NUTRITIONAL ADEQUACY OF HOME FOOD INVENTORIES OF SENIORS RECEIVING HOME-DELIVERED MEALS IN SOUTH CAROLINA

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ABSTRACT OF THE DISSERTATION

Nutritional Adequacy of Home Food Inventories of Seniors Receiving Home-Delivered Meals in South Carolina

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The aging of the American population and subsequent increase in chronic disease will have a profound effect on public health, social services and healthcare. In the United States, a healthy lifestyle, diet and exercise can help delay and/or treat chronic diseases and promote quality of life. Former studies have evaluated home food inventories in U.S households for several nutrients, yet data regarding in-home pantries of homebound older adults is scarce. Quality dietary intake is important when energy requirements are reduced due to aging; seniors may be at nutritional risk from vitamin and mineral inadequacies, contributing to a decline in health status and function. The in-home food inventory takes on major importance for the homebound due to physical, mental, economic and social limitations impacting food procurement, storage, preparation and consumption. The current study details the nutritional adequacy of the in-home food inventory of homebound seniors and examines gender and ethnic differences. Highest values for days meeting Daily Values and Dietary Reference Intakes were found for vitamin A and sodium. Convenience foods were abundant, providing economical, shelf-stable, and easy to prepare meals when functionally limited. Vitamin D and calcium were found to be the limiting nutrients in this study. The highest frequency of significant differences in home food inventories was found between races: White compared to non-White, and for females: White compared to non-White. Dairy products have repeatedly been reported as the major contributor of vitamin D for adults. In this study, the contribution of dairy products to total vitamin D ranged from 16.7% (non-White males) to 32.2% (White females); females had 51% more dairy products in their inventories than males. Fish and ready-to eat cereals took on major importance in food inventories, providing nutrient dense, shelf-stable and economical sources of vitamin D. Reduced consumption of milk and major sources of vitamin D, along with declining cutaneous synthesis of vitamin D with age present challenges in developing public health strategies to achieve adequate vitamin D intake in the older population.

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CHAPTER 1

INTRODUCTION

We have seen an escalation in the percentage of older adults in the United States population due to both an increase in life expectancy along with an elevated birth rate which occurred during the post-war years of 1946 through 1965. How the nation responds to the increased demand for health care and age-related services to enable older adults to remain healthy, live independently and practice healthy behaviors is of major concern**.**

Age and gender **s**pecific nutritional recommendations for older adults are defined in the Dietary Reference intakes for age categories fifty one to seventy years and over seventy years (Institute of Medicine of the National Academy of Sciences, 2010). Physiological, psychological, economic and social changes associated with aging places seniors at nutritional risk; under-nutrition in the elderly is estimated at about five to ten percent for those non-institutionalized (Locher, Vickers, Buys, Ellis, Lawrence, Newton, Roth, Ritchie, Bales, 2013). Energy requirements decrease with increasing age due to a decrease in physical activity; this combined with a decline in appetite contributes to loss of muscle mass and strength. Chronic medical conditions may require alterations in dietary intake; impaired digestion, absorption and metabolism have an influence on nutritional requirements. The challenge remains to meet nutritional requirements of vitamins and minerals while consuming a diet lower in energy (Bernstein & Munoz, 2012). A recent met-analysis identified six micronutrients of concern in community-dwelling adults: magnesium, selenium, riboflavin, thiamin, calcium and vitamin D (Borg, Verlaan, Hemsworth, Mijarends, Schols, Luiking &Lisette, 2015).

Home delivered meals (HDMs) are designed to provide a minimum of 1/3 the Recommended Dietary Allowance (RDA) to qualified individuals. Many rely on this meal as their main source of daily food intake (Sharkey, Branch, Zohoori, Guiliani, Busby-Whitehead & Haines, 2002), thus the in-home food inventory takes on major importance to supplement this meal due to physical, mental, financial and/or functional disabilities. The home food environment has been measured by food inventories, using survey data, self-reported or researcher administered checklists, direct observation, and telephone surveys, however, Universal Product Codes (UPCs) provide objective description of foods available in food pantries at the time of scanning. This analysis is part of a larger study of homebound seniors in five states receiving HDMs described elsewhere (Hallman et al, 2015; McWilliams et al, 2015) that was conducted in collaboration with Meals on Wheels America (MOWA).

The purpose of this study was to examine the in-home food inventories of two hundred clients of South Carolina who receive HDMs and provide comparisons to national recommendations across gender and race. The second chapter of this paper compares the total in-home food inventories to Daily Values (DVs) and RDAs. The third chapter estimates the amount of vitamin D available in food inventories, and the fourth details major food sources of vitamin D.

It is hoped that understanding gender, racial and cultural preferences in food selection will help public health professions working with government agencies to promote educational campaigns and food policies to improve and maintain the nutritional status in this vulnerable population who are at high risk for chronic diseases and dependent on their home food inventories especially when HDM delivery is disrupted. Adding to the nutrient density of foods through the process of fortification remains an option to be tested for safety and acceptability.

CHAPTER 2

NUTRITIONAL ADEQUACY OF HOME FOOD INVENTORIES OF SENIORS RECEIVING HOME DELIVERED MEALS IN SOUTH CAROLINA

Abstract

The continuing trend to "age in place" highlights the need for community-focused health services for the older population including social, health and nutrition services. Adequate nutrition helps promote quality of life, prevent and manage chronic health conditions, and delay death and disability especially for vulnerable populations such the homebound elderly who rely on home delivered meals (HDMs) supplemented by their in-home supply. Data suggest that older adults do not meet nutritional recommendations for energy, protein, calcium, magnesium, potassium, zinc, fiber, and vitamins D, B12, B6, C, E and K, but exceed folate and sodium recommendations. The purpose of this study was to evaluate the household food supplies of homebound seniors receiving HDMs. Universal Product Codes (UPCs) provided nutritional content and number of servings, and staff detailed the number of containers to enable assessment of in-home food supplies for total kilocalories, protein (g), total fat (g), total carbohydrate (g), cholesterol (mg), sodium (mg), dietary fiber (g), vitamins A (IU), C (mg), and D (IUs), calcium (mg) and iron (mg). Total amounts of each nutrient were then compared to respective Daily Values (DVs) and Dietary Reference Intakes (DRIs) to compute the number of days recommendations could be met. Participants in this study were homebound seniors (aged 60 and above) who lived alone, resided in South Carolina and received HDMs. Mann-Whitney U-values show the most significant differences in the studied nutrient content of in-home food inventories was between races (White compared to non-White), and for race and gender (White compared to non-White). Highest values for days meeting DVs and DRIs were found for vitamin A and sodium while lowest values were for vitamin D and calcium. Requirements for vitamin D and calcium increase with age; adequate intakes are recommended to prevent bone loss and lower hip fracture. Females and non-White older adults may be especially at risk for nutritional deficiencies.

Keywords: Homebound elderly, household food inventory, Universal Product Code, home-delivered meals, nutrition in aging

The CDC reports that longer life spans and aging "baby boomers" will result in a US 2030 population comprised of 20% older (Centers for Disease Control and Prevention, 2013), compared to 14.1% in 2013 (United States Census, 2014). The continuing trend to "age in place" highlights the need for community-focused health services for the older population including social, health and nutrition services. The Administration on Aging (AoA), part of the US Department of Health and Human Services (DHHS) recognizes and supports the desire of older Americans to maintain their independence in the community and works to provide health and social services, including that of home-delivered meals (HDMs). This serves as a less costly alternative to institutionalization (Sahyoun & Vaudin, 2014). Chronic disease is reported to affect 91% of older adults with 77% having at least two chronic diseases; this accounts for 75% of healthcare expenditures in the US (The National Council on Aging, 2013; Kleinman & Foster, 2011). Additional factors of cognitive impairment, isolation, multiple medication use, compromised mental and dental health contribute to their nutritional risk. (Locher, Ritchie, Robinson, Roth, Smith West & Burgio, 2008). Adequate nutrition helps promote quality of life, prevent and manage chronic health conditions, and delay death and disability especially for vulnerable populations such the homebound elderly who rely on HDMs supplemented by their in-home food supply.

Dietary Reference Intakes provide guidelines for adults in age categories 51 to 70 and over 70 (Institute of Medicine of the National Academy of Sciences, 2010.) The high diversity of this population makes it difficult to define nutritional requirements (Bernstein & Munoz, 2012). Energy requirements decrease with increasing age due to a decrease in physical activity; but nutrient needs may remain the same or increase due to altered absorption and metabolism (Bernstein, et al 2012). Thus, the challenge for older adults is to meet nutritional needs for vitamins and minerals while consuming a diet lower in energy (Bernstein et al, 2012). Increased intake of nutrient-dense foods is encouraged to achieve a quality dietary intake (Sahyoun & et al, 2014).

Objectives in Healthy People 2020 include reducing obesity to 30.5% (a 10% reduction from baseline statistics) and increasing the contribution of fruits and vegetables to the diet (U.S. Dept Health and Human Services). Undernutrition effects 10% of older adults living in their own homes (American Geriatrics Society: Healthy Aging Foundation 2012) but Body Mass Index (BMI) increases in those individuals who do not reduce their energy intake resulting in weight gain. Obesity remains a major concern as rates remain high (35.4%) in adults 60 and over (2012), impacting quality of life (Levi, Segal, St.Laurent & Rayburn, 2014; Heavey, 2012, American Geriatrics Society: Healthy Aging Foundation 2012) and increasing the risk of chronic conditions (Johnston, R., Poti, J., Popkin, B., & Kenan, W., 2014). Smit, Winter-Stone, Loprinzi, Tang and Crespo (2013) found higher prevalence of frailty in older obese or overweight adults compared to those of normal weight. While an increase in prevalence of obesity in those over 60 has been predicted (Basu, Seligman, & Winkleby, 2014, Johnson, Dwyer, Jensen, Miller, Speakman, Starke-Reed & Volpi, 2011); BMI and weight loss studies have been equivocal in predicting heath care expenditures and morbidity and mortality risk in over nourished or undernourished seniors (Yang, Brown, Burgio, Kilgore, Ritchie, Roth, West & Locher, 2012, Wells & Dumbrell, 2006).

Other studies have emphasized the importance of “healthful” diet patterns and intakes of fruit and vegetables among older adults (Hsiao, Mitchell, Coffman, Allman, Locher, Sawyer, Jensen & Hartman, 2013, Sharkey, Johnson & Dean, 2010); food insecurity may be contributing to a diminished diet quality in older adults (Johnson et al, 2011). Chronic medical conditions may require alterations in dietary intake; impaired digestion, absorption and metabolism have an influence on nutritional requirements. Data suggest that older adults do not meet nutritional recommendations for energy, protein, calcium, magnesium, potassium, zinc, fiber, vitamins D, B12, B6, C, E and K and potassium (Sahyoun et al, 2014; Pae, Meydani &Wu, 2012; El-Abbadi, Dao, &, Meydani, 2014; Bernstein et al, 2012; Wells et al, 2006; Lichtenstein, Rasmussen, Yu, Epstein & Russell, 2008; Johnson et al, 2011, Locher et al, 2008) . Other experts have warned of the excessive intake of sodium and folate **(**Lichtenstein et al, 2008; Bailey, Dodd, Gahche, Dwyer, McDowell, Yetley, Sempos, Burt, Radimer, & Picciano, 2010). The Scientific Report of the 2015 Dietary Guidelines Committee (2015) identified sodium and saturated fat as potentially over consumed nutrients, and vitamins A, D, E, C, folate, calcium, magnesium, fiber and potassium as under consumed relative to recommended intakes.

Physiological, psychological, economic and environmental factors contribute to the vulnerability of older adults and risk of a compromised nutritional status. The homebound may be receiving HDMs providing them with one-third of the daily Recommended Dietary Allowances. For most homebound seniors, HDMs typically comprise only 33% of the participant’s daily food and nutrient intake (Millen, Ohls, Ponza & MCool, 2002). Research suggests that in-home food inventories supply more than 70% of the food consumed in American homes making the in- home food inventory an important determinant of actual dietary intake at home (Sisk, Sharkey, McIntosh &

Anding, 2010) and of major importance to homebound seniors receiving HDMs due to economic, physical, social and /or mental limitations, difficulties in food preparation, consumption and their lack of access to transportation to purchase food.

The home food environment has been measured by food inventories, using survey data, self-reported or researcher administered checklists, direct observation, and telephone surveys. A novel technology using Universal Product Codes (UPC) scanning was pioneered by Byrd-Bredbenner (Byrd-Bredbenner, Mauer & Abbott, 2009) which, when matched to a database containing the information found on food labels, provides an objective collection of food and nutrition data as compared to prior methods. It has been used in several studies to measure food inventories of families with children and several ethnic groups (Byrd-Bredbenner & Abbot, 2009; Byrd-Bredbenner, Abbot & Cussler, 2009; Schefske, Bellows, Byrd-Bredbenner, Cuite, Rapport, Vivar & Hallman; 2010, Pinard, Yaroch, Hart, Serrano, McFerren, & Estabrooks, 2014; Stevens, Bryant, Wang, Borja & Bentley, 2012), yet little is known about the home food environment of older adults, even less about those who are homebound receiving HDMs.

The purpose of this study was to evaluate the household food supplies of homebound seniors receiving HDMs and describe the calorie and nutrient content, comparing nutrient availability to Daily Values (DVs) and Dietary Reference Intakes (DRIs).

Method

This cross-sectional study was part of a larger study of homebound seniors in five states receiving HDMs described elsewhere (Hallman et al, 2015; McWilliams et al, 2015) that was conducted in collaboration with Meals on Wheels America (MOWA).

Data was collected from 5/9/2011 to 3/14/2012; participants received $10 and a refrigerator thermometer as compensation for their participation. The study protocol was approved by the Institutional Review Board of Rutgers University. All participants signed an informed consent.

Sample

Participants in this study were recruited by Meals on Wheels staff, were home-bound seniors (aged 60 and above) with no overt signs of cognitive impairment, who lived alone, resided in South Carolina, and received HDMs beginning at least 6 months prior to the study.

Measurement

Trained staff inventoried home food supplies during a ten month period via handheld barcode scanners connected to laptop computers, with databases containing Universal Product Codes (UPCs) and nutritional information found on food labels (Bredbenner & Bredbenner, 2007). All foods were inventoried except those that do not make a significant contribution to the nutritional quality of a diet (i.e. alcoholic beverages, commercially prepared baby food, infant formula, pet foods, refrigerated leftovers, spices, condiments, coffee and tea).

Upon arrival in a participant's home, trained Meals on Wheels staff conducted a face-to-face interview to gather demographic, anthropometric and health, food safety and emergency preparededness data. Number and types of HDMs delivered (e.g. breakfast/lunch/dinner), gender, enrollment date and date of birth were entered into computers prior to the scheduled appointment.

Data Analysis

Nutrients evaluated in the food inventory were selected from those required by the Nutrition Labeling and Education Act and readily available from scanned UPCs and food labels: total kilocalories, protein (g), total fat (g), total carbohydrate (g), cholesterol (mg), sodium (mg), dietary fiber (g), Vitamin A (IU), Vitamin C (mg), calcium (mg) and iron (mg). In addition, because Vitamin D is such an important nutrient for older adults, it was estimated using available food facts panels on food packages, food manufacturers' websites and/or the USDA Nutrient Database, Release 26 (USDA, 2013). Vitamin D on facts labels expressed as a Daily Value (DV; i.e. 400 IUs) was converted to micrograms (ug) as follows, in order to provide uniformity within the dataset:

Vitamin D in IU = vitamin D in µg x 40

To determine which nutrients were in excess and/ or limiting, the total amount of kilocalories and nutrients in each household's food supply was then divided by: 1) the respective DV to determine the number of days nutrients were available at 100% the DV then 2) the respective DRI to determine the number of days nutrients were available at 100% DRI. Self-reported heights and weights allowed the calculation of Estimated Energy Requirement (EER) for adults age 19 and older for each participant using a physical activity [PA] factor of 1 and assuming sedentary lifestyle (Institute of Medicine, 2005):

Males EER = 662 – (9.53 x age [y] + 1 [PA] x (15.91 x w [kg] + 539.6 x ht [m])

Females EER = 354 – (6.91 x age [y] + 1 [PA] x (9.36 x w [kg] + 726 x ht [m])

According to The Centers for Disease Control and Prevention, Body Mass Index (BMI) provides a reliable tool for most people, and allows them to be screened for potential health risks associated with being overweight or obese. Although subject to measurement error, Body Mass Index (BMI) is the most widely used variable to classify sedentary populations as underweight (BMI less than 20), optimal weight (BMI 20-24.99), overweight (BMI 25-29.99), obese (BMI 30-39.99) or morbidly obese (BMI over 40). It is determined by dividing an individual's body weight by the square of their height, and is an indicator of body fat.

The availability of heights and weights allows the calculation of a BMI:

$$\text{Weight (lb)} / [\text{height (in)}]^2 \times 703$$

Demographic variables were stratified by gender then race and age; categorical variables were compared using chi-square. Mann-Whitney U-tests were used to determine the significance of nutrient comparisons as distribution of data was right skewed; T-tests were used for BMIs.

Results

Demographics/Anthropometrics

As shown in Table 1, the majority of clients were White females, over age 80 (median age 85), with incomes less than $900.00 per month. Most reported having attended and or completed a high school education. Males were on average younger, mean age was 78, median was 76. Females outnumbered males by 2.5 to 1. Of males who answered questions regarding education and/or income, most reported having attended or completed high school (46%) with incomes of <$900/month (44%). Most White males reported incomes over $1500.00/month while non-White males reported incomes less than $900.00 per month.

A comparison of age groups, 60-80 with those 80+ was significant for non-Whites and Whites ($p=0.022$). White males aged 60-80 were significantly different than White females ($p=0.035$), but this was not the case for non-Whites ($p=0.054$). Income was significant for all males compared to all females ($p=0.038$). The majority (54%) reported incomes <$900/month. Income was not significant for non-Whites (p=0.097) nor Whites (p=0.975) when comparing those 60-80 with those 80+. Education was significant in comparing all males and females (p=0.028), 56% having attended or completed high school. Education was also significant in the White population 60-80 when compared to those 80 years and older (p=0.020), but not in non-Whites (p=0.065).

T-tests resulted in statistically significant differences in BMIs between those aged 60-80 and those over 80 within races (p=0.005 for Whites, p= 0.021 for non-Whites); no difference was observed between males and females (p=.377). Although 63% of clients were classified as overweight or obese (BMI≥25), only 22% of clients reported restricting kilocalories, fat and/or carbohydrates in their diets. 2.6% of clients were characterized as underweight (BMI less than 20); 60% of the underweight were over age 80. 34% of all SC participants were at normal weight (BMI 20-24.99), 35% overweight, (BMI 25-29.99), 28% obese, (BMI 30-39.99), and 1% morbidly obese (BMI 40 or above), all of those morbidly obese were less than 80 years old.

Nutrients in Home Food Supplies

An examination of total in-home food pantries reveals that the majority of clients (62%) had enough kcals to meet RDI requirements for over 21 days, 24% could meet kcal needs for 15-21 days, 11% for 8-14 days and 3% had less than 7 days in their inventories. Two clients reported no food available**.** Non-White females were found to have the highest amounts of all studied nutrients in their food inventories with the exception of cholesterol and vitamin D; highest amounts of cholesterol and vitamin D were found in the non-White males.

Figure 1 details macronutrient contributions to total kilocalorie food inventory. The percentage of kilocalories from protein ranged from 13.1% (non-White females) to 15.8% (non-White males), with mean value for the total population of 13.7%. Mean contribution of carbohydrate was 52.8% for all of the South Carolina study participants, with the lowest value of 51.4% observed in White males and the high of 53.5% in White females. Fat contributed 34% of kilocalories (mean value) for the total population. Non-White males averaged 32.4% of their kilocalories from fat, while White males had a mean of 36.4% of kilocalories from fat. These were evaluated by chi square, but were not found to be statistically significant between studied groups.

Figures 2 and 3 summarize results in comparing studied nutrients within the food inventories to national recommendations. Figure 2 details Daily Values, included in this analysis for consistency; they are the standards used for Nutrition Facts Labels, and the source used to collect data for this study. Each bar represents the mean number of days available at 100% DV for all South Carolina clients. Vitamin A (deep blue) and sodium (orange) make up those nutrients meeting the highest numbers of days, while calcium (green) and Vitamin D (light blue) were available the least number of days. This pattern is repeated in Figure 3 which details Dietary Reference Values, vitamin A (orange) and sodium (teal) were available in the highest amounts, while recommendations for vitamin D (lavender) and calcium (pink) could meet the least number of days. Clients were able to meet needs for kcalories for 27-31 days and protein for 37-39 days.

Tables 2a and 2b display results of Mann-Whitney tests for in-home food supplies. With the exception of vitamin A, females exceeded males for nutrients studied ; statistically significant differences were found for kilocalories, protein, vitamin A, fiber (days DRIs), calcium and vitamin D (days DV), vitamin C, cholesterol, and iron (days DVs and DRIs). Compared to Whites, non-Whites had larger amounts all nutrients studied, differences were significant for kilocalories, protein, fiber (days DVs), vitamin A, vitamin C, iron and vitamin D (days meeting DVs and DRIs).

There were fewer significant differences when comparing food inventories within races and within the male gender: Tables 3a and 3b. White females generally had higher amounts of all nutrients when compared to White males; sodium and vitamin A were the exceptions. Statistically significant differences were found for kilocalories, protein, vitamin A and fiber (days DRIs), vitamin C and vitamin D (days DVs and DRIs. White females had lesser amounts of all nutrients in comparison to non-White females; the highest frequency of significant differences was seen within the female gender: kilocalories, protein, fat, (days DVs), carbohydrate, fiber, vitamin A, vitamin C, calcium and iron (days meeting DVs and DRIs). In comparing non-White females to non-White males, non-White females consistently had higher amounts of all nutrients except cholesterol and vitamin D. Differences were significant for kilocalories, carbohydrate (days DV and DRI), vitamin A, vitamin C and fiber (days DRIs). Food inventories of non-White males were higher than those of White males for most nutrients except fat and carbohydrate (DV), however only vitamin C was found to be statistically significant.

***Table 1*: Demographics/Anthropometrics for South Carolina Meals on Wheels Clients**

								Non-White			White		
	Total N	%	Male	%	Female	%	P-Value	60-80 yrs	80+	P-Value	60-80 yrs	80+	P-Value
All SC	200		58	29.0	142	71.0		43	37		44	74	.022
White Race	118	59.0	30	25.4	88	74.6	0.260						
African American	76	38.0	25	32.9	51	67.1							
Other	4	2.0	1	25.0	3	75.0							
No Race Noted	2	1.0	2	100	0								
Male (2 No Race)	58							18	8	0.054	16	14	0.035
Female	142							25	29		28	60	
900	74	37.4	18	24.3	56	75.7	0.038	28	13	0.097	15	18	.975
01-1125	23	11.6	5	21.7	18	78.3		3	2		7	11	
$1126-1500	17	9.1	6	35.3	11	64.7		1	5		5	7	
>$1500	22	10.6	12	54.5	10	45.5		3	2		7	9	
Refused	19	9.6	8	42.1	11	57.9	0.033	2	2	.434	3	12	0.040
Answer	43	21.7	7	16.3	36	83.7		6	13		7	17	
Education N=198			56	28.3	142	71.7							
8th grade or less	48	24.7	15	31.3	33	68.7	0.028	12	14	0.065	3	19	0.020
Attended/ Completed HS	110	55.6	26	23.6	84	76.4		25	19		30	36	
Attended/Completed College	29	14.1	14	48.3	15	51.7		6	1		10	12	
Attended/Completed Grad/Prof School	11	5.6	1	9.0	10	91.0		0	3		1	7	
BMI Means +/-SD	28.1+/-7.5		27.8+/-7.4		28.2+/-7.6		0.377	30.9+/-8.4	27.3+/-6.3	0.021	30.1+/-10.3	25.8+/-4.2.	0.005

Figure 1: **Caloric Distribution of Macronutrients**

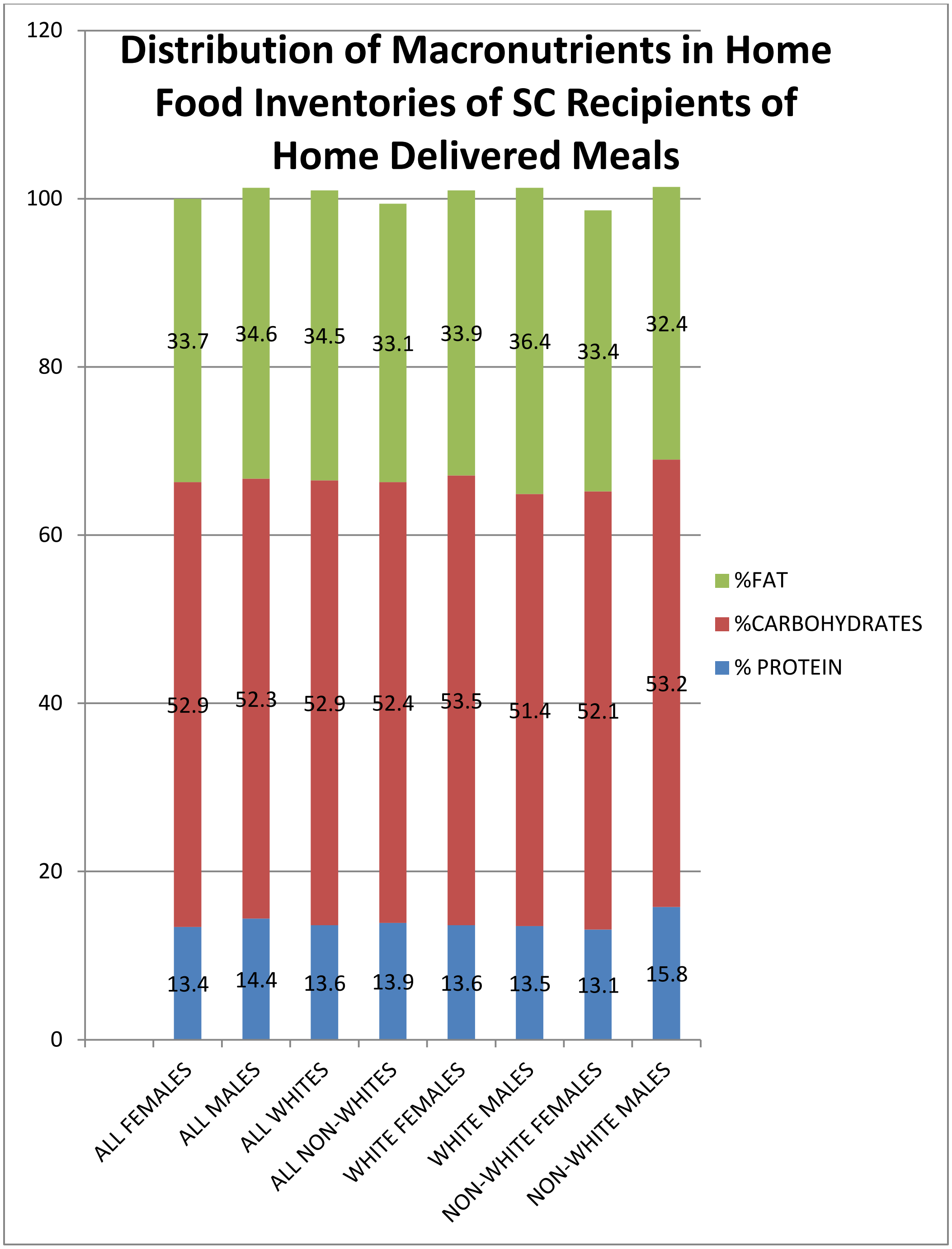


***Figure 2:* Mean Days at 100% Daily Values**

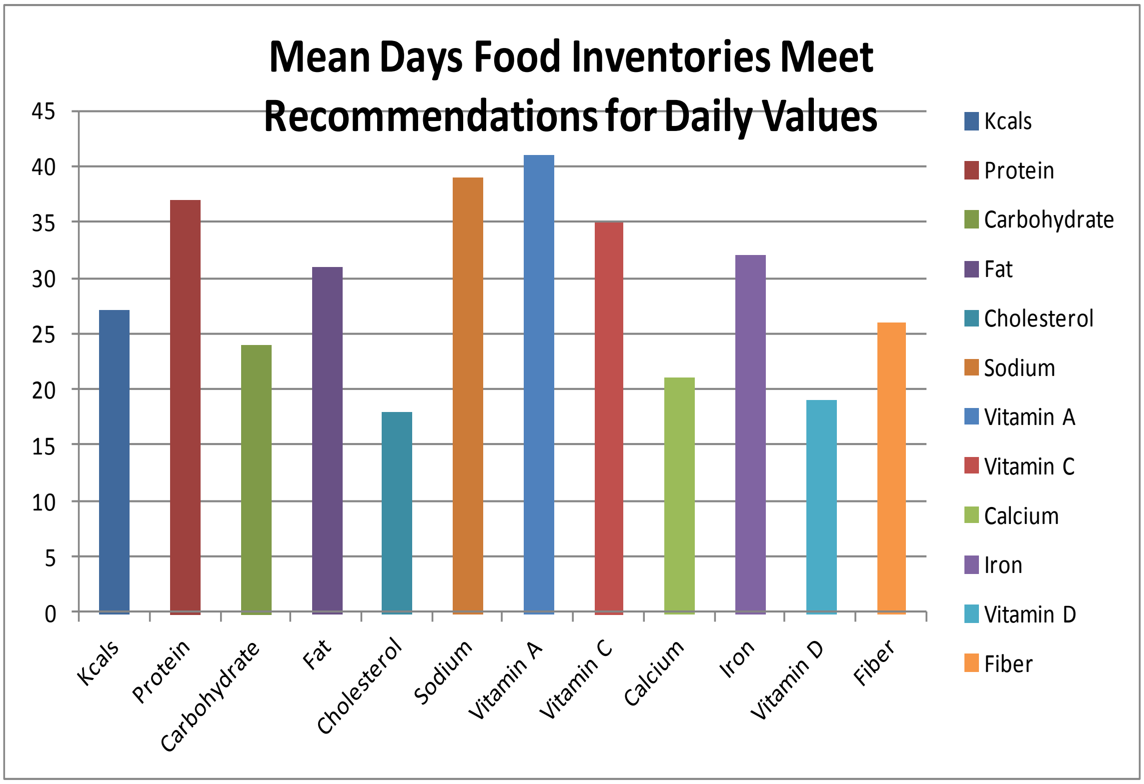


***Figure 3:* Mean Days at 100% Dietary Reference Intakes**

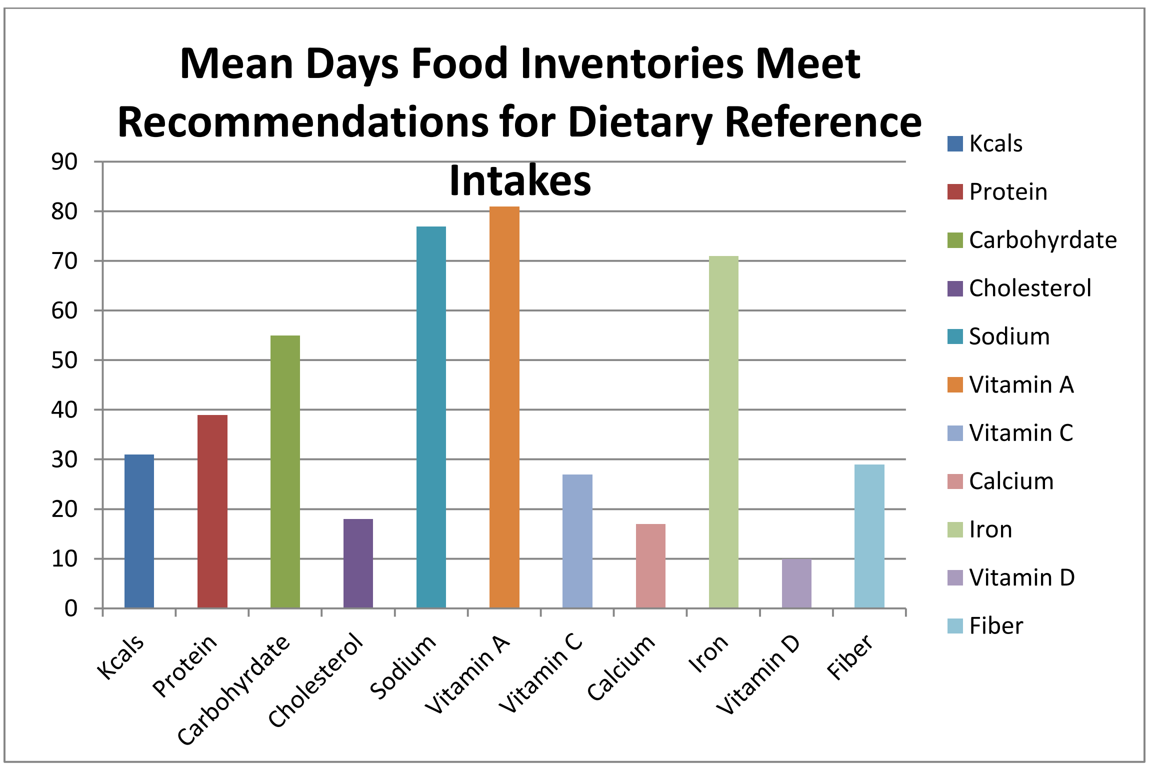


Table 2a: **Days Food Inventories meet Nutritional Adequacy for Daily Values**

	DV	ALL SC N=200		FEMALES N=142	MALES N=58	**p**		WHITE S N=118*	NON-WHITES N=80*	**p**
KCals	Mean	26.7		27.3	25.2	.106		25.0	29.5	.048
	SD	14.5		14.6	14.4			12.3	17.1	
	Median	23.3		24.6	20.0			22.0	26.5	
Protein	Mean	37.4		36.8	38.6	.230		33.3	43.9	.037
	SD	*25.5*		*22.3*	*32.3*			*18.0*	*32.8*	
	Median	30.0		30.9	29.4			29.2	36.6	
Carbohydrate (CHO)	Mean	23.9		24.7	21.8	.078		22.3	26.3	.052
	SD	*14.6*		*14.8*	*14.1*			*13.2*	*16.4*	
	Median	19.8		21.5	18.4			19.3	23.5	
Total Fat	Mean	30.8		31.3	29.4	.131		29.2	33.4	.189
	SD	*18.0*		*17.6*	*19.0*			*15.0*	*21.6*	
	Median	27.4		28.6	25.2			26.7	31.8	
Fiber	Mean	26.1		27.0	24.0	.087		24.3	29.1	.040
	SD	*17.3*		*17.1*	*17.9*			*15.6*	*19.5*	
	Median	22.9		22.8	22.1			20.9	24.1	
Cholesterol (Chol)	Mean	18.3		18.7	17.4	.035		16.7	20.9	.068
	SD	*14.2*		*12.1*	*18.4*			*11.5*	*17.2*	
	Median	14.9		15.5	14.0			14.3	15.3	
Sodium (Na)	Mean	39.0		39.3	38.3	.452		37.5	41.6	.164
	SD	*20.2*		*20.8*	*18.8*			*17.9*	*23.3*	
	Median	33.7		33.4	35.4			33.0	35.4	
Vit A	Mean	40.5		39.8	42.4	.072		37.3	45.8	.009
	SD	*48.1*		*34.5*	*71.5*			*54.6*	*36.8*	
	Median	26.5		27.2	21.1			25.6	34.9	
Vit C	Mean	34.5		37.5	27.3	.004		30.4	41.2	.004
	SD	*32.5*		*32.8*	*31.0*			*30.1*	*35.2*	
	Median	27.2		29.0	18.4			21.0	33.9	
Calcium (Ca)	Mean	20.6		22.1	16.9	.027		18.9	23.4	.330
	SD	*17.3*		*18.9*	*12.1*			*12.2*	*22.7*	
	Median	16.2		16.7	14.3			16.0	16.5	
Iron (Fe)	Mean	31.7		33.5	27.5	.012		27.0	39.2	.003
	SD	*26.2*		*26.4*	*25.3*			*19.3*	*32.8*	
	Median	24.2		25.1	18.6			22.5	28.7	
Vit D	Mean	19.2		20.0	17.4	.027		17.6	22.1	.048
	SD	*18.4*		*17.6*	*20.3*			*16.7*	*20.5*	
	Median	14.1		14.5	10.4			12.6	18.2	

*Missing race for 2 participants; White and non-White do not equal total of 200

***Table 2b:* Days Food Inventories meet Nutritional Adequacy for DRIs/RDAs**

	DRI/ RDA	ALL SC N=194*		FEMALES N=138*	MALE S N=56*	p		WHITE S N=118*	NON-WHITES N=75*	p
KCals EER (a)	Mean	30.9		33.9	23.5	.000		29.6	33.1	.147
	SD	17.9		18.3	14.5			15.9	20.6	
	Median	26.3		30.1	19.4			26.3	29.7	
Protein DRI/EAR(b)	Mean	39.3		40.6	36.0	.011		36.0	44.6	.215
	SD	*27.5*		*25.5*	*31.8*			*20.7*	*35.1*	
	Median	30.1		32.5	26.5			30.2	30.5	
		N=200		N=142	N=58			N=118	N=80	
Carbohydrate (CHO)	Mean	55.0		57.0	50.2	.078		51.5	60.8	.052
	SD	*33.7*		*34.1*	*32.6*			*30.5*	*37.8*	
	Median	45.9		49.5	42.4			44.5	54.2	
Cholesterol (Chol) Dietary Guidelines	Mean	18.3		18.7	17.4	.035		16.7	20.9	.068
	SD	*14.2*		*12.1*	*18.4*			*11.5*	*17.2*	
	Median	14.6		15.5	14.0			14.3	15.3	
Sodium (Na)	Mean	77.1		78.1	74.7	.468		74.4	81.7	.203
	SD	*40.1*		*41.5*	*36.7*			*35.7*	*46.0*	
	Median	66.2		66.1	68.3			65.4	69.1	
Vit A	Mean	81.0		85.2	70.7	.001		74.4	91.9	.013
	SD	*89.6*		*74.0*	*119.2*			*98.0*	*75.4*	
	Median	55.4		58.4	33.8			50.1	71.0	
Vit C	Mean	26.6		30.0	18.2	.0001		23.7	31.3	.006
	SD	*25.3*		*26.2*	*20.7*			*24.1*	*26.5*	
	Median	19.8		23.2	12.3			16.6	25.7	
Calcium (ca)	Mean	17.4		18.4	14.9	.076		15.9	20.0	.330
	SD	*14.7*		*15.7*	*11.4*			*10.2*	*19.4*	
	Median	13.7		13.9	12.3			13.7	13.8	
Iron (Fe)	Mean	71.4		75.3	61.9	.012		60.8	88.1	.003
	SD	*58.9*		*59.4*	*56.9*			*43.5*	*73.7*	
	Median	54.4		56.4	41.9			50.5	64.6	
Vit D	Mean	10.1		10.3	9.5	.052		9.0	12.0	.035
	SD	*9.8*		*9.3*	*11.0*			*8.4*	*11.4*	
	Median	7.1		7.7	5.5			6.4	9.6	
Fiber DRI/AI (c)	Mean	28.6		32.2	20.0	0		26.9	31.6	.062
	SD	*19.7*		*20.3*	*14.9*			*18.2*	*21.6*	
	Median	24.6		27.2	18.4			21.6	27.9	

*Missing values prohibiting calculation for race or kcal and/or protein on total population

3a: Days Food Inventories meet Nutritional Adequacy for Daily Values

	N	DV Days	KCals	Protein	CHO	Total Fat	Chol	Na	Vit A	Vit C	Ca	Iron	Vit D	Fiber
WHITE FEMALES	88	Mean	24.9	32.9	22.4	28.8	17.4	37.0	34.5	34.4	19.6	28.7	18.7	24.9
		SD	*12.3*	*17.3*	*12.7*	*14.8*	*11.3*	*18.1*	*31.9*	*32.8*	*12.9*	*20.7*	*17.0*	*16.2*
		Median	22.1	29.1	19.8	26.4	14.5	32.5	26.2	25.7	16.8	24.6	14.0	20.9
WHITE MALES	30	Mean	25.2	34.6	22.1	30.1	14.8	38.9	45.3	18.6	16.7	22.0	14.3	22.6
		SD	*12.5*	*20.2*	*14.9*	*15.6*	*12.1*	*17.4*	*94.2*	*15.4*	*9.8*	*13.7*	*15.8*	*13.8*
		Median	21.3	30.6	18.5	26.9	13.9	36.7	19.7	14.4	14.3	16.4	8.5	21.4
P-value			.436	.424	.413	.382	.109	.166	.0993	.008	.156	.052	.020	.345
NON-WHITE FEMALES	54	Mean	31.3	43.3	28.5	35.4	20.8	43.1	48.3	42.6	26.2	41.2	22.0	30.6
		SD	*17.1*	*27.5*	*17.1*	*20.8*	*13.1*	*24.4*	*37.2*	*32.4*	*25.4*	*32.5*	*18.6*	*18.0*
		Median	29.0	38.6	25.4	32.9	17.0	36.5	36.0	37.7	16.6	35.3	19.5	27.8
NON-WHITE MALES	26	Mean	25.9	45.1	21.9	29.3	21.1	38.5	40.8	38.3	17.8	34.8	22.1	26.0
		SD	*16.8*	*42.4*	*13.9*	*23.0*	*23.9*	*20.8*	*36.3*	*41.0*	*14.5*	*33.7*	*24.5*	*22.3*
		Median	19.1	29.6	17.8	18.5	14.4	30.5	34.9	26.0	14.6	23.0	17.0	23.1
P-value			.047	.192	.044	.064	.104	.239	.125	.123	.084	.075	.341	.071
WHITE FEMALES	88	Mean	24.9	32.9	22.4	28.8	17.4	37.0	34.5	34.4	19.6	28.7	18.7	24.9
		SD	*12.3*	*17.3*	*12.7*	*14.8*	*11.3*	*18.1*	*31.9*	*32.8*	*12.9*	*20.7*	*17.0*	*16.2*
		Median	22.1	29.1	19.8	26.4	14.5	32.5	26.2	25.7	16.8	24.6	14.0	20.9
NON-WHITE FEMALES	54	Mean	31.3	43.3	28.5	35.4	20.8	43.1	48.3	42.6	26.2	41.2	22.0	30.6
		SD	*17.1*	*27.5*	*17.1*	*20.8*	*13.1*	*24.4*	*37.2*	*32.4*	*25.4*	*32.5*	*18.6*	*18.0*
		Median	29.0	38.6	25.4	32.9	17.0	36.5	36.0	37.7	16.6	35.3	19.5	27.8
P-value			.009	.017	.011	.040	.068	.081	.015	.016	.203	.004	.127	.016
WHITE MALES	30	Mean	25.2	34.6	22.1	30.1	14.8	38.9	45.3	18.6	16.7	22.0	14.3	22.6
		SD	12.5	*20.2*	*14.9*	*15.6*	*12.1*	*17.4*	*94.2*	*15.4*	*9.8*	*13.7*	*15.8*	*13.8*
		Median	21.3	30.6	18.5	26.9	13.9	36.7	19.7	14.4	14.3	16.4	8.5	21.4
NON-WHITE MALES	26	Mean	25.9	45.1	21.9	29.3	21.1	38.5	40.8	38.3	17.8	34.8	22.1	26.0
		SD	*16.8*	*42.4*	*13.9*	*23.0*	*23.9*	*20.8*	*36.3*	*41.0*	*14.5*	*33.7*	*24.5*	*22.3*
		Median	19.1	29.6	17.8	18.5	14.4	30.5	34.9	26.0	14.6	23.0	17.0	23.1
P-value			.242	.195	.316	.152	.227	.330	.111	.032	.417	.085	.079	.472

Table 3b: **Days Food Inventories meet Nutritional Adequacy for DRIs/RDAs**

	N		KCals EER (a)	N	Protein EAR (b)	N	CHO	Chol (d)	Na	Vit A	Vit C	Ca	Fe	Vit D	Fiber AI (c)
WHITE FEMALES	88	Mean	31.9	88	38.0	88	51.7	17.4	73.8	74.0	27.5	16.4	64.6	9.4	29.6
		SD	16.0		*21.0*		*29.4*	*11.3*	*36.3*	*68.4*	*26.3*	*10.8*	*46.5*	*8.4*	*19.3*
		Median	28.5		31.9		45.6	14.5	64.0	56.0	20.6	14.0	54.5	7.1	24.8
WHITE MALES	30	Mean	23.0	30	30.3	30	51.1	14.8	76.0	75.4	12.4	14.5	49.5	7.7	18.9
		SD	*13.7*		*19.1*		*34.3*	*12.1*	*34.4*	*157.*	*10.3*	*8.1*	*30.8*	*8.4*	*11.5*
		Median	19.6		24.1		42.7	13.9	68.3	32.9	9.6	13.0	37.0	*4.7*	*17.8*
P-value			.0005		.022		.413	.109	.230	.005	.001	.291	.052	.034	.001
NON-WHITE FEMALES	50	Mean	37.5	51	45.2	54	65.7	20.8	85.1	103.5	34.1	21.8	92.8	11.8	36.4
		SD	21.4		*31.6*		*39.5*	*13.1*	*48.4*	*79.6*	*25.9*	*21.2*	*73.0*	*10.6*	*21.4*
		Median	32.9		32.7		58.6	17.0	72.9	77.0	30.0	13.8	79.3	9.7	33.1
NON-WHITE MALES	25	Mean	24.2	25	43.6	26	50.5	21.1	74.8	68.0	25.6	16.1	78.4	12.4	21.7
		SD	*16.0*		*42.0*		*32.2*	*23.9*	*40.4*	*60.5*	*27.3*	*14.5*	*75.7*	*13.2*	*18.6*
		Median	18.3		*27.7*		41.1	14.5	58.6	58.0	17.3	12.2	51.7	8.7	19.3
P-value			.002		.150		.040	.104	.200	.019	.028	.119	.075	.417	.001
WHITE FEMALES	88	Mean	31.9	88	38.0	88	51.7	17.4	73.8	74.0	27.5	16.4	64.6	9.4	29.6
		SD	*16.0*		*21.0*		*29.4*	*11.3*	*36.3*	*68.4*	*26.3*	*10.8*	*46.5*	*8.4*	*19.3*
		Median	28.5		31.9		45.6	14.5	64.0	56.0	20.6	14.0	54.5	7.1	24.8
NON-WHITE FEMALES	50	Mean	37.5	51	45.2	54	65.7	20.8	85.1	103.5	34.1	21.8	92.8	11.8	36.4
		SD	*21.4*		*31.6*		*39.5*	*13.1*	*48.4*	*79.6*	*25.9*	*21.2*	*73.0*	*10.6*	21.4
		Median	32.9		32.7		58.6	17.0	72.9	77.0	30.0	13.8	79.3	9.7	33.1
P-value			.058		.215		.011	.068	.099	.015	.016	.203	.004	.097	.016
WHITE MALES	30	Mean	23.0	30	30.3	30	51.1	14.8	76.0	75.4	12.4	14.5	49.5	7.7	18.9
		SD	*13.7*		*19.1*		*34.3*	*12.1*	*34.4*	*157.0*	*10.3*	*8.1*	*30.8*	*8.4*	*11.5*
		Median	19.6		24.1		42.7	13.9	68.3	32.9	9.6	13.0	37.0	*4.7*	*17.8*
NON-WHITE MALES	25	Mean	24.2	25	43.6	26	50.5	21.1	74.8	68.0	25.6	16.1	78.4	12.4	21.7
		SD	*16.0*		*42.0*		*32.2*	*23.9*	*40.4*	*60.5*	*27.3*	*14.5*	*75.7*	*13.2*	*18.6*
		Median	18.3		*27.7*		41.1	14.5	58.6	58.0	17.3	12.2	51.7	8.7	19.3
P-value			.476		.334		.316	.227	.319	.111	.032	.356	.085	.074	.472

a) EER. Estimated Energy Requirement; average energy intake predicted to maintain energy balance in a healthy adult of defined age, gender, weight, and level of physical activity. (p107), equation p 185 http://www.nal.usda.gov/fnic/DRI//DRI_Energy/107-264.pdf

(b) Estimated Average Requirement. Values are based on experimental or observational estimates assumed to be adequate when RDA cannot be determined =.66/kg/day.

(c) Adequate Intake; mean intake used when scientific evidence not sufficient to calculate EAR or RDA.

(d) 2010 Dietary Guidelines for Americans, recommendation dropped in 2015

Discussion

This cross-sectional study adds to the limited research addressing older Americans receiving HDMs. Although these meals are designed to provide 1/3 of the current Dietary Reference Intakes, limited mobility, economics and social factors place increased importance on the in-home food environment to provide adequate nutrition for recipients.

The Department of Homeland Security (DHS) recommends a two-week supply of basic foods in the event of an emergency, limiting those high in fat, protein and salt (DHS, 2014). The majority of clients in this study (62%) were found to have adequate kcals to meet their recommendations for over 21 days, only 14% had less than two weeks; protein inventories averaged 39 days, but sodium was found to be excessive in food pantries (average 77 days) . The complete food inventory remains an important factor to consider in designing meals; complementary foods contribute to nutritional adequacy. The development of basic food lists and/or meals recommended for an emergency stockpile for this population would be beneficial for preparedness. Additional research is needed to provide special attention to nutritional adequacy, convenience, regional availability, cultural and individual food preferences while limiting sodium.

Acceptable distribution of macronutrients as defined by the USDA Dietary Guidelines for Americans is as follows: 10-35% of kilocalories as protein, 45-65% carbohydrate and 20-35% fat. (USDA, 2010). As seen in Figure 1, all means were within these recommendations, however, % mean protein contents of inventories was found at the lower end of this range while % fat content averaged at the higher end of the recommended range; White males exceeded recommendations for fat although non-White females had the largest food inventory in terms of kilocalories.

At the time of data collection, Dietary Guidelines included cholesterol as a nutrient over consumed by Americans, and recommended to restricting intake to 300 mg/day. Cholesterol was evaluated as such in South Carolina food inventories resulting in a median of only about two weeks, a finding relatively limited compared to other nutrients studied and not highlighted in the discussion of results as it would be a nutrient of concern only if excessive. In 2015, this recommendation was dropped in Dietary Guidelines for Americans (due to insufficient evidence in the association of dietary cholesterol with serum cholesterol (USDA, 2015).

Dietary Guidelines of 2015 also identified vitamin C as a shortfall nutrient, under consumed relative to RDIs. In this study, food inventories of White males had lower amounts of available vitamin C and iron as compared to White females and non-White males; these were statistically significant. There is a risk for vitamin C deficiency in the elderly with limited food variety (National Institutes of Health, 2013); and although White males had fewer items recorded in the dataset from their food inventories as compared to White females or non-White females, non-White males had the least number of items recorded. Detailed examination of the major food sources of vitamin C in this segment of the population may provide insight into differences.

South Carolina lies within the “Stroke Belt”, a region observed to have significantly higher stroke prevalence as compared with non-southeastern regions of the US. Among other factors, socioeconomic status, overweight, obesity and hypertension have been studied as contributors to this excess in stroke (Liao, Greenlund, Croft, Keenan & Giles, 2009). To prevent and treat hypertension in seniors, The National Institutes of Health (NIH) recommends smoking cessation, eating a healthy diet, limiting sodium intake, engaging in physical activity and maintaining a healthy weight (NIH,2014).

Obesity remains a major public health focus in the US. Rates for those over 60 categorized as overweight reported as 71.6% (BMI ≥25); 35.4% for those with BMIs over 30 (Ogden, Carroll, Kit, and Flegal, 2014). The CDC reported 2013 statistics for SC adults over 18: 34.7% overweight, 31.7% obese (U.S DHHS, 2105). Similar results are reported in this study: 63% of clients overweight or obese with a BMI≥25, 35% overweight, (BMI 25-29.99), 28% obese, (BMI 30-39.99), and 1% morbidly obese (BMI 40 or above). Obesity is associated with many chronic diseases, and it is unclear whether it is a cause or result of disability in this population. Survival may have been shortened in those susceptible to negative health effects of obesity, but it may be protective in some providing a reserve in the event of critical illness.

Although plentiful in kilocalories, a poor diet can place seniors at a risk of malnutrition. It is estimated that 16% of those over 65 are classified as malnourished (Ahmed & Haboubi, 2010); over 80% of those ≥ 71 were found to exceed recommended energy allowances with intakes of nutrient-poor foods in NHANES 2001-2004 (Krebs-Smith, Guenther, Subar, Kirkpatrick & Dodd , 2010). Nutrient dense foods are recommended to maximize nutrients in kilocalories provided within the decreased energy requirements of aging. Further research into dietary composition and the substitution of nutrient dense foods in older adults is suggested.

Highest values for days meeting DVs and DRIs were found for vitamin A and sodium; nonperishable items such as canned vegetables, soups, packaged convenience foods and meals were frequently observed in home food pantries, providing economical shelf-stable foods that are easier to prepare if physical limitations are present. This finding is in accord with the excessive sodium intake reported by An (2015) who examined diets of program participants of home-delivered meals. Chemosensory alterations are highest in those over 80; (Rawal, Hoffman, Bainbridge, Huedo-Medina, & Duffy, 2015) perception of sweet and salty often diminishes first and along with reduced ability to smell, may result in higher use of salt (Orenstein, 2014). In addition, the presence of hypertension may increase the preference for salt in older adults (Villela, de-Oliveira, Villela, Bonardi, Bertani, Moriquti, Ferriolli & Lima, 2014).

Efforts aimed at providing fresh produce through the MOW program are currently being tested. The recipient of the meal receives the health benefit of unprocessed foods while local farmers receive financial support for fresh fruits and vegetables. Rural areas may experience additional barriers due to lack of access to a supermarket (Sharkey, Johnson & Dean, 2010), research regarding food purchase habits may provide insight into alternatives. Although USDA food patterns (USDA 2015) recommend 1½ to 2 cups of fruits per day, and 2 to 2 ½ cups vegetable per day for men and women over 51, the majority of clients in this study (55.5%) reported consuming only 2- ½ cup servings per day of fruit and/or vegetable, well below recommendations. One serving a day was reported by 37.5%.

The rate of obesity along with high sodium contents of food inventories place these seniors at higher risk for hypertension; the CDC reports that hypertension is present in 64% of men and 69.3% of women 65-74, and in 66.7% of men and 78.5% of women 75 and older (Centers for Disease Control, 2015). 68.5% of clients in this study responded that they had been informed by their healthcare provider that they were hypertensive, yet only 15% of clients in the study reported restricting sodium in their diets. Weight reduction, sodium restriction and/or added calcium intake have been recommended in blood pressure management for seniors (Morley & Thomas, 2007; American Heart Association, 2014).

Vitamin D and calcium were found to be the limiting nutrients in this study as demonstrated by the number of days dietary recommendations could be met. Requirements for vitamin D and calcium increase with age, adequate intakes are recommended to prevent bone loss and lower hip fracture in older adults (Centers for Disease Control, 2015). Absorption may decrease with age and dietary supplementation is often prescribed if intake from foods is inadequate. Detailed information concerning supplements was not available in this study.

This study had several strengths and limitations. Participants in this study were 200 homebound seniors who received HDM services, and UPC codes provided objective collection of data on all in-home food supplies at the time of scanning. The usual method to establish food consumption is that of self-reports, subject to individual recall. In addition, height and weight were self-reported; studies show obese individuals overestimate height and underestimate weight; overestimation of height increases with age as individuals recall their optimum heights.

The highest frequency of statistically significant differences in home food inventories was found between races: White compared to non-White, and for females: White compared to non-White. The majority of participants in this study were females; females outnumbered males by 2.5 to 1. The lack of significant findings may be attributable to the power of the study.

Conclusion

The rapid growth of older Americans means the nation needs to respond to the increased demand for health care and aging-related services to help older adults to remain healthy, live independently in the community and practice healthy behaviors. Those receiving home-delivered meals may have additional barriers in achieving proper nutrition in terms of food procurement, storage, preparation and consumption. Challenges remain in providing essential nutrients for those with decreased energy needs to achieve and support healthy weights and prevent early death, disability, and its associated healthcare costs. Results of this cross-sectional study expand the limited research addressing the in-home food supply of this vulnerable population, and could assist in policy and program development for providing nutritious and culturally acceptable meals to the growing population of older adults in order to maintain or improve their nutritional status.

CHAPTER 3

VITAMIN D IN HOME FOOD INVENTORIES OF SENIORS RECEIVING HOME-DELIVERED MEALS IN SOUTH CAROLINA

Abstract

Vitamin D is commonly recognized as essential for adequate bone metabolism and maintenance, and continues to be studied in relation to many non-skeletal disorders. Decreased skin production of the vitamin precursor along with limited time spent outside by older adults means that the elderly are at particular risk for obtaining too little vitamin D from sun exposure and thus must place more importance on deriving their vitamin D from food and supplementation to maintain good health. This paper focuses on the estimated household food inventory of vitamin D of older adults in South Carolina receiving home-delivered meals; the home food inventory providing an indication of dietary behaviors. Home food inventories were collected during home visits using specialized software and a database connecting the Universal Product Codes of specific products with the information presented on the nutrition facts labels of those products. Clients were found to have more than adequate amounts of available vitamin D to meet Daily Values for an average of 17 days, and Recommended Dietary Allowances for an average of 9 days. Interestingly, it was found that non-White clients possessed even higher amounts of vitamin D in their food inventories than White clients. Further analysis may provide insight into differences in food sources that may account for this disparity. This knowledge is important for those organizations involved in supplemental feeding programs, determining food fortification and vitamin D supplementation, and in developing nutrition education and interventions to improve and maintain vitamin D status in this vulnerable population.

Keywords: Vitamin D, homebound elderly, household food inventory, Universal Product Code, home-delivered meals, nutrition in aging

Increasing life expectancy, along with the elevated birth rate during the “baby boom” years (1946-1964) is leading to an increase in the percentage of older adults in the United States population. According to reports from the United States Census Bureau, the population aged 65 and older is expected to grow from 43.1 million (14.4% of the population) in 2012 to 92.0 million (20% of the population) in 2060 (United States Census Bureau, 2012). The nation will need to respond to the increased demand for health care and aging-related services to help older adults to remain healthy, live independently and practice healthy behaviors.

Nutritional recommendations for the older adult are defined in the Dietary Reference Intakes for age categories 51 to 70 years and over 70 years (Institute of Medicine of the National Academy of Sciences, 2010). Energy needs decrease with increasing age due to a decline in physical activity; but nutrient needs may remain the same or increase due to altered absorption and metabolism (Bernstein, Munoz & Academy of Nutrition and Dietetics, 2012). Thus, the challenge for older adults is to meet nutritional needs for vitamins and minerals while consuming a diet lower in energy (Bernstein et al, 2012). Data suggest that older adults do not meet needs for vitamins D, E, and K or nutritional requirements for calcium, potassium and fiber, but exceed folate and sodium recommendations (Lichtenstein, Rasmussen, Yu, Epstein & Russell, 2008).

Vitamin D inadequacy is considered a global issue (International Osteoporosis Foundation, 2014; Gutierrez, 2013). Prevalence of vitamin D deficiency (defined as less than 50 nmol/L) as determined in the National Health and Nutrition Examination Survey (NHANES) 2005-2006, revealed an overall prevalence of 41.6%, with those ages 55-59 and 60-64 having the highest rates: 49% and 47% respectively; (rates were not significantly different between sexes) (Forrest & Stuhldreher, 2011). Older age puts individuals at risk for vitamin D deficiency due to a reduced time spent in the sunlight, altered absorption and metabolism in the liver and kidneys, decreased amounts of dermal 7-dehydrocholersterol, and reduced consumption of fortified foods (Zhang & Naughton, 2010).

Dietary assessment of vitamin D intake has been reported by comparing 24 hour diet recalls with the Institute of Medicine's (IOM) Dietary Reference Intakes (Institute of Medicine of the National Academy of Sciences, 2010). Less than seven percent of those studied through NHANES 2005-2006 had adequate dietary vitamin D intakes when compared to IOM recommendations (Bailey, Dodd, Goldman, Gahche, Dwyer, Moshfegh, Sempos & Picciano, 2010). Wallace, Reider & Fulgoni (2013) also reported high levels of vitamin D insufficiency; low-income, overweight or obese minority populations were at greater risk for low vitamin D intake in NHANES 2001-2008 data. The Scientific Report of the 2015 Dietary Guidelines for Americans Advisory Committee identified vitamin D and calcium as nutrients under consumed by older adults and stressed their importance for maintaining skeletal health recommending supplementation when sun exposure is limited (Office of Disease Prevention and Health Promotion, 2015).

Vitamin D is essential to maintain normal levels of calcium and phosphorus in the blood and vital for bone mineralization (DeLuca, 2004; National Academy of Sciences, 2011). In addition to the role in preventing or treating osteoporosis, studies in recent years have linked low concentrations of vitamin D to increased risk for cancer, cardiovascular disease, diabetic nephropathy, muscle weakness, multiple sclerosis, depression, obesity, impaired physical function, declining cognitive function, and mood disorders. (Bikle, 2014; Norman & Powell, 2014; Guan, Yang, Zhang, Wang & Liao, 2014; Adamo, 2014; Archer, 2013; Autier, Boniol, Pizot & Mullie, 2014). It remains unclear if these relationships are causal or resulting from low vitamin D levels, long-term studies are needed to clarify these associations (Meehan & Penckofer, 2014).

Vitamin D can be produced in the body after sun exposure or obtained from food naturally containing vitamin D, vitamin D fortified foods, or vitamin D supplements. There are few naturally occurring dietary sources of vitamin D; the flesh of fatty fish (salmon, mackerel, tuna and sardines) and fish liver oil in lean fish, egg yolk, and mushrooms grown in ultraviolet light providing the richest sources of naturally occurring vitamin D. In the United States, most vitamin D (about 65 to 86%) is provided by vitamin D fortified foods, including fluid milk, breakfast cereals, margarines, juices, and select cheeses (Moore, Murphy & Holick, 2005; American Public health Association, 2008, U.S. Department of Health and Human Services, 2014). Other foods such as soy products and yogurt may be fortified with small amounts. In the past, vitamin D was only required to be declared on a food label if it was added as a fortificant (United States Food and Drug Administration, 2014). New Nutrition Facts labels will require the addition of nutrients of public health concern: vitamin D and potassium (U.S. Food and Drug Administration, 2015).

Sun exposure is considered an important source of vitamin D, accounting for 80-90% of vitamin D formation (Halfon, Phan &Teta, 2015). Cutaneous vitamin D synthesis is decreased in northerly geographic locations due to the angle of the sun, smog blocking sun rays, increased urbanization with resulting sedentary indoor lifestyles, clothing and concomitant surface area of exposed skin, the use of sunscreen, increased skin pigmentation and aging. The amount of the vitamin D precursor 7-dehydrocholesterol in the skin decreases with age, reducing the capacity of the skin to produce cholecalciferol (MacLaughlin & Holick, 1985). With equal sun exposure, individuals seventy years old are able to make only 25% percent of the vitamin D synthesized by a 20 year old (Holick, 2004).These age-related changes coupled with the decreased time spent outside by older adults means that the elderly are at particular risk for synthesizing too little vitamin D and thus must place more importance on deriving their vitamin D from food and supplementation to maintain good health.

Recent attention has been directed towards reducing falls and subsequent hip fractures in the elderly as these may result in long-term physical impairment. The CDC (2015) reports 258,000 hospital admissions annually for hip fractures and recommends adequate screening for osteoporosis and lifestyle changes: weight-bearing exercise and adequate intakes of both calcium and vitamin D; calcium supplements alone may not reduce fracture risk (Rizzoli, Bischoff-Ferrari, Dawson-Hughes & Weaver, 2014.) Increased vulnerability to adverse outcomes in the older adult, frailty, is linked to osteoporosis and low body mass index, both of which have nutritional implications and present significant public health issues of healthcare cost, morbidity and quality of life (Hubbard & Theou, 2012, Krishnan, Beck, Havelock, Eeles, Hubbard & Johansen, 2013, Fernandez-Barres, Martin, Canela, Garcia-Barco, Basora, Arija, 2015, Spiro & Buttriss, 2014).

Studies have reported low vitamin D intakes in the homebound, with significantly lower values on weekends when home-delivered meals were not available (Sharkey, 2003). Immobility and the inability to shop for oneself have been identified as barriers in meeting vitamin D requirements in this population (Locher, Ritchie, Roth, Sen,Vickers, & Vailas, 2009), placing greater emphasis on the availability of foods within the home. Data suggest that home food supplies are representative of actual eating behaviors supplying more than 70% of the food consumed by weight in American homes (Sisk, Sharkey, McIntosh, & Anding, 2010). Further research of the household food inventory of homebound seniors is needed; they likely depend more heavily on their home food inventory due to immobility, economics, health status and dietary restrictions.

The comprehensive inventory obtained from the use of a scanner provides an accurate and time-saving record of food items (Weinstein, Phillips, MacLeod, Arsenault & Ferris, 2006). Former studies have detailed a description of the amounts of calorie and selected nutrients in household food inventories (Schefske, Bellows, Byrd-Bredbenner, Cuite, Rapport, Vivar & Hallman, 2010; Byrd-Bredbenner, Abbot, & Cussler, 2009; Byrd-Bredbenner & Abbot, 2009), yet little is known about the vitamin D food sources in home food supplies. This study builds upon a previous report (Lashway, Hallman, Cuite, Byrd-Bredbenner, Ohman-Strickland, McWilliams & Robson) and describes the vitamin D available in the food supplies of homebound seniors to create recommendations that could assist the development of educational programs and/or policies intended to help supplemental feeding programs for older adults improve and maintain their vitamin D status.

Method

This cross-sectional study was part of a larger study of the homebound elderly described elsewhere (Hallman et al, 2014) that was conducted in collaboration with Meals on Wheels Association of America (MOWAA). Data was collected from 5/9/2011 to 3/14/2012; participants received compensation for their time. The study protocol was approved by the Institutional Review Board of Rutgers University. All participants signed an informed consent.

Sample

Participants in this study resided in South Carolina, and were recruited by Meals on Wheels staff. To be eligible to participate, individuals had to be home-bound seniors (aged 60 and above) with no overt signs of cognitive impairment, who lived alone, and had been receiving home delivered meals from their local Meals on Wheels (MOW) agency for at least six months prior to the start of the study. Participants received $10 and a refrigerator thermometer as compensation for their participation.

Measurement

Data collection occurred during a ten month period beginning in May 2011. Trained staff used handheld barcode scanners connected to laptop computers, following the protocol created by Byrd-Bredbenner & Bredbenner (2007) to conduct the inventories of participant's home food supplies. All foods were inventoried except those that do not make a significant contribution to the nutritional quality of a diet (i.e. alcoholic beverages, commercially prepared baby food, infant formula, pet foods, refrigerated leftovers, spices, condiments, coffee and tea) The inventory software was linked to databases matching Universal Product Codes (UPCs) with nutritional content.

Upon arrival in a participant's home, trained Meals on Wheels staff conducted a face-to-face interview to gather demographic data. Race, highest education level completed, monthly income, gender and date of birth were entered into computers prior to the scheduled appointment.

During data cleaning, the vitamin D content of inventoried foods was estimated using information from the USDA Nutrient Database, Release 26 (USDA, 2013), associated nutrition facts panels on food packages, or food manufacturers' websites. Fluid milk was assumed to be fortified (Institute of Medicine, 2011). Vitamin D on facts labels expressed as a Daily Value (DV; i.e. 400 IUs) were converted to micrograms (ug) as follows, in order to provide uniformity within the dataset:

Vitamin D in IU = vitamin D in μg x 40

Data Analysis

The total amount of Vitamin D available from each item in the food inventory was calculated by multiplying the amount of vitamin D per serving by the number of servings per container. Total household food supply of vitamin D availability was computed by summing up the vitamin D supplied by all foods in the household. Means and standard deviations were calculated for the total available vitamin D in the entire sample.

Total vitamin D was then divided by the Daily Value (400) to determine the number of days vitamin D would be available at 100% DV. Recommended Dietary Allowances (RDAs) for vitamin D are listed by gender and life stage group: 15 ug/day (600 IUs) for men and women 51 to 70 years, and 20 ug/day (800 IUs) for age 70 and above (Institute of Medicine, 2011). The total amount of household vitamin D was divided by the age appropriate reference value to determine the total number of days vitamin D was available at 100% RDA. As discussed previously, Mann-Whitney tests were used to determine significance.

Comparisons of vitamin D availability were made by race and gender. A log transformation was performed to correct for abnormally distributed data and allow for analysis by ANOVA. The constant of 1.01 was substituted for zero values in the dataset. Significance level was set at P=.05.

Demographic variables were stratified by sex then race and age; compared using chi-square. T-tests were performed on BMIs.

Results

Demographics/Anthropometrics

As shown in Table 1, the majority of clients were White females, over age 80 (median age 85), with incomes less than $900.00 per month. Most reported having attended and or completed a high school education. Males were on average younger, mean age was 78, median was 76. Females outnumbered males by 2.5 to 1. Of males who answered questions regarding education and/or income, most reported having attended or completed high school (46%) with incomes of <$900/month (44%). Most White males reported incomes over $1500.00/month while non-White males reported incomes less than $900.00 per month.

A comparison of age groups, 60-80 with those 80+ was significant for non-Whites and Whites (p=0.022). White males aged 60-80 were significantly different than White females (p=0.035), but this was not the case for non-Whites (p=0.054). Income was significant for all males compared to all females (p=0.038). The majority (54%) reported incomes <$900/month. Income was not significant for non-Whites (p=0.097) nor Whites (p=0.975) when comparing those 60-80 with those 80+. Education was significant in comparing all males and females (p=0.028), 56% having attended or completed high school. Education was also significant in the White population 60-80 when compared to those 80 years and older (p=0.020), but not in non-Whites (p=0.065).

T-tests resulted in statistically significant differences in BMIs between those aged 60-80 and those over 80 within races (p=0.005 for Whites, p= 0.021 for non-Whites); no difference was observed between males and females (p=.377).

Vitamin D in Household Food Inventories

The mean total amounts of vitamin D determined from household inventories are shown in Table 2 with gender and race comparisons in Figure 1. Figure 2 details the numbers of days the participants are able to meet their nutritional recommendations for Daily Values and Recommended Daily Allowances.

Mean in-home food inventories contained 7686 IUs of vitamin D, sufficient to meet recommendations for the DV for 19 days and RDA for 10 days. Overall, females had in-home vitamin D inventories that were 15% higher than males, significant at P=0.016. Non-Whites had on average a 25% higher household vitamin D inventory compared to Whites, but this difference was not significant (P=0.484). White females had 31% more vitamin D in their household inventories compared to their male counterparts, this result was significant (P=0.007). In comparison, non-White males had only about .003% more than their race's female counterpart, P=.0.632, not significant. Non-White females also had 18% more on average in household vitamin D inventories than White females (p=.994); non-White males had 54% more than White males (p=.223).

***Table 1*: Demographics/Anthropometrics for South Carolina Meals on Wheels Clients**

	Total N	%	Male	%	Female	%	P-Value	Non-White 60-80 yrs	Non-White 80+	P-Value	White 60-80 yrs	White 80+	P-Value
All SC	200		58	29.0	142	71.0		43	37		44	74	**.022**
White Race	118	59.0	30	25.4	88	74.6	0.260						
African American	76	38.0	25	32.9	51	67.1							
Other	4	2.0	1	25.0	3	75.0							
No Race Noted	2	1.0	2	100	0								
Male (2 No Race)	58							18	8	0.054	16	14	0.035
Female	142							25	29		28	60	
<$900	74	37.4	18	24.3	56	75.7	0.038	28	13	0.097	15	18	.975
$901-1125	23	11.6	5	21.7	18	78.3		3	2		7	11	
$1126-1500	17	9.1	6	35.3	11	64.7		1	5		5	7	
>$1500	22	10.6	12	54.5	10	45.5		3	2		7	9	
Refused	19	9.6	8	42.1	11	57.9	0.033	2	2	.434	3	12	0.040
No Answer	43	21.7	7	16.3	36	83.7		6	13		7	17	
Education N=198			56	28.3	142	71.7							
8th grade or less	48	24.7	15	31.3	33	68.7	**0.028**	12	14	0.065	3	19	**0.020**
Attended/ Completed HS	110	55.6	26	23.6	84	76.4		25	19		30	36	
Attended/Completed College	29	14.1	14	48.3	15	51.7		6	1		10	12	
Attended/Completed Grad/Prof School	11	5.6	1	9.0	10	91.0		0	3		1	7	
BMI Means +/-SD	28.1+/-7.5		27.8+/-7.4		28.2+/-7.6		0.377	30.9+/-8.4	27.3+/-6.3	0.021	30.1+/-10.3	25.8+/-4.2.	0.005

***Table 2*: Vitamin D in South Carolina Food Inventories**

	N		Total (IUs)	SD	P-Value	Days DV (400IUs)	SD	P-Value	Days RDA (600-800 IUS)	SD	P-Value
ALL SC	200		7685.61	7369.02		19.21	18.42		10.09	9.82	
White Race	118		7032.97	6682.69	0.484	17.58	16.71	0.048	8.99	8.43	0.035
Non-Whites	80		8821.10	8215.22		22.05	20.54		11.95	11.42	
White Females	88		7485.51	6778.27	**0.007**	18.71	16.95	**0.020**	9.44	8.43	0.034
White Males	30		5705.53	6316.17		14.26	15.79		7.65	8.41	
Non-White Females	54		8813.93	7443.10	0.632	22.03	18.61	0.341	11.75	10.57	0.417
Non-White Males	26		8836.0	9788.77		22.09	24.47		12.36	13.22	
All Males	58		6938.72	8130.70		17.35	20.33		9.53	11.00	
All Females	142		7990.68	7042.15	**0.016**	19.98	17.61	**0.027**	10.32	9.33	**0.023**
Males											
White			5705.53	6316.17		14.26	15.79		7.65	8.41	
Non-White	26		8836.0	9788.77	0.223	22.09	24.47	.079	12.36	13.22	0.074
Females											
White	99		7485.51	6778.27		18.71	16.95		9.44	8.43	
Non-White	54		8813.93	7443.10	0.994	22.03	18.61	0.127	11.75	10.57	0.097

***Figure 1:* Mean Total Vitamin D in Household Food Inventories (IUs)**

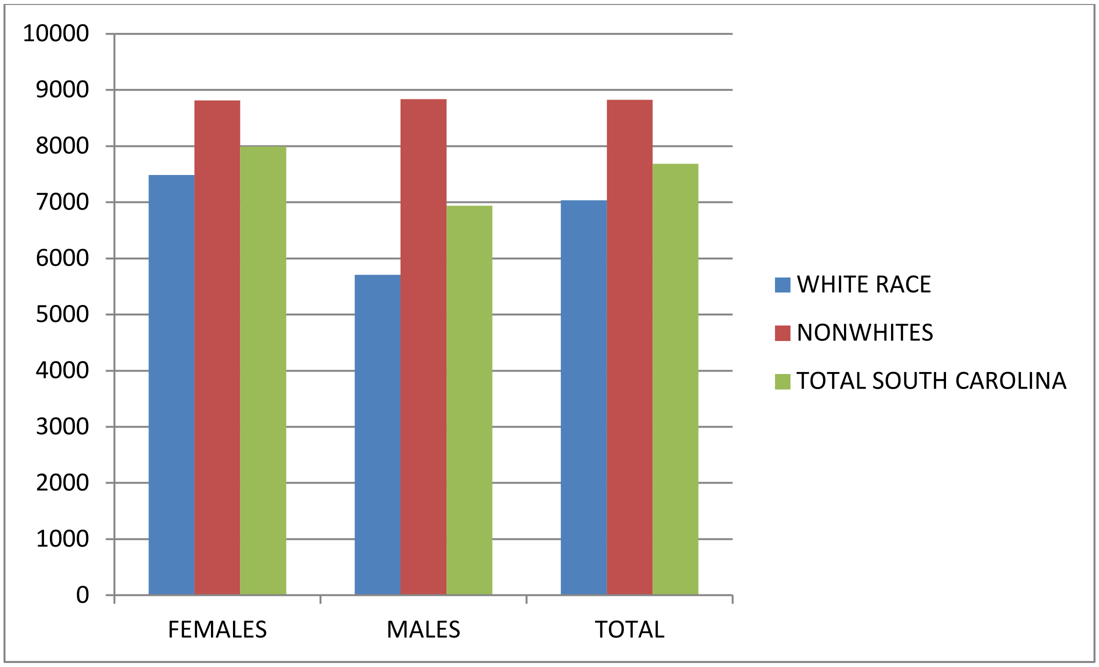
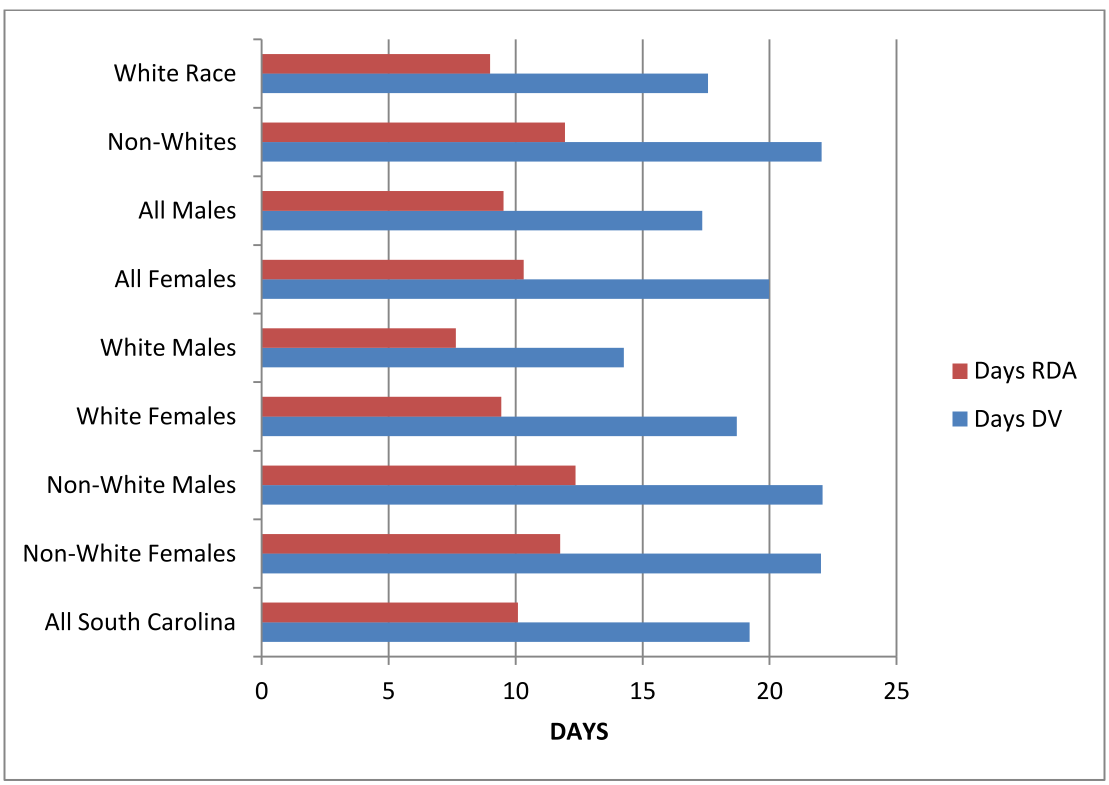


***Figure 2:* Number of Days Participants Can Meet Daily Value and Recommended Dietary Allowance for Vitamin D**



Discussion

This paper focuses on the overall in-home food inventory of vitamin D as determined by barcodes during home visits of homebound adults in South Carolina receiving home-delivered meals. A report by An (2015) found home-delivered meals to be effective in improving the dietary intakes of most nutrients of concern to older adults, however total energy, fat and vitamin D intake were not significantly increased. The Older Americans Act Nutrition Program was intended to address the needs of those over 60 by authorizing home-delivered and congregate meals designed to provide 1/3 of their corresponding Dietary Reference Intakes. To efficiently and effectively improve and support the nutritional status of this population, additional research is needed in evaluating the total diet of the homebound whose physical, mental, economic and social limitations result in greater dependence on the in-home food inventory to supplement home-delivered meals, especially in event that home delivery of meals is disrupted.

Obesity has been found to be associated with vitamin D deficiency (defined as serum 25 OHD levels less than 30ng/.mL), possibly due to the avoidance of sun in those overweight, a higher uptake of adipose tissue, or the increased production of metabolites suppressing hepatic synthesis (Wortsman, Matsuoka, Chen, Lu & Holick, 2000; Wallace, Reider & Fulgoni, 2013). Samuel & Borrell (2013) recently found 85% of obese adults with suboptimum levels suggesting that obese individuals may require greater vitamin D intake than thinner individuals to obtain optimum levels. This study found 63% of clients overweight or obese with a BMI ≥25; 35% classified as overweight and 28% classified as obese (BMI ≥30). The combined effects of reduced dermal production of vitamin D in older adults along with the presence of adiposity may present an argument for additional studies to determine if fortification and/ or supplementation is necessary in this segment of the population. Fortification is an inexpensive method to increase vitamin D intake in the diet but it is not without its hazards; safety of added levels is an issue. The National Institutes of Health define potential toxicity as blood levels of 25[OH] D) consistent above 200 ng/ml, and this is almost always the result of dietary supplements containing vitamin D (National Institutes of Health, 2011.)

Analysis of in-home food pantries showed that clients had more than adequate amounts of vitamin D despite the fact that the Institute of Medicine raised the recommended dietary allowance in 2010 to optimize bone health (National Academy of Sciences, 2011). Women consistently had higher inventories of vitamin D in their pantries than their male counterparts; however this gender difference was not statistically significant in the non-White race. Non-Whites were found to have in-home food inventories containing higher amounts of vitamin D than their White counterparts. Although p-values did not prove a statistical difference between races, further analysis into specific food sources of vitamin D may provide insight into differences. There were 40% more Whites than non-Whites, females outnumbered males by 2.5/1, possibly influencing the power of the study to show statistically significant differences.

Multiple sources report that African Americans have lower serum levels of vitamin D than Whites but half the prevalence of osteoporosis (Blann, 2015). Serum levels of 25(OH)D remain the best indicator of vitamin D status, however, a recent consensus statement recommended serum testing for diagnostic purposes only as most older adults will have low levels of serum 25(OH)D (American Geriatrics Society, 2014). Blood testing would require cost justification and place an additional burden on the individual; assumptions in this study can only be made about the availability of vitamin D in food inventories.

Requirements for vitamin D and calcium increase with age; adequate intakes are recommended to prevent bone loss and lower hip fracture in older adults (Centers for Disease Control, 2015). Absorption decreases with age and dietary supplementation is often prescribed if intake from foods is inadequate. A 2010 review of NHANES data found that 37% of adults studied reported using vitamin D supplements yet a high prevalence of those ≥ 71 failed to meet DRIs (Bailey et al, 2010). Detailed information concerning supplements was not available in this study but warrants further study to accurately estimate available nutrients.

This study had several strengths and limitations. The subjects in this study were 200 homebound seniors who received HDM services, and UPC codes provided objective collection of data on all in-home food supplies at the time of scanning. The usual method to establish food consumption is that of self-reports, subject to individual recall. In addition, height and weight were self-reported; studies show obese individuals overestimate height and underestimate weight. In addition, older individuals recall their optimum heights resulting in overestimation of current height.

Conclusion

The aging of our population and subsequent increase in chronic disease will have a profound effect on public health, social services and healthcare. Heart disease, cancer and cerebrovascular disease continue to be leading causes of death in those over 65. A healthy lifestyle, diet and exercise can help delay and/or treat chronic diseases and promote quality of life. Reduced intake of vitamin D containing foods, reduced dermal production of vitamin D, altered absorption and metabolism in the liver and kidneys, and obesity contribute to increased risk for deficiency in older adults. Vitamin D has been linked to metabolic disorders, cancer, heart disease, hypertension, diabetes, autoimmune diseases, and cognitive disorders. It remains unclear whether treatment of low levels of vitamin D will prevent or treat these diseases; long-term studies are needed. It is prudent for the medical community to continue to encourage adequate intakes for seniors to support the traditional role of vitamin D in skeletal health to decrease risks of falls and fractures. Although the homebound may be receiving home-delivered meals providing 1/3 RDA, their in-home food inventory takes on major importance to obtain adequate vitamin D due to limited mobility, economics and social factors. In this study, examination of the in-home food inventories of homebound adults in South Carolina showed more than adequate supplies of vitamin D.

CHAPTER 4

MAJOR FOOD SOURCES OF VITAMIN D IN HOME FOOD INVENTORIES OF SENIORS RECEIVING HOME-DELIVERED MEALS IN SOUTH CAROLINA

Abstract

The homebound senior remains at risk for vitamin D insufficiency due to limited sun exposure, increased use of sunscreen, clothing cover, impaired absorption and metabolism along with the decreased ability to synthesize vitamin D, and physical, social and economic limitations. Former studies have used universal product codes to evaluate home food inventories in U.S households for several nutrients yet little is known about the vitamin D sources in home food supplies. Studies have suggested that the in-home food inventories supply more than 70% of the food consumed in American homes making the in- home food inventory an important determinant of actual dietary intake at home. This study describes the major sources of vitamin D in the in-home food inventory of homebound seniors to provide insight into gender and ethnic differences regarding their sources of vitamin D. Fortified milk provided a mean of 21.5% of vitamin D for the homebound SC population receiving home delivered meals, with non-Whites possessing 27% less milk than Whites, values nearly half of that reported in NHANES 2003-2006. Fish was the major source of vitamin D in non-Whites, and was found to contribute 25.3% of total vitamin D for non-White males. This may be a function of culture, food preferences, real or perceived lactose intolerance, storage or purchasing barriers, and/or cost. To improve nutrient inadequacies, the attention to cultural differences, altered sensory perceptions, dietary restrictions and food preferences needs consideration when providing cost-effective home-delivered meals.

Keywords: home delivered meals, homebound adults, household food inventory, vitamin D, food sources vitamin D

A recent statement by the Centers for Disease Control warned of the risk of falls in adults aged 65 and over resulting in moderate to severe injuries such as hip fractures and head trauma. Prevention of disability takes on increased importance with the trend to "age in place" in the United States. Adequate calcium and vitamin D is recommended to reduce the risk of hip fractures and limiting independence in those affected (Centers for Disease Control and Prevention, 2015).

Vitamin D has long been recognized for its role in maintaining normal levels of calcium and phosphorus in the blood to promote skeletal homeostasis. In addition to its traditional role in preventing or treating osteoporosis, studies in recent years have linked low concentrations of vitamin D to cancer, cardiovascular disease, diabetic nephropathy, muscle weakness and frailty, multiple sclerosis, depression, obesity, impaired physical function, declining cognitive function, mood disorders, and type 2 diabetes. (National Institutes of Health, 2013,Clemente-Postigo, Munoz-Garach, Serrano, Garrido-Sanchez, Bernal-Lopez, Fernandez-Garcia, Moreno-Santos, Garriga, Castellano-Castillo, Carnargo, Fernandez-Real, Cardona, Tinahones &Macias-Gonzales, 2015, Bikle, 2014, Norman & Powell, 2014, Guan, Yang, Zhang, Wang & Liao, 2014, Adamo, 2014, Archer, 2013, Autier, Boniol, Pizot & Mullie, 2014, Halfon, Phan &Tetra, 2015). Although a recent study of recipients of Home Delivered Meals (HDMs) in North Carolina showed a promising reduction in falls in the homebound elderly studied when vitamin D supplements were offered (Houston, Tooze, Demons, Davis, Shertzer-Skinner, Kearsley, Kritchevsky & Williamson, 2015), it remains unclear whether treatment of low levels of vitamin D will prevent or treat other diseases; randomized control trials needed (Hossein-nezhad & Holick, 2013). Recommended Dietary Allowances (RDAs) were raised in 2010 and based on the optimization of bone health. RDAs range from 600 International Units for those aged 51- 70 to 800 International Units for men and women age 70 and above. The optimal dose and duration of vitamin D required to reduce mortality risk among older adults warrants further investigation (Chowdhury, Kunutsor, Vitezova, Oliver-Williams, Chowdhury, Kiefte-de-jong, Khan, Baena, Prabhakaran, Hoshen, Feldman, Pan, Johnson, Crowe, Hu &Franco, 2014).

Vitamin D deficiency is now a recognized global public health issue, but questions remain as to levels of 25(OH) D defined as deficiency (Hossien-nezhad et al, 2013). The Institute of Medicine (IOM) maintains that a blood level above 20 ng/mL is sufficient, while others stress levels above 30 ng/mL to minimize fall fracture in older adults (Dawson-Hughes, 2015).

Sun exposure is considered an important source of vitamin D, accounting for 80-90% of vitamin D formation with nutritional intake providing the remainder. (Halfon et al, 2015). Cutaneous vitamin D synthesis is affected by geographic location, increased urbanization with resulting sedentary indoor lifestyles, air pollution, clothing, surface area of exposed skin, the use of sunscreen and increased skin pigmentation. The amount of 7-dehydrocholesterol in the skin decreases with age; reduced function of the liver and kidneys results in lower vitamin D synthesis, placing added importance on major food and dietary supplementation to assure adequate vitamin D intake in older adults.

Natural food sources of vitamin D are limited to the flesh of fatty fish (salmon, mackerel, tuna and sardines) and fish liver oil in lean fish, and egg yolk. Most of the vitamin D in the American diet is provided by fortified foods (National Institutes of Health, 2014); dairy products contribute 60% (Quann, Fulgonni & Auestad, 2015). Fluid milk contains 100 IUs vitamin D per cup (National Academy of Sciences, 2011). Additional sources include fortified cereals, margarines and juices, UV-exposed mushrooms and other dairy products.

Dietary assessment of vitamin D intake has been reported by comparing twenty-four hour diet recalls with the Institute of Medicine's (IOM) Dietary Reference Intakes. Major food sources of vitamin D identified for adults more than fifty-one (NHANES 2003-2006) were that of milk (44% of total vitamin D) and fish or shellfish (17%) (O'Neil, Keast, Fulgoni & Nicklas, 2012). Earlier NHANES data showed vitamin D intake primarily from milk (58%), and nutritional supplements (30%-40%), with ready to eat cereal providing only 5% of total vitamin D (Calvo, Whiting and Barton, 2005). Further analysis found a significant difference in comparing vitamin D intake in black men and women in the US with their white counterparts; the former consuming lower amounts of fluid milk, ready to eat cereals and supplements. A recent study of an elderly German cohort reported a higher contribution of fish to dietary vitamin D (40%), followed by eggs (15%), fats and oils (13%), breads (12%) and with milk only contributing 12% (Jungert, Spinneker, Nagel & Neuhauser-Berthold, 2013).

Although this last study sheds light on the vitamin D intake of those 66 and older, data regarding dietary intake of US elderly is scarce; large individual differences exist (Engelheart & Akner, 2015). Challenges remain to provide adequate vitamin and mineral intake in the face of a reduce energy requirement; placing the elderly at increased risk for micronutrient deficiencies. A recent systematic review identified six nutrients of public health concern in community-dwelling older adults: vitamin D, thiamin, riboflavin, Ca Mg and Se (Borg, S., Verlaan, S., Hemsworth, J., Mijnarends, D., Schols, J., Luiking, C.,

& de Groot, L. 2015). Home-delivered meals are designed to provide 1/3 of their corresponding Dietary Reference Intakes, but physical, mental, economic and social limitations may result in greater dependence on in-home food inventory to supplement these meals. The in-home food inventory takes on added importance in the event that delivery of meals is disrupted; this has occurred in recent years with hurricanes.

Former studies have evaluated home food inventories in U.S households for saturated fat, total fat, cholesterol, sodium, total carbohydrate, sugar, dietary fiber, protein, vitamin A, vitamin C, calcium, iron and calories (Schefske, Bellows, Byrd-Bredbenner, Cuite, Rapport, Vivar & Hallman, 2010; Byrd-Bredbenner, Abbot, & Cussler, 2009; Byrd-Bredbenner & Abbot, 2009), yet little is known about the vitamin D sources in home food supplies. This study builds upon a previous report (Lashway, Hallman, Cuite, Byrd-Bredbenner, Ohman-Strickland, McWilliams, & Robson) and describes the major sources of vitamin D in the in-home food inventory of homebound seniors to provide insight into gender and ethnic differences regarding their sources of vitamin D. It is hoped this will assist in creating recommendations for educational programs and/or policies intended to help supplemental feeding programs for older adults to improve and maintain their vitamin D status.

Method

This cross-sectional study was part of a larger study of the homebound elderly described elsewhere (Hallman et al, 2014) that was conducted in collaboration with Meals on Wheels Association of America (MOWAA). Data was collected from 5/9/2011 to 3/14/2012; participants received compensation for their time. The study protocol was approved by the Institutional Review Board of Rutgers University. All participants signed an informed consent.

Sample

Participants in this study resided in South Carolina, and were recruited by Meals on Wheels staff. To be eligible to participate, individuals had to be home-bound seniors (aged 60 and above) with no overt signs of cognitive impairment, who lived alone, and had been receiving home delivered meals from their local Meals on Wheels (MOW) agency for at least six months prior to the start of the study. Participants received $10 and a refrigerator thermometer as compensation for their participation.

Measurement

Data collection occurred during a ten month period beginning in May 2011. Trained staff used handheld barcode scanners connected to laptop computers, following the protocol created by Byrd-Bredbenner & Bredbenner (2007) to conduct the inventories of participant's home food supplies. All foods were inventoried except those that do not make a significant contribution to the nutritional quality of a diet (i.e. alcoholic beverages, commercially prepared baby food, infant formula, pet foods, refrigerated leftovers, spices, condiments, coffee and tea) The inventory software was linked to databases matching Universal Product Codes (UPCs) with nutritional content.

Upon arrival in a participant's home, trained Meals on Wheels staff conducted a face-to-face interview to gather demographic data. Race, highest education level completed, monthly income, gender and date of birth were entered into computers prior to the scheduled appointment.

During data cleaning, the vitamin D content of inventoried foods was estimated using information from the USDA Nutrient Database, Release 26 (USDA, 2013), associated nutrition facts panels on food packages, or food manufacturers' websites. Fluid milk was assumed to be fortified (Institute of Medicine, 2011). Vitamin D on facts labels expressed as a Daily Value (DV; i.e. 400 IUs) were converted to micrograms (ug) as follows, in order to provide uniformity within the dataset:

Vitamin D in IU = vitamin D in μg x 40

Data Analysis

The total amount of Vitamin D available from each item in the food inventory was calculated by multiplying the amount of vitamin D per serving by the number of servings per container. Total household food supply of vitamin D availability was computed by summing up the vitamin D supplied by all foods in the household.

Household supplies of vitamin D were further detailed into food categories, the original 49 categories were collapsed into 11, using the USDA Food Categories (2008) as reference for food groupings. This was consistent with that used in NHANES (O'Neil et al, 2012). Although some foods could be further consolidated, they were analyzed to indicate the importance of shelf stable items in this population. This would enable comparison of the most recent data available from NHANES addressing major food sources of vitamin D in the population.

Percentages of foods were calculated and show amounts each food or major food group contributed to the total amount of vitamin D obtained from the food inventory; totals do not add up to 100% due to rounding. Comparisons detail differences found between gender and races; categorical analysis for 2xr tables by Simple Interactive Statistical Analysis (SISA).

Results

Demographics/Anthropometrics

As shown in Table 1, the majority of clients were White females, over age 80 (median age 85), with incomes less than $900.00 per month. Most reported having attended and or completed a high school education. Males were on average younger, mean age was 78, median was 76. Females outnumbered males by 2.5 to 1. Of males who answered questions regarding education and/or income, most reported having attended or completed high school (46%) with incomes of <$900/month (44%). Most White males reported incomes over $1500.00/month while non-White males reported incomes less than $900.00 per month.

A comparison of age groups, 60-80 with those 80+ was significant for non-Whites and Whites (p=0.022). White males aged 60-80 were significantly different than White females (p=0.035), but this was not the case for non-Whites (p=0.054). Income was significant for all males compared to all females (p=0.038). The majority (54%) reported incomes <$900/month. Income was not significant for non-Whites (p=0.097) nor Whites (p=0.975) when comparing those 60-80 with those 80+. Education was significant in comparing all males and females (p=0.028), 56% having attended or completed high school. Education was also significant in the White population 60-80 when compared to those 80 years and older (p=0.020), but not in non-Whites (p=0.065).

T-tests resulted in statistically significant differences in BMIs between those aged 60-80 and those over 80 within races (p=0.005 for Whites, p= 0.021 for non-Whites); no difference was observed between males and females (p=0.377).

Major Food Sources

Table 2 displays the results of major food sources of vitamin D in terms of ranks of availability in food inventories; NHANES 2203-2006 rankings are included for a national comparison. Fish and shellfish take on the role as the primary sources of vitamin D for males and non-Whites; ready to eat cereals are secondary in importance. Other groups had larger amounts of milk in their food inventories. Spreads were ranked 3rd in importance for Whites, but only 5th or 6th for non-Whites. Detailed percentages for all of South Carolina and race and gender comparisons can be seen in Tables 3 and 4.

Figure 1 compares the contribution of food groups providing the majority of vitamin D between results from South Carolina food inventories and available NHANES data (O'Neil et al, 2012). Whites are compared to non-Whites in Figure 2, females to males in Figure 3.

The six food groups that made up about 80% of the total vitamin D in the NHANES survey were: milk (43.9%), fish and shellfish (16.8%), eggs (6%), ready-to-eat cereals (5.6%), fruit juice (3.6%), and pork/ham/bacon (3.4%); the remainder provided by luncheon meats/hot dogs (3%), spreads (2.7%), cheese (2.2%), milk drinks (2.2%) and nutritional supplements (1.6%). In contrast, analysis of SC inventories showed the six highest sources contributing 80% of total vitamin D : milk (21.5%), and fish and shellfish, (21.1%), ready-to eat cereals (13.7%), spreads (11.3%), eggs and egg substitutes (11%), and cheese (4.1%); the remainder provided by nutritional supplements

(4.1%), luncheon meats/hot dogs (3.3%), pork/ham/bacon (3%), fruit juice (.6%), and milk drinks (.4). These differences between NHANES and SC were statistically significant, p=.009.

Although individual differences between importance of food groups may be apparent upon inspection for South Carolina participants, when considered as a whole only White males and non-White males were found to have significant differences, p=.006. Milk, fish and shellfish, eggs, and ready to eat cereals were ranked as the top four sources of vitamin D. Spreads rounded out the top five sources for most groups; nutritional supplements were found in larger amounts in the inventories of non-White males.

Table 1: Demographics/Anthropometrics for South Carolina Meals on Wheels Clients

								Non-White			White		
	Total N	%	Male	%	Female	%	P-Value	60-80 yrs	80+	P-Value	60-80 yrs	80+	P-Value
All SC	200		58	29.0	142	71.0		43	37		44	74	**.022**
White Race	118	59.0	30	25.4	88	74.6	0.260						
African American	76	38.0	25	32.9	51	67.1							
Other	4	2.0	1	25.0	3	75.0							
No Race Noted	2	1.0	2	100	0								
Male (2 No Race)	58							18	8	0.054	16	14	**0.035**
Female	142							25	29		28	60	
<$900	74	37.4	18	24.3	56	75.7	0.038	28	13	0.097	15	18	.975
$901-1125	23	11.6	5	21.7	18	78.3		3	2		7	11	
$1126-1500	17	9.1	6	35.3	11	64.7		1	5		5	7	
>$1500	22	10.6	12	54.5	10	45.5		3	2		7	9	
Refused	19	9.6	8	42.1	11	57.9	0.033	2	2	.434	3	12	0.040
No Answer	43	21.7	7	16.3	36	83.7		6	13		7	17	
Education N=198			56	28.3	142	71.7							
8th grade or less	48	24.7	15	31.3	33	68.7	**0.028**	12	14	0.065	3	19	**0.020**
Attended/ Completed HS	110	55.6	26	23.6	84	76.4		25	19		30	36	
Attended/Completed College	29	14.1	14	48.3	15	51.7		6	1		10	12	
Attended/Completed Grad/Prof School	11	5.6	1	9.0	10	91.0		0	3		1	7	
BMI Means +/-SD	28.1+/-7.5		27.8+/-7.4		28.2+/-7.6		0.377	30.9+/-8.4	27.3+/-6.3	0.021	30.1+/-10.3	25.8+/-4.2.	0.005

***Table 2*: Ranks of Major Food Sources of Vitamin D in Food Inventories**

	NHANES 2003-2006	ALL SC	FEMALES	MALES	WHITES	NON-WHITES	WHITE FEMALES	WHITE MALES	NON-WHITE FEMALES	NON-WHITE MALES
N	406	200	142	58	118	80	88	30	54	26
Milk	1	1	1	2	1	3	1	1	1	3
Fish and Shellfish	2	2	2	1	2	1	2	2	2	1
Eggs and Egg Substitutes	3	5	5	4	4	4	4	4	4	4
Ready to eat cereals	4	3	3	3	5	2	5	5	3	2
Spreads: Margarine and butter	8	4	4	5	3	5	3	3	5	6
Nutritional Supplements	11	7	7	8	7	6	7	9	8	5
Cheese	9	6	6	9	6	9	6	8	9	7
Luncheon meats, hot dogs, sausage	7	8	8	7	9	8	8	6	7	9
Pork, ham bacon	6	9	9	6	8	7	9	7	6	8
Fruit juice	5	10	11	N/A	11	N/A	11	N/A	10	N/A
Milk drinks	10	11	10	N/A	10	10	10	N/A	N/A	N/A

***Table 3:* Food Sources of Vitamin D among SC Older Adults vs. NHANES and Gender Comparisons**

	ALL SC	NHANES 2003-2006	Females	Males	White Females	White Males	Non-White Females	Non-White Males
N	200	406	142	58	88	30	54	26
% FROM FOOD GROUP								
Milk	21.5	43.9	23.9	15.5	25.8	20.3	21.0	11.3
Fish and Shellfish	21.1	16.8	21.6	19.9	22.6	16.7	20.0	25.3
Eggs and Egg Substitute	11.0	6.0	9.9	13.5	11.1	14.3	8.1	7.9
Ready to eat cereals	13.7	5.6	13.7	14.0	10.3	7.8	19.1	20.5
Spreads: Margarine and butter	11.3	2.7	11.3	11.3	13.4	16.4	8.0	6.3
Nutritional Supplements	4.1	1.6	4.2	3.8	4.3	1.5	3.9	6.7
Cheese	4.1	2.2	4.4	3.5	5.4	1.9	2.7	5.4
Luncheon meats, hot dogs, sausage	3.3	3.0	2.8	4.3	1.9	5.0	4.4	4.0
Pork, ham bacon	3.0	3.4	2.4	4.5	1.1	4.3	4.5	4.7
Fruit juice	0.6	3.6	0.9	0	0.9	0	0.9	0
Milk drinks	0.4	2.2	0.64	0	1.0	0	0	0
TOTAL*	94.1	91.0	95.5	90.3	97.8	88.2	92.6	92.1
P-value	**0.009**		**0.871**		**0.339**		**0.658**	

*Totals do not equal 100% due to rounding and additional sources not included in table: other meats, other dairy and mushrooms

Table 4: **Food Sources of vitamin D among SC Older Adults Race Comparisons**

	Whites	Non-Whites	White Females	Non-White Females	White Males	Non-White Males
N	118	80	88	54	30	26
% FROM FOOD GROUP						
Milk	24.4	17.8	25.8	21.0	20.3	11.3
Fish and Shellfish	21.1	21.7	22.6	20.0	16.7	25.3
Eggs and Egg Substitute	11.9	8.1	11.1	8.1	14.3	7.9
Ready to eat cereals	9.7	19.5	10.3	19.1	7.8	20.5
Spreads: Margarine and butter	14.1	7.5	13.4	8.0	16.4	6.3
Nutritional Supplements	3.6	4.8	4.3	3.9	1.5	6.7
Cheese	4.5	3.6	5.4	2.7	1.9	5.4
Luncheon meats, hot dogs, sausage	2.7	4.3	1.9	4.4	5.0	4.0
Pork, ham bacon	1.9	4.6	1.1	4.5	4.3	4.7
Fruit juice	0,7	0.6	0.9	0.9	0	0
Milk drinks	0.7	0	1.0	0	0	0
TOTAL*	95.3	92.5	97.8	92.6	88.2	92.1
P-value	**0.457**		**0.402**		**0.006**	

*Totals do not equal 100% due to rounding and additional sources not included in table: other meats, other dairy and mushrooms

***Figure 1*: Food Sources of Vitamin D in Homebound Seniors in South Carolina Compared with NHANES Ages 51+**

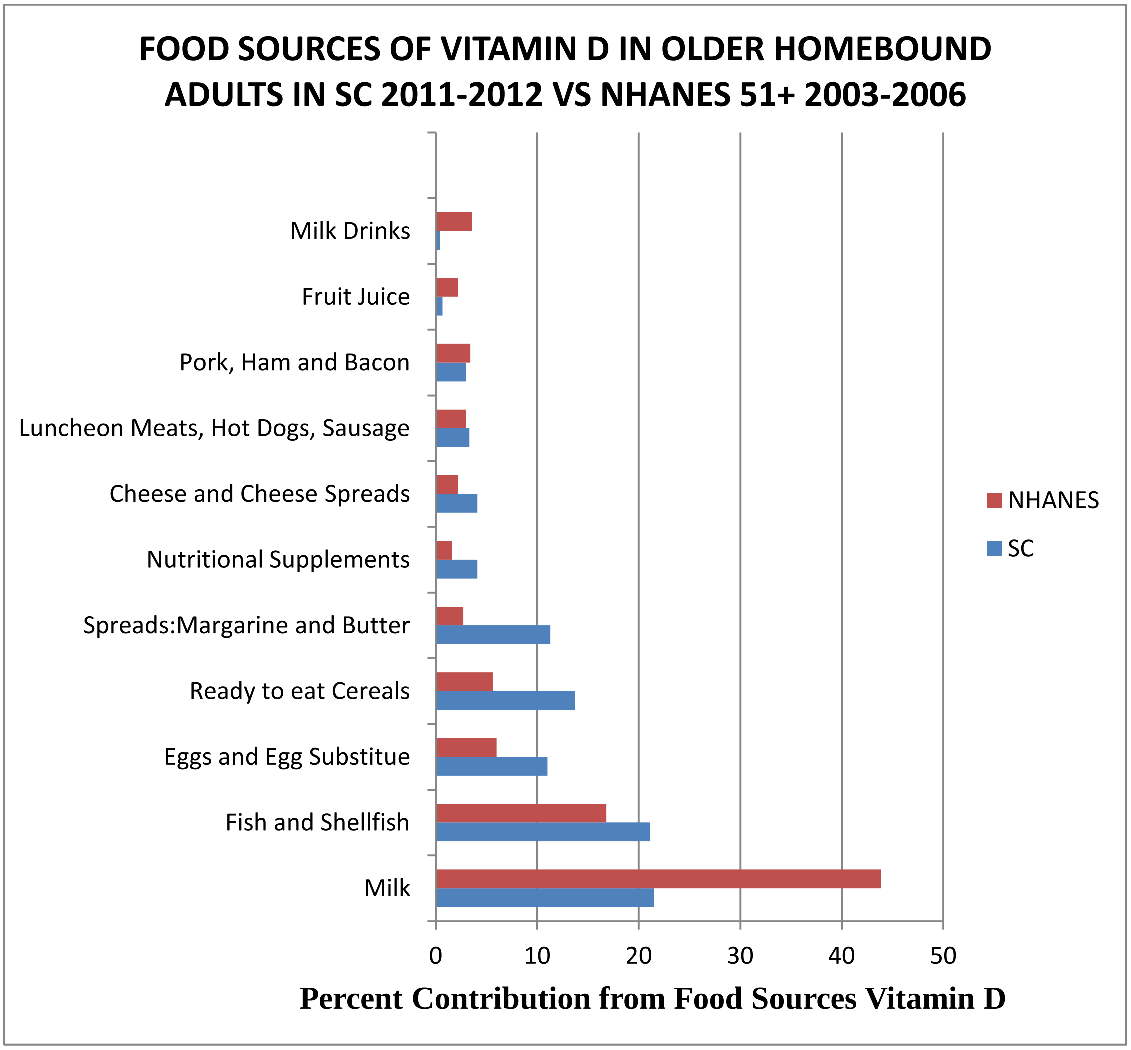


Figure 2: **Whites vs. non-Whites: Food Sources Vitamin D**

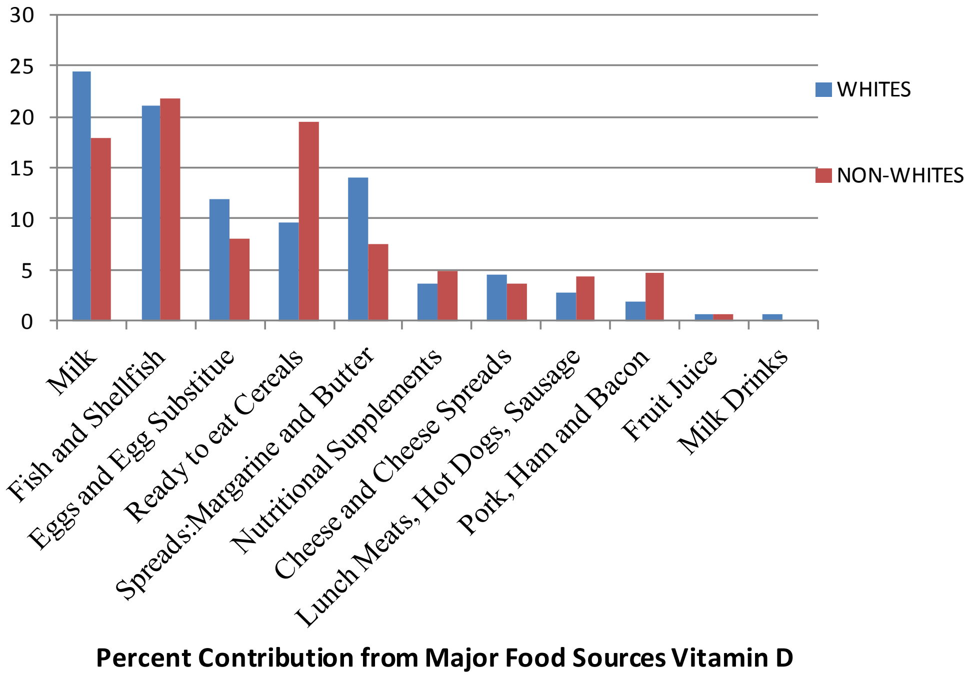


Figure 3: **Females vs. Males: Food Sources Vitamin D**

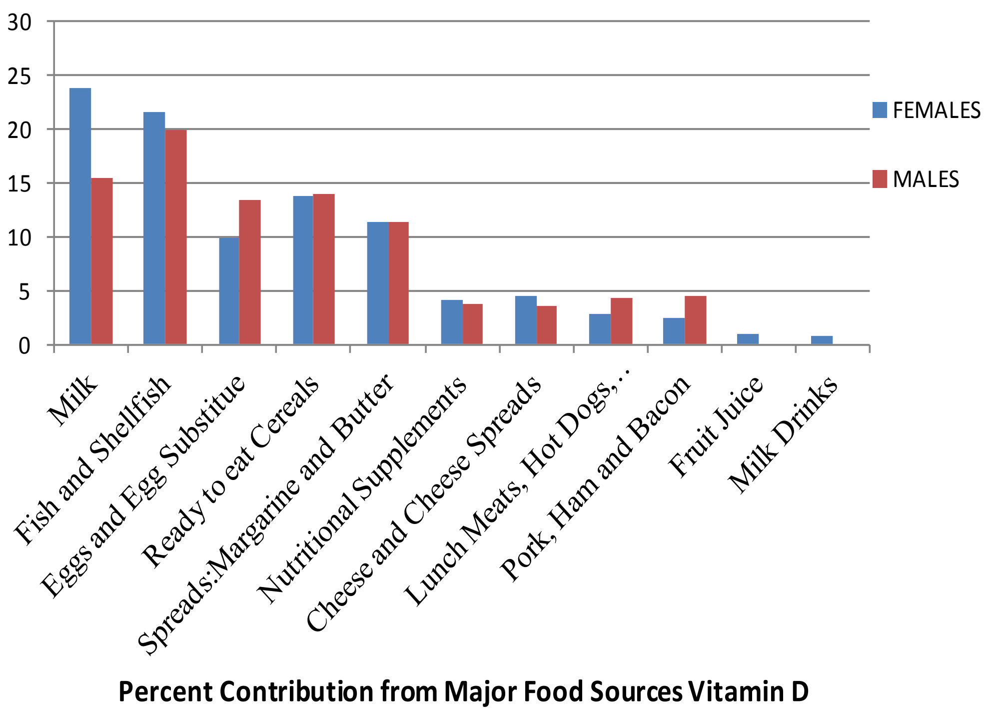


Table 5**: Nutrient Density & Cost Comparison/Oz Portion of Food Sources of Vitamin D in Common Supermarket**

Food Item 1 oz portion	Cost /oz	KCals	CHO g	Fat g	Protein g	Ca mg	K mg	Vit A IU	Vit C mg	Iron mg	Vit D µg
Canned Milk	**.08**	40.0	3.0	2.0	2.0	80	90.0	0	0	0	**0.6**
Canned Salmon	**.16**	36.4	0	1.4	5.5	68.2	100.0	0	0	.16	**4.42**
Canned Tuna (water)	**.16**	25	0	0	5.5	0	48.8	0	0	.36	**0.75**
Egg (large) **	**.14**	70	0	5.0	6.0	20.0	70.0	300	0	.72	**1.0***
Low fat Milk 2%	**.03**	15.0	1.5	0.63	1.00	37.5	47.5	62.5	0.3	0	**0.32**
Ready to eat Cereal (Cornflakes)	**.12**	110.0	26.0	0	2.0	0	70.0	1250	15.0	9.0	**1.0**

United States Department of Agriculture-USDA National Nutrient Database for Standard Reference, Release 28 –USDA: http://ndb.nal.usda.gov/ndb/foods/show/112?manu=&fgcd=**USDA price average for Southeast in Oct 2015: http://www.ams.usda.gov/mnreports/pybshellegg.pdf

Discussion

Home delivered meals are designed to provide 1/3 of the RDA, however, this meal may be the primary source of daily intake (Sharkey, Branch, Zohoori, Giuliani, Busby-Whitehead & Haines, 2002), only supplemented by the in-home food inventories. Studies have suggested that the in-home food inventories supply more than 70% of the food consumed in American homes making the in- home food inventory an important determinant of actual dietary intake at home (Sisk, Sharkey, McIntosh & Anding, 2010). The homebound seniors are likely exceeding this estimate due to economic, physical, social and /or mental limitations, difficulties in food preparation, consumption and their lack of access to transportation to purchase food. To improve nutrient inadequacies, the attention to cultural differences, altered sensory perceptions, dietary restrictions and food preferences needs consideration when providing cost-effective home-delivered meals. This paper expands former reports examining the nutritional content of food inventories of homebound older adults in South Carolina and details their major food sources of vitamin D, and may be beneficial in meal provision and nutrition education.

Vitamin D and calcium have long been accepted as important in skeletal maintenance with a recent recommendation from the CDC regarding fall prevention in older adults (Centers for Disease Control and Prevention, 2015). It appears low levels vitamin D may have an influence on many health outcomes, including the most recent report describing the decline in cognitive abilities in older adults (Harvey, Beckett, Green, Tomaszewsi, Reed, Olichney, Mungas & DeCarli, 2015). The homebound senior remains at risk for vitamin D insufficiency due to limited sun exposure, increased use of sunscreen, clothing cover, impaired absorption and metabolism along with the decreased ability to synthesize vitamin D, and physical, social and economic limitations.

Vitamin D content of foods can be found expressed as a % of Daily Values on a food label. At the time of this study, vitamin D content was only required on a label if it was added as a fortificant (United States Food and Drug Administration, 2014). To aid consumers in making informed food choices, the Food and Drug Administration proposed changes to the nutrition facts label to reflect nutrients of public health concern: vitamin D and potassium (U.S. Food and Drug Administration, 2015).

Dairy products have repeatedly been reported as the major contributor of vitamin D for adults, providing up to 60% of dietary vitamin D intake in the United States (Quann et al, 2015, Miller and Auestad, 2013). In this study, contribution of dairy products to total vitamin D ranged from 16.7% (non-White males) to 32.2% (white females); females had 51% more dairy products in their inventories than males. Moore and Radcliffe (2013) reported fortified milk providing the greatest source of vitamin D in NHANES 2007-2010 (43.7%); with a difference across race groups. Fortified milk provided a mean of 21.5% of vitamin D for the SC population, with non-Whites possessing 27% less milk than Whites, values nearly half of that reported in NHANES 2003-2006. Although the USDA guidelines recommend 3 cup servings per day from the dairy group (U.S. Department of Agriculture, 2015), milk consumption in the United States has continued to decline (U.S, Department of Agriculture, Economic Research Service, 2014). The majority of clients in this study (51.5%) reported consuming 2 servings of the dairy group per day (2 cups), 39.5% consume 1 cup/day and only 3% met dietary recommendations for dairy intake (3 cups).

Fish was the major source of vitamin D in non-Whites, and was found to contribute 25.3% of total vitamin D for non-White males. This may be a function of culture, food preferences, real or perceived lactose intolerance, storage or purchasing barriers, and/or cost. Lactase deficiency is more prevalent in African Americans, (National Institutes of Health, 2013); prevalence appears to increase with age (National Institutes of Health, 2013, Beto, 2015). Fish is the major contribution to vitamin D intake in the United Kingdom and Japan, and made up 40% of total vitamin D for independently living elderly subjects in Germany, suggesting geographic, cultural and food fortification differences (Jungert et al, 2014).

Ready to eat cereals were ranked third in importance for a vitamin D source for all of South Carolina, but secondary only to fish for non-Whites in this study. In NHANES data (O'Neil et al, 2012), ready-to eat cereals provided 5.6% of total vitamin D. Alberston, Wold & Joshi (2012) reported frequent consumption of ready to eat cereals associated with a higher intake of fiber, calcium, magnesium, vitamins B12, E and D, all key nutrients in senior populations. Increased intake of breakfast cereals has been suggested to concurrently increase milk intake in adults (Hill, Jonnalagadda, Albertson, Joshi & Weaver, 2012). This study documents the importance of ready-to-eat cereals, and their frequent consumption may be beneficial for meals and snacks, although generally considered a breakfast food.

Pork, ham and bacon contributed a mean of 4.6% of vitamin D in food inventories of non-Whites as compared to 1.9% for Whites, and 3.4% of vitamin D in NHANES data. Salting and frying meats were traditional methods of preservation that continue to influence cooking today. Fat back (fat from the back of a pig) is used as an ingredient to season and add moisture to foods; fat back was recorded in 9% of food inventories, of these, 72% were women.

Serum levels of 25(OH)D remain the best indicator of vitamin D status, however, a recent consensus statement recommended serum testing for diagnostic purposes only as most older adults will have low levels of serum 25(OH)D (American Geriatrics Society, 2014). It may be recommended for those who are homebound or have diagnoses that increase deficiencies (Drezner, Rosen & Mulder, 2015). Levels reflect that which is produced with sunlight and exogenous vitamin D from foods and supplements. Blood testing would require cost justification and place an additional burden on the individual; assumptions in this study can only be made about the availability of vitamin D in food inventories. .

Energy requirements decrease with increasing age; requirements for vitamin D and calcium increase with age; adequate intakes are recommended to prevent bone loss and lower hip fracture in older adults (Centers for Disease Control, 2015). The challenge for older adults is to meet nutritional needs for vitamins and minerals while consuming a diet lower in energy (Bernstein & Munoz, 2012). Increased intake of nutrient-dense foods is encouraged to achieve a quality dietary intake (Sahyoun & Vaudin, 2014). Table 4 details macro and micronutrients in major food sources of vitamin D providing cost per ounce. Appeal, convenience and price have been previously identified as most important factors in food selection of homebound adults (Locker, Ritchie, Roth, Sen, Vickers & Vallas, 2009); canned fish (especially salmon) and ready-to-eat cereal are reasonable nutrient-dense alternatives to fluid milk when budgets, access and storage are limited.

Vitamin D supplementation is often prescribed if intake from foods is inadequate. A 2010 review of NHANES data found that 37% of adults studied reported using vitamin D supplements yet a high prevalence of those ≥ 71 failed to meet DRIs (Bailey, Dodd, Gahche, Dwyer, McDowell, Yetley, Sempos, Burt, Radimer, & Picciano, 2010). Detailed information concerning supplements was not available in this study but warrants further study to accurately estimate available nutrients.

This study had several strengths and limitations. The subjects in this study were 200 homebound seniors who received HDM services, and UPC codes provided objective collection of data on all in-home food supplies at the time of scanning. The usual method to establish food consumption is that of self-reports, subject to individual recall. In addition, height and weight were self-reported; studies show obese individuals overestimate height and underestimate weight. In addition, older individuals recall their optimum heights resulting in overestimation of current height.

Conclusion

Although national studies have identified dairy products, especially milk as the major source of vitamin D in the diet of American adults, this study of in-home food pantries details other major sources of vitamin D. Canned fish and ready-to-eat cereals provide nutrient density, are shelf-stable and economical for homebound adults who may have limitations of food procurement, storage, preparation and consumption. Programs providing home-delivered meals need to consider these food preferences, cultural practices and sensory perceptions to improve and maintain nutritional status in homebound seniors.

CONCLUSION

To efficiently and effectively improve and support the nutritional status of this population, additional research is needed in evaluating the total diet of the homebound whose physical, mental, economic and social limitations result in greater dependence on the in-home food inventory to supplement home-delivered meals, especially in event that home delivery of meals is disrupted. Results of this cross-sectional study expand the limited research addressing the in-home food supply of this vulnerable population. Understanding gender, racial and cultural preferences in food choices will help public health professionals in working with government agencies to promote educational campaigns and food policies to improve and maintain the nutritional status in this vulnerable population who are at high risk for osteoporosis, diabetes, cancer, hypertension and heart disease. Adding to the nutrient density of preferred foods through the process of fortification remains an option to be tested for safety and acceptability.

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