drugs a day.	1
Without wanting to, I have lost or gained 10 pounds in the last 6 months.	2
I am not always physically able to shop, cook, and/or feed myself.	2
TOTAL	

Total your nutrition score.

0-2 **Good!** Recheck your nutritional score in 6 months.

3-5 **You are at moderate nutritional risk.** See what you can do to improve your eating habits and lifestyle. Your office on aging, senior nutrition program, senior citizens center, or health department can help. Recheck your nutrition score in 3 months.

6+ **You are at high nutritional risk**. Bring this checklist the next time you see your doctor, dietitian, or other qualified health care or social service professional. Talk with them about any problems you may have. Ask for help to improve your nutritional risk.

Remember: Warning signs suggest risk, but do not represent diagnosis of any condition.

Materials developed and distributed by the Nutrition Screening Initiative, a project of: AMERICAN ACADEMY OF FAMILY PHYSICIANS, THE AMERICAN DIETETIC ASSOCIATION, and NATIONAL COUNCIL ON AGING, INC.

Nestlé Nutrition Institute

Mini Nutritional Assessment MNA®

Last name: First name:

Sex: Age: Weight, kg: Height, cm: Date:

Complete the screen by filling in the boxes with the appropriate numbers. Add the numbers for the screen. If score is 11 or less, continue with the assessment to gain a Malnutrition Indicator Score.

Screening

A Has food intake declined over the past 3 months due to loss of appetite, digestive problems, chewing or swallowing difficulties?
0 = severe decrease in food intake
1 = moderate decrease in food intake
2 = no decrease in food intake ☐

B Weight loss during the last 3 months
0 = weight loss greater than 3kg (6.6lbs)
1 = does not know
2 = weight loss between 1 and 3kg (2.2 and 6.6 lbs)
3 = no weight loss ☐

C Mobility
0 = bed or chair bound
1 = able to get out of bed / chair but does not go out
2 = goes out ☐

D Has suffered psychological stress or acute disease in the past 3 months?
0 = yes 2 = no ☐

E Neuropsychological problems
0 = severe dementia or depression
1 = mild dementia
2 = no psychological problems ☐

F Body Mass Index (BMI) (weight in kg) / (height in m²)
0 = BMI less than 19
1 = BMI 19 to less than 21
2 = BMI 21 to less than 23
3 = BMI 23 or greater ☐

Screening score ☐☐
(subtotal max. 14 points)

12-14 points: Normal nutritional status
8-11 points: At risk of malnutrition
0-7 points: Malnourished

For a more in-depth assessment, continue with questions G-R

Assessment

G Lives independently (not in nursing home or hospital)
1 = yes 0 = no ☐

H Takes more than 3 prescription drugs per day
0 = yes 1 = no ☐

I Pressure sores or skin ulcers
0 = yes 1 = no ☐

J How many full meals does the patient eat daily?
0 = 1 meal
1 = 2 meals
2 = 3 meals ☐

K Selected consumption markers for protein intake
- At least one serving of dairy products (milk, cheese, yoghurt) per day yes ☐ no ☐
- Two or more servings of legumes or eggs per week yes ☐ no ☐
- Meat, fish or poultry every day yes ☐ no ☐

0.0 = if 0 or 1 yes
0.5 = if 2 yes
1.0 = if 3 yes ☐.☐

L Consumes two or more servings of fruit or vegetables per day?
0 = no 1 = yes ☐

M How much fluid (water, juice, coffee, tea, milk...) is consumed per day?
0.0 = less than 3 cups
0.5 = 3 to 5 cups
1.0 = more than 5 cups ☐.☐

N Mode of feeding
0 = unable to eat without assistance
1 = self-fed with some difficulty
2 = self-fed without any problem ☐

O Self view of nutritional status
0 = views self as being malnourished
1 = is uncertain of nutritional state
2 = views self as having no nutritional problem ☐

P In comparison with other people of the same age, how does the patient consider his / her health status?
0.0 = not as good
0.5 = does not know
1.0 = as good
2.0 = better ☐.☐

Q Mid-arm circumference (MAC) in cm
0.0 = MAC less than 21
0.5 = MAC 21 to 22
1.0 = MAC 22 or greater ☐.☐

R Calf circumference (CC) in cm
0 = CC less than 31
1 = CC 31 or greater ☐

Assessment (max. 16 points) ☐☐.☐

Screening score ☐☐.☐

Total Assessment (max. 30 points) ☐☐.☐

Malnutrition Indicator Score

24 to 30 points	☐	normal nutritional status
17 to 23.5 points	☐	at risk of malnutrition
Less than 17 points	☐	malnourished

Ref. Vellas B, Villars H, Abellan G, et al. *Overview of MNA® - Its History and Challenges.* J Nut Health Aging 2006; 10: 456-465.
Rubenstein LZ, Harker JO, Salva A, Guigoz Y, Vellas B. Screening for Undernutrition in Geriatric Practice: *Developing the Short-Form Mini Nutritional Assessment (MNA-SF).* J. Geront 2001; 56A: M366-377.
Guigoz Y. The Mini-Nutritional Assessment (MNA®) *Review of the Literature – What does it tell us?* J Nutr Health Aging 2006; 10: 466-487.

For more information: www.mna-elderly.com

Nestlé Nutrition Institute

Mini Nutritional Assessment MNA®

Last name: First name:

Sex: Age: Weight, kg: Height, cm: Date:

Complete the screen by filling in the boxes with the appropriate numbers. Total the numbers for the final screening score.

Screening

A Has food intake declined over the past 3 months due to loss of appetite, digestive problems, chewing or swallowing difficulties?
0 = severe decrease in food intake
1 = moderate decrease in food intake
2 = no decrease in food intake ☐

B Weight loss during the last 3 months
0 = weight loss greater than 3 kg (6.6 lbs)
1 = does not know
2 = weight loss between 1 and 3 kg (2.2 and 6.6 lbs)
3 = no weight loss ☐

C Mobility
0 = bed or chair bound
1 = able to get out of bed / chair but does not go out
2 = goes out ☐

D Has suffered psychological stress or acute disease in the past 3 months?
0 = yes 2 = no ☐

E Neuropsychological problems
0 = severe dementia or depression
1 = mild dementia
2 = no psychological problems ☐

F1 Body Mass Index (BMI) (weight in kg) / (height in m^2) ☐
0 = BMI less than 19
1 = BMI 19 to less than 21
2 = BMI 21 to less than 23
3 = BMI 23 or greater ☐

IF BMI IS NOT AVAILABLE, REPLACE QUESTION F1 WITH QUESTION F2.
DO NOT ANSWER QUESTION F2 IF QUESTION F1 IS ALREADY COMPLETED.

F2 Calf circumference (CC) in cm
0 = CC less than 31
3 = CC 31 or greater ☐

Screening score ☐☐
(max. 14 points)

12-14 points: ☐ Normal nutritional status
8-11 points: ☐ At risk of malnutrition
0-7 points: ☐ Malnourished

Ref. Vellas B, Villars H, Abellan G, et al. *Overview of the MNA® - Its History and Challenges.* J Nutr Health Aging 2006;10:456-465.
Rubenstein LZ, Harker JO, Salva A, Guigoz Y, Vellas B. *Screening for Undernutrition in Geriatric Practice: Developing the Short-Form Mini Nutritional Assessment (MNA-SF).* J. Geront 2001;56A: M366-377.
Guigoz Y. *The Mini-Nutritional Assessment (MNA®) Review of the Literature - What does it tell us?* J Nutr Health Aging 2006; 10:466-487.
Kaiser MJ, Bauer JM, Ramsch C, et al. *Validation of the Mini Nutritional Assessment Short-Form (MNA®-SF): A practical tool for identification of nutritional status.* J Nutr Health Aging 2009; 13:782-788.

For more information: www.mna-elderly.com

IRB #2011V883

Consent Form to Participate in Research

Title: The Effect of Participation in Meals on Wheels and More (MOWAM) in Austin, TX, on Dietary Intake and Health Status of Participants

Principal Investigator and Contact Information:

Texas State University – School of Family & Consumer Sciences

- Dr. BJ Friedman, RD, Professor
  Phone: 512-245-8342 Email: bfriedman@txstate.edu
- Dr. Sylvia Crixell, RD, Professor
  Phone: 512-245-2155 Email: scrixell@txstate.edu
- Seanna Marceaux, RD, Graduate Student and Director of Nutrition Services at MOWAM **Phone: 512-628-8150** Email: sm34601@txstate.edu

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Information

We are inviting you to participate in a research project for Meals and Wheels and More in Austin (MOWAM). This form gives you information about the research project. Please read this form and ask questions about anything you do not understand before you decide if you want to participate. You will get a copy of this form to keep.

Why are we asking you to help in this research project?

We are asking you because you have just completed your "Initial Assessment" for the Meals on Wheels and More (MOWAM) Program and you are at least 65 years of age.

Your participation in this study is voluntary – that means you are volunteering to help, and can stop at any time. Participation in this study will not affect your current participation or future services from MOWAM.

Why are we doing this research study?

The reason for this study is to learn about what foods you and other participants of MOWAM usually eat, both before and after participating in MOWAM.

How many people will be involved?

There will be between 150 and 200 clients of MOWAM in Austin, TX taking part in this

study.

What will happen if you help us in this research study?

1. Today, once you have completed the "Initial Assessment" for Meals and Wheels and More (MOWAM), we will ask you extra questions (92 questions) about your usual food intake. This should take about 20 minutes.

2. In approximately 3 months we will call to schedule another visit. During the visit, we will ask some of the same questions we asked today. We will also ask the same 92 questions about your usual food intake.

What are the possible risks?

- There are no known risks in this study.

What are the possible benefits to you or to other people?

- The knowledge gained from this study will help MOWAM learn about how well the program works and make improvements.
- Would you like us to tell you about the results of this study after it is done? __Yes. __No.
- If yes, should we ___email, ___mail or ___call you?

How will we protect your privacy and your records?

- The information about your diet will be kept at MOWAM along with your usual records. Paper records will be kept in a locked file cabinet, and electronic records will be kept on a secure computer.
- The secure computer is password protected.
- Only the Director of Nutrition Services at MOWAM and the research investigators will be able to study the diet and health information collected in this research project.
- If the results of this research study are published or presented at MOWAM or at a scientific meeting, we will not identify any person who participated in the study.
- Records will be kept in a locked file and shredded January 2014.

Will the researchers get anything from your help in this study?

The researchers will benefit from the study because they will learn more about how MOWAM helps participants. They may also publish the results of the study in a journal article or present the results to others interested in MOWAM.

Will you receive compensation for your participation in this study?
Participants will not receive compensation for participating in this study.

If you have any questions about this study

- You can ask any questions about this study to Texas State Professors (Dr. BJ Friedman and Dr. Sylvia Crixell) or the Director of Nutrition Services at MOWAM (Ms. Seanna Marceaux). Contact information is at the top of this form.
- If you have any concerns, you can contact the Texas State University Institutional Review Board chair, Dr. Jon Lasser [(512) 245-3413, lasser@txstate.edu] or compliance specialist, Ms. Becky Northcut [(512) 245-2314].

What if you don't want to continue in the study?

- If you decide to help in this study, it is on a volunteer basis.
- You have the right to refuse to be in this study.
- You can stop at any time after giving your consent. This decision will not affect in any way your current or future status with Meals on Wheels and More or Texas State University.

We will give you a copy of this consent form to keep.

If you're willing to volunteer for this research, please sign below.

Statement of Consent:
I have read the above information and clearly understand my role as a participant in the study. I have asked questions and have received answers. I, _____, consent to participate in the study.

Signature: _____ Date: _____

Signature of Investigator: _____ Date: _____

MNA-SF Script

Script was written with guidance from the Nestle MNA-SF User Guide.

A. In the last 3 months, have you been eating less, more, or about the same amount of food? If less, is this because of a loss of appetite, digestive problems, chewing/swallowing difficulties? If less, have you been eating a lot less or just a little less?

B. In the last 3 months, have you lost any weight unintentionally? If yes, more or less than 6 pounds?

C. I see you are able to move around your home, are you able to go outside and do things such as shop, run errands?

D. In the last 3 months, have you had the flu, pneumonia, or an infection? Have you been in the hospital and for what reason (broken bones?, infection, etc.?)

   In the last 3 months, have you lost a loved one? Moved recently? Had any financial difficulties?

E. Have you been feeling 'down' or sad?

Mr./Mrs. XXXXX, as part of the way MOWAM makes sure you are getting enough nutrition, we would like to measure your calf. The reason we do this is because when older adults don't get enough nutrition, they begin to lose muscle and the first place we usually lose muscle is in our calves. May I measure your calf muscle?

Screening (MNA®-SF)

Complete the screen by filling in the boxes with the appropriate numbers. Total the numbers for the final screening score.

Key Points

Ask the patient to answer questions A – F, using the suggestions in the shaded areas. If the patient is unable to answer the question, ask the patient's caregiver to answer or check the medical record.

A

Has food intake declined over the past three months due to loss of appetite, digestive problems, chewing or swallowing difficulties?

Score 0 = Severe decrease in food intake
1 = Moderate decrease in food intake
2 = No decrease in food intake

Ask patient or caregiver or check the medical record

- *"Have you eaten less than normal over the past three months?"*
- If so, *"is this because of lack of appetite, chewing, or swallowing difficulties?"*
- If yes, *"have you eaten much less than before or only a little less?"*

B

Involuntary weight loss during the last 3 months?

Score 0 = Weight loss greater than 3 kg (6.6 pounds)
1 = Does not know
2 = Weight loss between 1 and 3 kg (2.2 and 6.6 pounds)
3 = No weight loss

Ask patient / Review medical record

- *"Have you lost any weight without trying over the last 3 months?"*
- *"Has your waistband gotten looser?"*
- *"How much weight do you think you have lost? More or less than 3 kg (or 6 pounds)?"*

Though weight loss in the overweight elderly may be appropriate, it may also be due to malnutrition. When the weight loss question is removed, the MNA® loses its sensitivity, so it is important to ask about weight loss even in the overweight.

C

Mobility?

Score 0 = Bed or chair bound

1 = Able to get out of bed/chair, but does not go out

2 = Goes out

Ask patient / Review patient's medical record / Ask caregiver

- *"How would you describe your current mobility?"*
- *"Are you able to get out of a bed, a chair, or a wheelchair without the assistance of another person?" – if not, would score 0*
- *"Are you able to get out of a bed or a chair, but unable to go out of your home?" – if yes, would score 1*
- *"Are you able to leave your home?" – if yes, would score 2*

D

Has the patient suffered psychological stress or acute disease in the past three months?

Score 0 = Yes

2 = No

Ask patient / Review patient medical record / Use professional judgment

- *"Have you been stressed recently?"*
- *"Have you been severely ill recently?"*

E

Neuropsychological problems?

Score 0 = Severe dementia or depression

1 = Mild dementia

2 = No psychological problems

Review patient medical record / Use professional judgment / Ask patient, nursing staff or caregiver

- *"Do you have dementia?"*
- *"Have you had prolonged or severe sadness?"*

The patient's caregiver, nursing staff or medical record can provide information about the severity of the patient's neuropsychological problems (dementia).

F1

Body mass index (BMI)?
(weight in kg / height in m^2)

Score 0 = BMI less than 19
1 = BMI 19 to less than 21
2 = BMI 21 to less than 23
3 = BMI 23 or greater

Determining BMI

BMI is used as an indicator of appropriate weight for height (Appendix 1)

BMI Formula – US units

- BMI = (Weight in Pounds / [Height in inches x Height in inches]) x 703

BMI Formula – Metric units

- BMI = (Weight in Kilograms / [Height in Meters x Height in Meters])

1 Pound = 0.45 Kilograms
1 Inch = 2.54 Centimeters

Before determining BMI, record the patient's weight and height on the MNA® form.

1. If height has not been measured, please measure using a stadiometer or height gauge (Refer to Appendix 2).
2. If the patient is unable to stand, measure height using indirect methods such as measuring demi-span, arm span, or knee height. (See Appendix 2).
3. Using the BMI chart provided (Appendix 1), locate the patient's height and weight and determine the BMI.
4. Fill in the appropriate box on the MNA® form to represent the BMI of the patient.
5. To determine BMI for a patient with an amputation, see Appendix 3.

IF BMI IS NOT AVAILABLE, REPLACE QUESTION F1 WITH QUESTION F2.
DO NOT ANSWER QUESTION F2 IF QUESTION F1 IS ALREADY COMPLETED.

F2 Answer only if unable to obtain BMI.

Calf circumference (CC) in cm

0 = CC less than 31

3 = CC 31 or greater

Measuring Calf Circumference

1. The subject should be sitting with the left leg hanging loosely or standing with their weight evenly distributed on both feet.
2. Ask the patient to roll up their trouser leg to uncover the calf.
3. Wrap the tape around the calf at the widest part and note the measurement.
4. Take additional measurements above and below the point to ensure that the first measurement was the largest.
5. An accurate measurement can only be obtained if the tape is at a right angle to the length of the calf.

To measure calf circumference in bed-bound elderly, please refer to Appendix 4

Add the numbers to obtain the screening score.

Screening Score
(Max. 14 points)

12-14	points:	Normal nutritional status
8-11	points:	At risk of malnutrition
0-7	points:	Malnourished

For proposed intervention, please see the algorithm on the next page.

For more information, go to www.mna-elderly.com

RESPONDENT ID NUMBER

TODAY'S DATE

	DAY	YEAR
Jan		
Feb		
Mar		2000
Apr		2001
May		2002
Jun		2003
Jul		2004
Aug		2005
Sep		2006
Oct		2007
Nov		2008
Dec		2009

BRIEF FOOD QUESTIONNAIRE

This form is about the foods you usually eat.
It will take about 15 - 25 minutes to complete.

- **Please answer each question as best you can. Estimate if you aren't sure.**
- **Use only a No. 2 pencil.**
- **Fill in the circles completely, and erase completely if you make any changes.**

Please print your name in this box.

SEX
- Male
- Female

If female, are you pregnant or breast feeding?
- No
- Yes
- Not female

AGE

WEIGHT pounds

HEIGHT ft. in.

This form is about your usual eating habits in the past year or so. This includes all meals or snacks, at home or in a restaurant or carry-out. There are two kinds of questions for each food.

HOW OFTEN, on average, did you eat the food during the past year?
*Please DO NOT SKIP any foods. Mark "Never" if you didn't eat it.

HOW MUCH did you usually eat of the food?
*Sometimes we ask how many you eat, such as 1 egg, 2 eggs, etc., ON THE DAYS YOU EAT IT.
*Sometimes we ask "how much" as A, B, C or D. LOOK AT THE ENCLOSED PICTURES. For each food, pick the picture (bowls or plates) that looks the most like the serving size you usually eat. (If you don't have pictures: A=1/4 cup, B=1/2 cup, C=1 cup, D= 2 cups.)

EXAMPLE: This person drank apple juice twice a week, and had one glass each time. Once a week he ate a "C"-sized serving of rice (about 1 cup).

TYPE OF FOOD	HOW OFTEN IN THE PAST YEAR: NEVER	A FEW TIMES per YEAR	ONCE per MONTH	2-3 TIMES per MONTH	ONCE per WEEK	TWICE per WEEK	3-4 TIMES per WEEK	5-6 TIMES per WEEK	EVERY DAY	HOW MUCH EACH TIME (SEE PORTION SIZE PICTURES FOR A-B-C-D)				
Apple juice	○	○	○	○	○	●	○	○	○	How many glasses each time	● 1	○ 2	○ 3	○ 4
Rice	○	○	○	○	●	○	○	○	○	How much each time	○ A	○ B	● C	○ D

PLEASE DO NOT WRITE IN THIS AREA

TYPE OF FOOD	HOW OFTEN IN THE PAST YEAR: NEVER	A FEW TIMES per YEAR	ONCE per MONTH	2-3 TIMES per MONTH	ONCE per WEEK	TWICE per WEEK	3-4 TIMES per WEEK	5-6 TIMES per WEEK	EVERY DAY	HOW MUCH EACH TIME (SEE PORTION SIZE PICTURES FOR A-B-C-D)				
How often do you eat each of the following foods all year round?														
Eggs, including egg biscuits or Egg McMuffins (Not egg substitutes)	○	○	○	○	○	○	○	○	○	How many eggs each time	○ 1	○ 2	○ 3	○ 4
Bacon or breakfast sausage, including sausage biscuit	○	○	○	○	○	○	○	○	○	How many pieces	○ 1	○ 2	○ 3	○ 4
Cooked cereals like oatmeal, cream of wheat or grits	○	○	○	○	○	○	○	○	○	Which bowl		○ B	○ C	○ D
Cold cereals like Corn Flakes, Cheerios, Special K, fiber cereals	○	○	○	○	○	○	○	○	○	Which bowl		○ B	○ C	○ D
Which cereal do you eat most often? **MARK ONLY ONE:** ○ Product 19, Just Right, Total ○ Bran Buds, Raisin Bran, Fruit-n-Fiber, other fiber cereals ○ Other cold cereal, like Corn Flakes, Cheerios, Special K														
Cheese, sliced cheese or cheese spread, including on sandwiches.	○	○	○	○	○	○	○	○	○	How many slices	○ 1	○ 2	○ 3	○ 4
Yogurt (not frozen yogurt)	○	○	○	○	○	○	○	○	○	How much	○ A	○ B	○ C	○ D
How often do you eat each of the following fruits?														
Bananas	○	○	○	○	○	○	○	○	○	How many each time	○ 1/2	○ 1	○ 2	○ 3
Apples or pears	○	○	○	○	○	○	○	○	○	How many	○ 1/2	○ 1	○ 2	○ 3
Oranges, tangerines, not including juice	○	○	○	○	○	○	○	○	○	How many	○ 1/2	○ 1	○ 2	○ 3
Applesauce, fruit cocktail, or any canned fruit	○	○	○	○	○	○	○	○	○	How much	○ A	○ B	○ C	○ D
Any other fruit, like grapes, melon, strawberries, peaches	○	○	○	○	○	○	○	○	○	How much	○ A	○ B	○ C	○ D

TYPE OF FOOD	HOW OFTEN IN THE PAST YEAR: NEVER	A FEW TIMES per YEAR	ONCE per MONTH	2-3 TIMES per MONTH	ONCE per WEEK	TWICE per WEEK	3-4 TIMES per WEEK	5-6 TIMES per WEEK	EVERY DAY	HOW MUCH EACH TIME (SEE PORTION SIZE PICTURES FOR A-B-C-D)				
How often do you eat each of the following vegetables, including fresh, frozen, canned or in stir fry, at home or in a restaurant?														
French fries, fried potatoes or hash browns	○	○	○	○	○	○	○	○	○	How much	○ A	○ B	○ C	○ D
White potatoes not fried, incl. boiled, baked, mashed & potato salad	○	○	○	○	○	○	○	○	○	How much	○ A	○ B	○ C	○ D
Sweet potatoes, yams, or sweet potato pie	○	○	○	○	○	○	○	○	○	How much	○ A	○ B	○ C	○ D
Rice, or dishes made with rice	○	○	○	○	○	○	○	○	○	How much	○ A	○ B	○ C	○ D
Baked beans, chili with beans, pintos, any other dried beans	○	○	○	○	○	○	○	○	○	How much	○ A	○ B	○ C	○ D
Refried beans	○	○	○	○	○	○	○	○	○	How much	○ A	○ B	○ C	○ D
Green beans or green peas	○	○	○	○	○	○	○	○	○	How much	○ A	○ B	○ C	○ D
Broccoli	○	○	○	○	○	○	○	○	○	How much	○ A	○ B	○ C	○ D
Carrots, or stews or mixed vegetables containing carrots	○	○	○	○	○	○	○	○	○	How much	○ A	○ B	○ C	○ D
Spinach, or greens like collards	○	○	○	○	○	○	○	○	○	How much	○ A	○ B	○ C	○ D
Cole slaw, cabbage	○	○	○	○	○	○	○	○	○	How much	○ A	○ B	○ C	○ D
Green salad	○	○	○	○	○	○	○	○	○	How much	○ A	○ B	○ C	○ D
Raw tomatoes, including in salad	○	○	○	○	○	○	○	○	○	How much	○ 1/4	○ 1/2	○ 1	○ 2
Catsup, salsa or chile peppers	○	○	○	○	○	○	○	○	○	How many TBSP.	○ 1	○ 2	○ 3	○ 4
Salad dressing or mayonnaise (Not lowfat)	○	○	○	○	○	○	○	○	○	How many TBSP.	○ 1	○ 2	○ 3	○ 4
Any other vegetable, like corn, squash, okra, cooked green peppers, cooked onions	○	○	○	○	○	○	○	○	○	How much	○ A	○ B	○ C	○ D
Vegetable soup, vegetable beef, chicken vegetable, or tomato soup	○	○	○	○	○	○	○	○	○	Which bowl		○ B	○ C	○ D

PLEASE DO NOT WRITE IN THIS AREA

TYPE OF FOOD	HOW OFTEN IN THE PAST YEAR: NEVER	A FEW TIMES per YEAR	ONCE per MONTH	2-3 TIMES per MONTH	ONCE per WEEK	TWICE per WEEK	3-4 TIMES per WEEK	5-6 TIMES per WEEK	EVERY DAY	HOW MUCH EACH TIME (SEE PORTION SIZE PICTURES FOR A-B-C-D)
MEATS										
Do you ever eat chicken, meat or fish? ○ Yes ○ No IF NO, SKIP TO NEXT PAGE										
Hamburgers, cheeseburgers, meat loaf, at home or in a restaurant	○	○	○	○	○	○	○	○	○	How much meat: ○ 1/8 lb. ○ 1/4 lb. ○ 1/2 lb. ○ 3/4 lb.
Tacos, burritos, enchiladas, tamales	○	○	○	○	○	○	○	○	○	How much: ○ A ○ B ○ C ○ D
Beef steaks, roasts, pot roast, or in frozen dinners or sandwiches	○	○	○	○	○	○	○	○	○	How much: ○ A ○ B ○ C ○ D
Pork, including chops, roasts, or dinner ham	○	○	○	○	○	○	○	○	○	How much: ○ A ○ B ○ C ○ D
When you eat beef or pork, do you ○ Avoid eating the fat ○ Sometimes eat the fat ○ Often eat the fat ○ I don't eat meat										
Mixed dishes with meat or chicken, like stew, corned beef hash, chicken & dumplings, or in frozen meals	○	○	○	○	○	○	○	○	○	How much: ○ A ○ B ○ C ○ D
Fried chicken, at home or in a restaurant	○	○	○	○	○	○	○	○	○	# medium pieces: ○ 1 ○ 2 ○ 3 ○ 4
Chicken or turkey not fried, such as baked, grilled, or on sandwiches	○	○	○	○	○	○	○	○	○	How much: ○ A ○ B ○ C ○ D
When you eat chicken, do you ○ Avoid eating the skin ○ Sometimes eat the skin ○ Often eat the skin ○ N/A										
Fried fish or fish sandwich, at home or in a restaurant	○	○	○	○	○	○	○	○	○	How much: ○ A ○ B ○ C ○ D
Any other fish or shellfish not fried, including tuna	○	○	○	○	○	○	○	○	○	How much: ○ A ○ B ○ C ○ D
Hot dogs, or sausage like Polish, Italian or Chorizo	○	○	○	○	○	○	○	○	○	How many: ○ 1 ○ 2 ○ 3 ○ 4
Boloney, sliced ham, turkey lunch meat, other lunch meat	○	○	○	○	○	○	○	○	○	How many slices: ○ 1 ○ 2 ○ 3 ○ 4
When you eat lunch meats, are they ○ Usually low-fat ○ Sometimes ○ Rarely low-fat ○ N/A										

PLEASE DO NOT WRITE IN THIS AREA

TYPE OF FOOD	HOW OFTEN IN THE PAST YEAR: NEVER	A FEW TIMES per YEAR	ONCE per MONTH	2-3 TIMES per MONTH	ONCE per WEEK	TWICE per WEEK	3-4 TIMES per WEEK	5-6 TIMES per WEEK	EVERY DAY	HOW MUCH EACH TIME (SEE PORTION SIZE PICTURES FOR A-B-C-D)				
Pasta, breads, spreads, snacks														
Spaghetti, lasagna, or other pasta with tomato sauce	○	○	○	○	○	○	○	○	○	How much	○ A	○ B	○ C	○ D
Cheese dishes without tomato sauce, like macaroni and cheese	○	○	○	○	○	○	○	○	○	How much	○ A	○ B	○ C	○ D
Pizza, including carry-out	○	○	○	○	○	○	○	○	○	How many slices	○ 1	○ 2	○ 3	○ 4
Biscuits, muffins	○	○	○	○	○	○	○	○	○	How many each time	○ 1	○ 2	○ 3	○ 4
Rolls, hamburger buns, English muffins, bagels	○	○	○	○	○	○	○	○	○	How many each time	○ 1/2	○ 1	○ 2	○ 3
White bread or toast, including French, Italian, or in sandwiches	○	○	○	○	○	○	○	○	○	How many slices	○ 1	○ 2	○ 3	○ 4
Dark bread like rye or whole wheat, including in sandwiches	○	○	○	○	○	○	○	○	○	How many slices	○ 1	○ 2	○ 3	○ 4
Tortillas	○	○	○	○	○	○	○	○	○	How many each time	○ 1	○ 2	○ 3	○ 4
Margarine on bread, potatoes or vegetables	○	○	○	○	○	○	○	○	○	How many pats (Tsp.)	○ 1	○ 2	○ 3	○ 4
Butter on bread, potatoes or vegetables	○	○	○	○	○	○	○	○	○	How many pats (Tsp.)	○ 1	○ 2	○ 3	○ 4
Peanuts or peanut butter	○	○	○	○	○	○	○	○	○	How many TBSP.	○ 1	○ 2	○ 3	○ 4
Snacks like potato chips, corn chips, popcorn (Not pretzels)	○	○	○	○	○	○	○	○	○	How much	○ A	○ B	○ C	○ D
Doughnuts, cake, pastry, pie	○	○	○	○	○	○	○	○	○	How many pieces	○ 1	○ 2	○ 3	○ 4
Cookies (Not lowfat)	○	○	○	○	○	○	○	○	○	How many	○ 1-2	○ 3-5	○ 6-7	○ 8+
Ice cream, frozen yogurt, ice cream bars	○	○	○	○	○	○	○	○	○	How much	○ A	○ B	○ C	○ D
When you eat ice cream or frozen yogurt, is it	○ Usually low-fat	○ Sometimes	○ Rarely low-fat	○ N/A										
Chocolate candy, candy bars	○	○	○	○	○	○	○	○	○	How many bars	① small	① medium	① large	② large

TYPE OF BEVERAGE	HOW OFTEN IN THE PAST YEAR									HOW MUCH EACH TIME SEE PORTION SIZE PICTURES FOR A-B-C-D				
	NEVER	A FEW TIMES per YEAR	ONCE per MONTH	2-3 TIMES per MONTH	ONCE per WEEK	TWICE per WEEK	3-4 TIMES per WEEK	5-6 TIMES per WEEK	EVERY DAY					
How often do you drink the following beverages?														
Real orange or grapefruit juice, Welch's grape juice, Minutemaid juices, Juicy Juice	○	○	○	○	○	○	○	○	○	How many glasses each time	○ 1	○ 2	○ 3	○ 4
Hawaiian Punch, Sunny Delight, Hi-C, Tang, or Ocean Spray juices	○	○	○	○	○	○	○	○	○	How many glasses each time	○ 1	○ 2	○ 3	○ 4
Kool Aid, Capri Sun or Knudsen juices	○	○	○	○	○	○	○	○	○	How many glasses each time	○ 1	○ 2	○ 3	○ 4
Instant breakfast milkshakes like Carnation, diet shakes like Slimfast, or liquid supplements like Ensure	○	○	○	○	○	○	○	○	○	How many glasses or cans	○ 1	○ 2	○ 3	○ 4
Glasses of milk (any kind)	○	○	○	○	○	○	○	○	○	How many glasses	○ 1	○ 2	○ 3	○ 4
When you drink glasses of milk what kind do you usually drink? **MARK ONLY ONE:**	○ Whole milk ○ Reduced fat 2% milk ○ Low-fat 1% milk				○ Non-fat milk ○ Rice milk ○ Soy milk				○ I don't drink milk or soy milk					
Cream, Half-and-Half or non-dairy creamer in coffee or tea	○	○	○	○	○	○	○	○	○	Total TBSP. on those days	○ 1	○ 2	○ 3-4	○ 5+
Regular soft drinks, or bottled drinks like Snapple (Not diet drinks)	○	○	○	○	○	○	○	○	○	How many bottles or cans	○ 1	○ 2	○ 3-4	○ 5+
Beer	○	○	○	○	○	○	○	○	○	How many bottles or cans	○ 1	○ 2	○ 3-4	○ 5+
Wine or wine coolers	○	○	○	○	○	○	○	○	○	How many glasses	○ 1	○ 2	○ 3-4	○ 5+
Liquor or mixed drinks	○	○	○	○	○	○	○	○	○	How many drinks	○ 1	○ 2	○ 3-4	○ 5+

During the past year, have you taken any vitamins or minerals regularly, at least once a month?

○ No, not regularly ○ Yes, fairly regularly →

(IF YES) WHAT DID YOU TAKE FAIRLY REGULARLY?

VITAMIN TYPE	HOW OFTEN					FOR HOW MANY YEARS?					
	DIDN'T TAKE	A FEW DAYS per MONTH	1-3 DAYS per WEEK	4-6 DAYS per WEEK	EVERY DAY	LESS THAN 1 YR.	1 YEAR	2 YEARS	3-4 YEARS	5-9 YEARS	10+ YEARS
Multiple Vitamins. Did you take...											
Regular Once-A-Day, Centrum, or Thera type	○	○	○	○	○	○	○	○	○	○	○
Stress-tabs or B-Complex type	○	○	○	○	○	○	○	○	○	○	○
Antioxidant combination type	○	○	○	○	○	○	○	○	○	○	○
Single Vitamins (not part of multiple vitamins)											
Vitamin A (not beta-carotene)	○	○	○	○	○	○	○	○	○	○	○
Beta-carotene	○	○	○	○	○	○	○	○	○	○	○
Vitamin C	○	○	○	○	○	○	○	○	○	○	○
Vitamin E	○	○	○	○	○	○	○	○	○	○	○
Folic acid, folate	○	○	○	○	○	○	○	○	○	○	○
Calcium or Tums, alone or combined with vit. D or magnesium	○	○	○	○	○	○	○	○	○	○	○
Zinc	○	○	○	○	○	○	○	○	○	○	○
Iron	○	○	○	○	○	○	○	○	○	○	○
Selenium	○	○	○	○	○	○	○	○	○	○	○
Vitamin D, alone or combined with calcium	○	○	○	○	○	○	○	○	○	○	○

If you took vitamin C or vitamin E:

How many milligrams of **vitamin C** did you usually take, on the days you took it?

○ 100 ○ 250 ○ 500 ○ 750 ○ 1000 ○ 1500 ○ 2000 ○ 3000+ ○ don't know

How many IUs of **vitamin E** did you usually take, on the days you took it?

○ 100 ○ 200 ○ 300 ○ 400 ○ 600 ○ 800 ○ 1000 ○ 2000+ ○ don't know

How often do you use fat or oil in cooking?

○ Less than once per week ○ A few times per week ○ Once a day ○ Twice a day ○ 3+ per day

What kinds of fat or oil do you usually use in cooking? MARK ONLY ONE OR TWO

○ Don't know, or Pam ○ Butter/margarine blend ○ Lard, fatback, bacon fat
○ Stick margarine ○ Low-fat margarine ○ Crisco
○ Soft tub margarine ○ Corn oil, vegetable oil
○ Butter ○ Olive oil or canola oil

Did you ever drink more beer, wine or liquor than you do now? ○ Yes ○ No

Do you smoke cigarettes now? ○ Yes ○ No

IF YES, On the average about how many cigarettes a day do you smoke now?

○ 1-5 ○ 6-14 ○ 15-24 ○ 25-34 ○ 35 or more

What is your ethnic group? (MARK ONE OR MORE)

○ Hispanic or Latino ○ Black or African American ○ American Indian or Alaska Native
○ White, not Hispanic ○ Asian ○ Native Hawaiian or Other Pacific Islander

Thank you very much for filling out this questionnaire. Please take a minute to go back and fill in anything you may have skipped.

PLEASE DO NOT WRITE IN THIS AREA

Survey: The Impact of Participation in Meals on Wheels and More in Austin, TX on Dietary Intake and Health Status

"Mr./Mrs. __ we are contacting you today to ask you a few questions about how Meals on Wheels is going to help us improve our services. Your answers will not affect the services Meals on Wheels and More provides to you. May I ask you a few questions?"

Q1A. Do you like the MOW meals?	Q1B. What don't you like about the meals?
a. Yes (always) [go to Q2]	a. I'm not used to this kind of food
b. Yes (usually) [go to Q2]	b. The foods don't taste good to me
c. Sometimes [go to Q1B]	c. The foods don't 'agree' with me
d. No (usually not [go to Q1B]	d. Too many vegetables
e. Never [go to Q1B]	e. Other_____

2. Which of the following is true about how many of the meals you eat from MOWAM?
   a. I eat every meal delivered.
   b. I almost always eat the meals.
   c. I eat the meals about half the time.
   d. I usually don't eat the meals.
   e. I never eat the meals

3. When you eat a meal, how much of each meal do you 'usually' eat?
   a. Whole meal
   b. Almost all of it (About ¾)
   c. About ½
   d. Less than half (About ¼)
   e. Not very much, if any

4. Considering your overall diet, how much are you eating now compared to before you started your meal service?
   a. More
   b. Less
   c. About the same

5. If you are eating less food now that you are receiving Meals on Wheels and More, is it because you:
   a. Don't like the food
   b. Have been ill
   c. Don't have much of an appetite
   d. Are trying to eat less (to lose weight)
   e. Have less food in your house now than before
   f. Are sharing the meals with another person
   g. Other_____

6. Where did you get food before Meals on Wheels and More began delivering meals to you? (Check all that apply)
   a. Food I made or bought
   b. Food friends or family brought to me
   c. Fast food
   d. I often skipped meals
   e. Other_____

7. How is the other food (besides MOW meals) in your home provided?
   a. Food I buy
   b. Food friends or family bring to me
   c. Fast food
   d. I often skip meals
   e. Other_____

8. How much money do you spend on food now compared to before you began receiving meals from MOWAM?
   a. More
   b. Less
   c. About the same

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VITA

Seanna Moore Marceaux was born in El Paso, TX, on April 2, 1977, the daughter of Jeannette Ann Moore and Gordon David Moore. After completing her work at Clint High School, Clint, TX, in 1995, she entered the University of Texas at San Antonio where she received a Bachelor of Arts in May 2000. During the following years, she was employed as an elementary educator with the Northside Independent School District of San Antonio, TX. In August of 2005, she entered Texas State University-San Marcos and received the degree of Bachelor of Science in May 2007 and received the credential of Registered Dietitian in October 2008. In January 2010, she entered the Graduate College of Texas State.

Permanent Email Address: seanna.marceaux@gmail.com

This thesis was typed by Seanna M. Marceaux.