EXAMINING DIETARY INTAKE, FOOD SECURITY AND HEALTH AMONG THE POPULATION WITH LOW INCOMES

by

Yue Qin

A Dissertation

Submitted to the Faculty of Purdue University

In Partial Fulfillment of the Requirements for the degree of

Doctor of Philosophy

Department of Nutrition Science

West Lafayette, Indiana

May 2023

THE PURDUE UNIVERSITY GRADUATE SCHOOL
STATEMENT OF COMMITTEE APPROVAL

Dr. Heather A. Eicher-Miller, Chair
Department of Nutrition Science

Dr. Dennis A. Savaiano
Department of Nutrition Science

Dr. Regan L. Bailey
Department of Nutrition Science

Bruce A. Craig
Department of Statistics

Approved by:
Dr. Laura E. Murray-Kolb

To my mom, dad and all my loved ones who have been with me through this journal, nearby and far away.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Food insecurity describes the lack of access to foods and affects 10.2% of general U.S. households and 27% of low-income households in 2021. Food insecurity is a pervasive public health concern in the United States and has been linked to poor dietary intake and diet quality, overweight and obesity (especially among women), and risk of other chronic diseases, such as diabetes, hypertension and dyslipidemia.

To better understand food security status and address its associated health and dietary outcomes among low-income populations, a conceptualized model was built and served as research framework for the dissertation, including 1) internal factors and motivations, such as traits related to self-efficacy and sufficiency that may influence diet and health; 2) external factors of temporary support, such as financial benefits from assistance programs that low-income populations are eligible for that may influence diet and health; and 3) external factors of potentially long-term support, such as nutrition education programs targeting low-income groups that may foster internalized knowledge that could sustain impact and improvement of diet and health in the long-term. Each chapter of this dissertation addresses a component of the model.

Cross-sectional analysis of a sample of rural veterans using food pantries quantified psychological traits related to self-motivation and efficacy including grit and help seeking, at the individual and internal factors level of the conceptualized model, and their links to food security and resource use, and revealed an inverse association between grit score and risk of food insecurity. The findings provided evidence for future interventions targeting food insecurity improvement to include education and resources that address traits related to self-efficacy, such as grit, among low-income populations to improve health outcomes directly or through improving food security or use of resources.

Using nationally representative data, the second study investigated relationships between food assistance through the Supplemental Nutrition Assistance Program (SNAP) participation, a type of societal level external support, and dietary outcomes among low-income older U.S. adults. There were no differences in dietary quality, usual nutrient intake or risk of inadequacy between SNAP participants and eligible nonparticipants. Furthermore, results revealed a high prevalence of not meeting the Estimated Average Requirement from dietary sources for several nutrients

(vitamins A, C, D, E, calcium, and magnesium) but the prevalence was lower when nutrients from dietary supplements were included. The results highlight a need for continued effort to improve nutrient and dietary intake among low-income older adults.

External factors of potentially long-term support (e.g. nutrition education and food assistance) were evaluated for relationships with body mass index. A longitudinal sample of low-income women interested in participating in nutrition education through SNAP-Education (SNAP-Ed) was examined to determine the relationship between nutrition education (SNAP-Ed) and food assistance program participation through (SNAP, WIC), separately and in combination, with long-term changes in body mass index. No differences in changes of weight status over time were observed by nutrition education, food assistance, or combination participation. The prevalence of obesity was high among this sample, calling for targeted obesity prevention interventions and further support of healthy lifestyle promotion among low-income populations.

The findings shown in this dissertation further reveal a high health burden among low-income groups. The studies filled several research gaps described in the conceptualized model. The results may be used to inform future tailored interventions to address food insecurity, dietary and health outcomes at individual and societal levels, incorporating internal motivation and external support to mediate health and dietary risks among low-income population.

CHAPTER 1. INTRODUCTION

1.1 Food Insecurity

Poverty thresholds are a set of income thresholds varying by family size and composition but not geographical locations used by the U.S. Census Bureau to determine poverty (1,2). Food insecurity, where there is limited or uncertain access to adequate food, is a pervasive public health concern in the United States (3) more prevalent among low-income households, below 185% poverty threshold, at 26.5% in 2021 compared to average U.S. households (10.2%) (4). Food insecurity is associated with numerous adverse dietary and health outcomes. Previous literature has shown food insecurity was linked to poor dietary intake and diet quality (5,6), overweight and obesity (especially among women) (7–9), and risk of other chronic diseases, such as diabetes, hypertension and dyslipidemia (10,11).

To better understand food security status and address its associated health and dietary outcomes among low-income populations, a conceptualized model (Figure 1), incorporates elements from the Health Belief model (12) and the Social Ecological Model (13), to serve as a research framework for this dissertation. The model includes: 1) internal factors and motivations, such as traits related to self-efficacy and sufficiency that may influence diet and health; 2) external factors of temporary support, such as financial benefits from assistance programs low-income populations are eligible for that may influence diet and health; and 3) external factors of potentially long-term support,, such as nutrition education programs targeting low-income groups that may foster internalized knowledge that could sustain impact and improvement of diet and health in the long-term.

The following sections will overview these 3 components of the conceptualized model in alignment with the 3 goals of this dissertation, introducing the background and existing literature gaps and providing justifications for these goals and the research included in this dissertation.

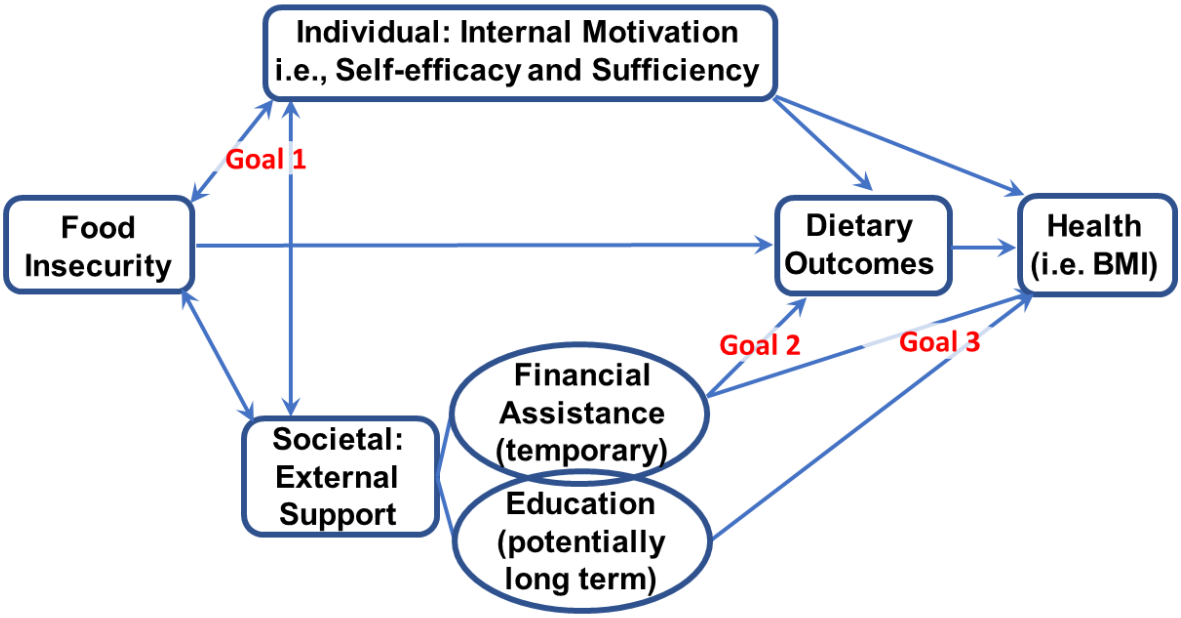

Figure 1.1 Conceptualized model for research framework to address food insecurity and its associated health risk among low-income populations.

1.2 Self-Efficacy, grit and help-seeking

Self-efficacy and sufficiency are part of the internal motivation for dietary and health outcomes at an individual level shown in the conceptualized model in figure 1. Some psychological traits could be related to self-efficacy and sufficiency, including help seeking, behaviors that might be related to the use of assistance programs and resources to help improve health and quality of life among low-income groups (14–16), and grit, a trait that indicates the determination to pursue long-term goals and future planning (17,18).

The poor health and high disease risk among low-income at-risk populations draws attention to the necessity for assessing traits related to self-efficacy that may potentially be improved through interventions. Specifically, help seeking behaviors were linked with improved motivation and performance (19), while grit was shown to be a favorable quality when facing adversities (20). However, help seeking behaviors among low-income populations or its potential association with food insecurity are unknown. Only two studies examined association between grit and food security (21,22). Nikolaus et al. (21) analyzed a cross-sectional sample of parent-child dyads from low-income households with data collected using an online survey while Myers et al. (22) used a

triangulation to collect data from of low-income households in a Louisiana community through online and in-person approaches. Both studies reported inverse association between grit and risk of food insecurity. Although the studies focused on low-income populations for high prevalence of food insecurity, neither assessed food assistance or other resource use or examined its potential relationship with grit. Grit may be a psychological factor that could be improved through interventions, fostering food security improvement. Evaluation of the relationship with food insecurity status, either directly or through use of societal or external resources through assistance programs is important to this end. However, only these two studies examined grit and food insecurity, and none focused on help seeking and food insecurity. Further assessment of these traits and investigation of their relationships to food security and use of resources among low-income groups are needed to potentially inform tailored intervention, through external resources such as education, to improve food insecurity and ultimately health outcomes among low-income populations.

1.3 Food Assistance (SNAP) Participation and Dietary Outcomes

Food assistance provides temporary financial assistance to low-income populations as an example of external support on the societal level illustrated in the conceptualized model shown in figure 1. Many food assistance programs were created to alleviate food insecurity. Their eligibility is based on the poverty guidelines, which are simplified versions of the poverty thresholds, (23,24). The largest federally funded food assistance program is the Supplemental Nutrition Assistance Program (SNAP). SNAP aims to alleviate food insecurity by improving access to healthy foods through monetary assistance to U.S. households with a monthly income at or below 130% of the federal poverty guidelines, or poverty income ratio (PIR), to purchase foods (25). SNAP Education (SNAP-Ed) compliments SNAP and provides nutrition education to SNAP eligible populations to promote healthy lifestyle behaviors recommended in the Dietary Guidelines for Americans (26). The participation in either of the programs is not required for participation in the other. The Special Supplemental Nutrition Program for Women Infants and Children (WIC) is another federal nutrition assistance programs that provides financial benefits to households with income less than or equal to 185% of PIR to improve access to food among pregnant, breastfeeding, or non-breastfeeding postpartum women, as well as infants, toddlers, and children under the age of five years (27,28). Existing evidence suggests that food assistance participation, specifically SNAP, is

associated with reduced likelihood and severity of food insecurity (29–37). Research also has shown improvement of food security because of SNAP-Ed participation (38–40), but there are mixed results for WIC participation and food security (41–44).

Unlike food security status, links between dietary outcomes and food assistance program participation, specifically SNAP, are not clear. For dietary quality specifically, some research has shown lower dietary quality among SNAP participants compared to eligible or noneligible nonparticipants using nationally representative data (45–48). On the other hand, some studies reported SNAP participation had no impact on dietary quality using local or nationally representative samples (49–51). Others found diet quality decreased as time passed since receipt of SNAP benefits among a longitudinal sample of women from Central Texas (52), or improved dietary quality with SNAP participation among non-Hispanic white participants using nationally representative sample (53). Most studies (45,46,50–53) used the Healthy Eating Index (HEI) to quantify dietary quality, which evaluates the conformance of dietary intake to the Dietary Guidelines for Americans (54,55), while other studies used a modified version of the HEI (47,49), or the American Heart Association diet scores (48).

Similar to dietary quality links with SNAP, limited evidence is present on the association between SNAP participation and nutrient intake, with mixed findings. A few previous studies reported no differences in nutrient intake between SNAP participants and income-eligible nonparticipants (45,47,56), but the risk for inadequate intake for several assessed nutrients were higher among SNAP participants compared to higher income nonparticipants (45,56). A few early studies examined the effect of SNAP participation on nutrient intake directly using longitudinal designs or economic modeling, and reported SNAP participation had no impact on nutrient intake among older adults (57,58), or negatively impacted nutrient intake among adults or elderly specifically (59,60). Only three studies (45,47,56) estimated usual nutrient intake, which is the habitual intake of nutrients over the long-term. Usual nutrient intake estimation is important because dietary and nutrient recommendations are intended to be met over time rather than on a single day. Among the three studies that estimated usual nutrient intake, two of them utilized the most up-to-date and rigorous methodology (the National Cancer Institute method) (47,56), while only one (56) examined a comprehensive list of nutrients (vitamins A, C, D, B6, B12, E, folate, niacin, riboflavin, thiamin, calcium, iron, magnesium, phosphorus, and zinc) with all nutrients of public health concern or those of high risk for inadequacy among low-income populations (6,26).

None of the studies considered intake from dietary supplements (DS) despite the high prevalence of DS use among Americans (52%) and especially for those who are elderly (75%), including low-income groups (66%) (61). Previous research also suggested that intake from DS might represent an important contribution to total nutrient intake for those that experience food insecurity (6). Estimation of usual nutrient intake from all sources (dietary and DS) among the low-income population, and especially groups with high prevalence of DS use, such as older adults, is needed to understand the current nutrient and dietary intake status. Furthermore, comparison of usual intake among those using SNAP or not is needed to determine links of food assistance, as a societal external support, with dietary outcomes, and understand the role of DS among these low-income populations.

1.4 Food Assistance, Nutrition Education and Weight Status

Nutrition education represents another type of external support at a societal level, along with food assistance, that may support low-income populations to mitigate health burdens by addressing food insecurity, healthful dietary intake, and health promoting lifestyles (Figure 1). Diet is a modifiable factor that influences weight status and obesity, which is associated with high prevalence of numerous chronic diseases (62,63). Overweight and obesity are more prevalent among populations with low-income and/or food insecurity compared to higher income (64,65) and/or food secure groups (7,8). Efforts from nutrition education and food assistance programs could support healthy weight in these groups through improved access to and selection of healthful foods. Additionally, nutrition education could be internalized to affect internal motivation and self-efficacy, which in turn might help reduce health risks in the long run. However, the links between education and food assistance programs participation separately and in combination with weight status as a health outcome have not been fully addressed.

Federal nutrition education programs, such as SNAP-Ed, do not provide direct financial assistance but offer nutrition education to SNAP-eligible populations. Yet, evaluations of nutrition education on weight status are limited. One study assessed weight status among a convenience sample of SNAP-Ed participants in Georgia and reported high prevalence of overweight (31%) and obesity (42%) (66). Similarly, another study compared two types of nutrition education curriculum among low-income parents and children, using a quasi-experimental design, also reported high prevalence of overweight (33%) and obesity (38%) among adult SNAP-Ed

participants (67). Prior randomized, controlled trials of SNAP-Ed improved long-term food security status, independent of other food assistance program participation, but not dietary quality or nutrient intake (38,39,68). However, the long-term impact of SNAP-Ed on weight status is unknown and stronger evidence from rigorous study designs are needed to fully evaluate program impacts and inform interventions targeting the low-income population to address the obesity epidemic.

Similar to SNAP-Ed, there is a lack of evidence on the association between WIC participation on weight status among adult participants. WIC targets low-income groups including: pregnant, breastfeeding and postpartum women, and infants and children up to five years old (69). Some studies found improvements in some measures of diet quality and nutrient intake after the WIC food package revision (70–72). Yet, the relationship between WIC and weight status has not been evaluated despite a potential link, either directly through benefits or indirectly through modifying other factors related to weight, such as dietary intake.

Unlike the other programs, extensive early studies have examined SNAP participation and its association with weight status. Most findings suggested a link between SNAP participation and increased weight or increased risk of overweight and obesity, especially among women (7,73–81). Yet, some reported this association among men only (82) or no association at all (83). Other studies found differential effects on weight status with SNAP participation varied by residential environment and age at receipt (84), and amount of benefits received (85). The studies used both cross-sectional (7,76,77,79,81,82,85,86) and longitudinal designs (73–75,78,80,83,84) to examine the impact of current, short-term and long-term participation of SNAP on weight status. Investigation SNAP participation on longitudinal weight status using recent samples among the low-income groups would help provide updated evidence of a potential relationship.

It is worth noting that a high percentage of the low-income groups that participated in nutrition education programs also participated in at least one of the other food assistance programs (38,39,87). However, evaluation of a combination of food assistance programs with education programs on short-term or long-term weight status is not documented. The combined effect of multiple program participation and potential interaction between different resource use should be explored, as understanding of such relationships could provide novel insights to design customized weight maintenance or obesity prevention interventions delivered through combinations of different programs using existing program framework, for enhanced effectiveness and reduced

cost. These societal level endeavors will hopefully improve weight status and reduce obesity-related disease risk and ultimately health among the low-income population.

1.5 Research Gap

Efforts addressing health risks through food security and dietary outcomes among the low-income populations could be approached from three aspects using the conceptualized model, including internal aspects of self-motivation and self-efficacy, and external aspects of food assistance programs and nutrition education programs. However, research gaps exist in all three areas of these model. This dissertation will explore this model through the lens of these three areas and will address several gaps in knowledge: 1. Associations between psychological traits including grit and help-seeking with food insecurity and resource use among the low-income population; 2. Current estimates of usual nutrient intake from dietary sources and with DS and dietary quality among SNAP participants and eligible nonparticipants; and 3. Links between long-term participation of food assistance programs (SNAP and/or WIC) and nutrition education program (SNAP-Ed) individually and in combination, and participant weight status.

1.6 Dissertation Research Goals, Hypothesis and Objectives

Goal 1: Examine the association of grit and help-seeking behavior with food insecurity and the use of resources among rural veterans at least 18 years of age from five food pantries in southern Illinois counties using a cross-sectional sample from March 2021 to November 2021

Hypothesis 1: Grit will be inversely associated with risk of food insecurity; help-seeking will be positively related to resource use

Goal 1 objectives:

1. Determine the grit status
2. Determine the help-seeking status
3. Determine the food security status
4. Determine the resource status
5. Characterize the associations between grit, help-seeking, with food insecurity and resource use, respectively

Goal 2: Determine and compare usual nutrient intake and dietary quality of low-income (PIR below 130%) older U.S. adults at least 60 years SNAP participants and income eligible nonparticipants using a nationally representative sample from 2007-2016 National Health and Nutrition Examination Survey

Hypothesis 2: Usual nutrient intake and dietary quality will be higher among SNAP participants compared to income eligible nonparticipants

Goal 2 objectives:

1. Determine and compare the national estimates of mean usual intake of nutrients from food, total nutrients (from food and supplements) by SNAP use and non-use
2. Determine and compare the national estimates of the proportion below the Dietary Reference Intake (DRI) recommendations by SNAP use and non-use
3. Determine and compare the national estimates of Healthy Eating Index (HEI) 2015 by SNAP use and non-use

Goal 3: Determine the long-term (1 year) links of participation in a SNAP-Ed intervention, food assistance programs, and their combination with BMI among a longitudinal randomized controlled trial (RCT) sample of Indiana SNAP-Ed eligible (PIR below 185%) women at least 18 years

Hypothesis 3: Participants' BMI will change over time with differences in different comparison groups by food assistance and education program use

Goal 3 objectives:

1. Determine the potential long-term impacts on BMI of direct, adult-focused SNAP-Ed intervention vs. no direct, adult-focused SNAP-Ed intervention among the RCT sample
2. Determine the potential long-term relationship of BMI with SNAP participation vs. no SNAP participation among the longitudinal sample
3. Determine the potential long-term relationship of BMI with SNAP participation only vs. SNAP and WIC participation among the longitudinal sample
4. Determine the potential long-term relationship of BMI with SNAP-Ed and SNAP and/or WIC vs. no SNAP-Ed but with SNAP and/or WIC or SNAP-Ed with neither SNAP nor WIC among the longitudinal sample

1.7 Dissertation Organization

The dissertation is organized in as "article-based" style, with each chapter consisting of articles published or submitted to peer-reviewed journals. Chapter 2 examines the association of grit and help-seeking behavior with food insecurity and the use of resources among rural veterans from five food pantries in southern Illinois counties using a cross-sectional sample. Chapter 3 determines and compares usual nutrient intake and dietary quality of low-income older adults by SNAP use. Chapter 4 determines the long-term impact of participation in a SNAP-Ed intervention, and relationships of food assistance programs, and their combination on BMI among lower income women in Indiana.

1.8 References

1. U.S. Census Bureau. How the Census Bureau Measures Poverty [Internet]. [cited 2023 Feb 14]. Available from: https://www.census.gov/topics/income-poverty/poverty/guidance/poverty-measures.html

2. U.S. Census Bureau. POV-01. Age and Sex of All People, Family Members, and Unrelated Individuals [Internet]. [cited 2023 Feb 14]. Available from: https://www.census.gov/data/tables/time-series/demo/income-poverty/cps-pov/pov-01.html#par_textimage_30

3. U.S. Department of Agriculture Economic Reserach Service. Definitions of Food Security [Internet]. [cited 2022 Oct 6]. Available from: https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-u-s/definitions-of-food-security/

4. U.S. Department of Agriculture Economic Research Service. Food Security Status of U.S. Households in 2021 [Internet]. [cited 2023 Feb 14]. Available from: https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-u-s/key-statistics-graphics/#householdtype

5. Leung CW, Epel ES, Ritchie LD, Crawford PB, Laraia BA. Food Insecurity Is Inversely Associated with Diet Quality of Lower-Income Adults. J Acad Nutr Diet Elsevier B.V.; 2014;114:1943-1953.e2.

6. Cowan AE, Jun S, Tooze JA, Eicher-Miller HA, Dodd KW, Gahche JJ, et al. Total usual micronutrient intakes compared to the dietary reference intakes among U.S. adults by food security status. Nutrients MDPI AG; 2020;12.

7. Townsend MS, Peerson J, Love B, Achterberg C, Murphy SP. Food insecurity is positively related to overweight in women. J Nutr 2001;131:1738–45.

8. Martin KS, Ferris AM. Food Insecurity and Gender are Risk Factors for Obesity. J Nutr Educ Behav 2007;39:31–6.

9. Nettle D, Andrews C, Bateson M. Food insecurity as a driver of obesity in humans: The insurance hypothesis. Behav Brain Sci Cambridge University Press; 2017;40.

10. Seligman HK, Laraia BA, Kushel MB. Food insecurity is associated with chronic disease among low-income NHANES participants. J Nutr 2010;140:304–10.

11. Laraia B. Food Insecurity and Chronic Disease. Am Soc Nutr Adv Nutr 2013;4:203–12.

12. Hochbaum G, Rosenstock I, Kegels S. Health Belief Model. United States Public Health Service; 1952.

13. Centers for Disease Control and Prevention. The Social-Ecological Model: A Framework for Prevention [Internet]. [cited 2023 Feb 20]. Available from: https://www.cdc.gov/violenceprevention/about/social-ecologicalmodel.html

14. Tanielian T, Jaycox LH. Invisible Wounds of War Psychological and Cognitive Injuries, Their Consequences, and Services to Assist Recovery. RAND Center for Military Health Policy Research.

15. Stecker T, Fortney JC, Sherbourne CD. An Intervention to increase Mental Health Treatment Engagement among OIF veterans: A pilot trial. Mil Med Association of Military Surgeons of the US; 2011;176:613–9.

16. McFall M, Malte C, Fontana A, Rosenheck RA. Effects of an outreach intervention on use of mental health services by veterans with posttraumatic stress disorder. Psychiatr Serv 2000;51:369–74.

17. Duckworth AL, Quinn PD. Development and validation of the short Grit Scale (Grit-S). J Pers Assess 2009;91:166–74.

18. Adams J, Nettle D. Time perspective, personality and smoking, body mass, and physical activity: An empirical study. Br J Health Psychol Br J Health Psychol; 2009;14:83–105.

19. Karabenick SA. Seeking help in large college classes: A person-centered approach. Contemp Educ Psychol 2003;28:37–58.

20. Credé M, Tynan MC, Harms PD. Much ado about grit: A meta-analytic synthesis of the grit literature. J Pers Soc Psychol American Psychological Association Inc.; 2017;113:492–511.

21. Nikolaus CJ, Schierer M, Ellison B, Eicher-Miller HA, Gundersen C, Nickols-Richardson SM. Grit is associated with food security among US parents and adolescents. Am J Health Behav 2019;43:207–18.

22. Myers CA, Beyl RA, Martin CK, Broyles ST, Katzmarzyk PT. Psychological mechanisms associated with food security status and BMI in adults: A mixed methods study. Public Health Nutr 2020;23:2501–11.

23. Office of the Assistant Secretary for Planning and Evaluation. Poverty Guidelines [Internet]. [cited 2023 Feb 14]. Available from: https://aspe.hhs.gov/topics/poverty-economic-mobility/poverty-guidelines

24. Office of the Assistant Secretary for Planning and Evaluation. Frequently Asked Questions Related to the Poverty Guidelines and Poverty [Internet]. [cited 2023 Feb 14]. Available from: https://aspe.hhs.gov/topics/poverty-economic-mobility/poverty-guidelines/frequently-asked-questions-related-poverty-guidelines-poverty#main-content

25. U.S. Department of Agriculture Food and Nutrition Service. Supplemental Nutrition Assistance Program (SNAP) | USDA-FNS [Internet]. [cited 2020 Sep 29]. Available from: https://www.fns.usda.gov/snap/supplemental-nutrition-assistance-program

26. U.S. Department of Agriculture and U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2020–2025. 9th Edition [Internet]. DietaryGuidelines.gov. 2020 [cited 2021 Nov 3]. p. 139. Available from: DietaryGuidelines.gov

27. Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) | USDA-FNS [Internet]. [cited 2020 Sep 29]. Available from: https://www.fns.usda.gov/wic

28. WIC Eligibility Requirements | USDA-FNS [Internet]. [cited 2020 Sep 29]. Available from: https://www.fns.usda.gov/wic/wic-eligibility-requirements

29. Gundersen C, Kreider B, Pepper J V. Partial identification methods for evaluating food assistance programs: A case study of the causal impact of snap on food insecurity. Am J Agric Econ 2017;99:875–93.

30. Kreider B, Pepper J V., Gundersen C, Jolliffe D. Identifying the effects of SNAP (Food Stamps) on child health outcomes when participation is endogenous and misreported. J Am Stat Assoc 2012;107:958–75.

31. Mabli J, Ohls J, Dragoset L, Castner L, Santos B. Measuring the Effect of Supplemental Nutrition Assistance Program (SNAP) Participation on Food Security. Prep by Math Policy Res US Dep Agric Food Nutr Serv 2013;

32. Nord M, Golla AM. Does snap decrease food insecurity? Untangling the self-selection effect. Econ Res Rep No 85, US Dept Agric Econ Res Serv 2009;

33. Mabli J. SNAP Participation and Urban and Rural Food Security. Prepared by Mathematica Policy Research for the U.S. Department of Agriculture, Food and Nutrition Service; 2014.

34. Yen ST, Andrews M, Chen Z, Eastwood DB. Food stamp program participation and food insecurity: An instrumental variables approach. Am J Agric Econ 2008;90:117–32.

35. Ratcliffe C, McKernan SM, Zhang S. How much does the supplemental nutrition assistance program reduce food insecurity? Am J Agric Econ 2011;93:1082–98.

36. Mykerezi E, Mills B. The impact of food stamp program participation on household food insecurity. Am J Agric Econ 2010;92:1379–91.

37. Borjas GJ. Food insecurity and public assistance. J Public Econ 2004;88:1421–43.

38. Eicher-Miller HA, Rivera RL, Sun H, Zhang Y, Maulding MK, Abbott AR. Supplemental Nutrition Assistance Program-Education Improves Food Security Independent of Food Assistance and Program Characteristics. Nutrients NLM (Medline); 2020;12.

39. Rivera RL, Maulding MK, Abbott AR, Craig BA, Eicher-Miller HA. SNAP-Ed (supplemental nutrition assistance program-education) increases long-term food security among Indiana households with children in a randomized controlled study. J Nutr American Society for Nutrition; 2016;146:2375–82.

40. Eicher-Miller HA, Mason AC, Abbott AR, McCabe GP, Boushey CJ. The Effect of Food Stamp Nutrition Education on the Food Insecurity of Low-income Women Participants. J Nutr Educ Behav J Nutr Educ Behav; 2009;41:161–8.

41. Black MM, Cutts DB, Frank D a, Geppert J, Skalicky A, Levenson S, et al. Special Supplemental Nutrition Program for Women , Infants , and Surveillance Study. Pediatrics 2004;114:169–76.

42. Oberholser CA, Tuttle CR. Assessment of Household Food Security among Food Stamp Recipient Families in Maryland. Am J Public Health 2004;94:790–5.

43. Metallinos-Katsaras E, Gorman KS, Wilde P, Kallio J. A longitudinal study of WIC participation on household food insecurity. Matern Child Health J 2011;15:627–33.

44. Insolera N, Cohen A, Wolfson JA. SNAP and WIC Participation During Childhood and Food Security in Adulthood, 1984-2019. Am J Public Health 2022;112:1498–506.

45. Cole N, Fox MK. Diet Quality of Americans by Food Stamp Participation Status: Data from the National Health and Nutrition Examination Survey, 1999-2004. U.S. Department of Agriculture, Food and Nutrition Service, Office of Research, Nutrition and Analysis. 2008.

46. Nguyen BT, Shuval K, Njike VY, Katz DL. The Supplemental Nutrition Assistance Program and dietary quality among US adults: findings from a nationally representative survey. Mayo Clinic proceedings. 2014. p. 1211–9.

47. Leung CW, Ding EL, Catalano PJ, Villamor E, Rimm EB, Willett WC. Dietary intake and dietary quality of low-income adults in the Supplemental Nutrition Assistance Program. Am J Clin Nutr 2012;96:977–88.

48. Fang Zhang F, Liu J, Rehm CD, Wilde P, Mande JR, Mozaffarian D. Trends and Disparities in Diet Quality Among US Adults by Supplemental Nutrition Assistance Program Participation Status. JAMA Netw open 2018;1:e180237.

49. Leung C, Cluggish S, Villamor E, Catalano P, Willett W, Rimm E. Few changes in food security and dietary intake from short-term participation in the Supplemental Nutrition Assistance Program among low-income Massachusetts adults. J Nutr Educ Behav 2014 2014;46:68–74.

50. Gregory CA, Ver Ploeg M, Andrews M, Coleman-Jensen A. Supplemental nutrition assistance program (SNAP) participation leads to modest changes in diet quality. United States Department of Agriculture Economic Research Service Economic Research Report Number 147. 2013.

51. Fox MK, Hamilton W, Lin B-H. Effects of Food Assistance and Nutrition Programs on Nutrition and Health, Volume 3, Literature Review. Food Assistance and Nutritiion Research Report Number 19-3. 2004.

52. Sanjeevi N, Freeland-Graves J. Monthly Variations in Dietary Intake of Women Participating in the Supplemental Nutrition Assistance Program. J Acad Nutr Diet Elsevier Inc; 2019;119:261–71.

53. Nguyen BT, Shuval K, Bertmann F, Yaroch AL. The supplemental nutrition assistance program, food insecurity, dietary quality, and obesity among US adults. Am J Public Health 2015;105:1453–9.

54. U.S. Department of Agriculture Food and Nutrition Service. Healthy Eating Index [Internet]. [cited 2023 Feb 14]. Available from: https://www.fns.usda.gov/healthy-eating-index-hei

55. U.S. Department of Agriculture and U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2020–2025. 9th Edition. 2020.

56. Condon E, Drilea S, Jowers K, Lichtenstein C, Mabli J, Madden E, et al. Diet Quality of Americans by SNAP Participation Status: Data from the National Health and Nutrition Examination Survey, 2007–2010. 2015.

57. Butler JS, Ohls JC, Posner B. The Effect of the Food Stamp Program on the Nutrient Intake of the Eligible Elderly. J Hum Resour 1985;20:405–20.

58. Posner BM, Ohls JC, Morgan JC. The impact of food stamps and other variables on nutrient intake in the elderly. J Nutr Elder 1987;6:3–16.

59. Butler JS, Raymond JE. The effect of the food stamp program on nutrient intake. Econ Inq 1996;34:781–98.

60. Fey-Yensan N, English C, Pacheco HE, Belyea M, Schuler D. Elderly food stamp participants are different from eligible nonparticipants by level of nutrition risk but not nutrient intake. J Am Diet Assoc 2003;103:103–7.

61. Cowan AE, Jun S, Gahche JJ, Tooze JA, Dwyer JT, Eicher-Miller HA, et al. Dietary supplement use differs by socioeconomic and health-related characteristics among U.S. adults, NHANES 2011–2014. Nutrients. 2018. p. 1114.

62. Must A, Spadano J, Coakley EH, Field AE, Colditz G, Dietz WH. The disease burden associated with overweight and obesity. J Am Med Assoc 1999;282:1523–9.

63. Ogden CL, Yanovski SZ, Carroll MD, Flegal KM. The Epidemiology of Obesity. Gastroenterology 2007;132:2087–102.

64. Campbell AD, Baker EH. Do income inequalities in higher weight status depend on social integration? Soc Sci Res 2019;83:102301.

65. Kim TJ, Von Dem Knesebeck O. Income and obesity: What is the direction of the relationship? A systematic review and meta-analysis. BMJ Open 2018;8.

66. Bailey C, Lee JS. Overweight and Obesity, Weight Perception, and Weight Management Practices Among Supplemental Nutrition Assistance Program–Education (SNAP-Ed) Participants in Georgia: A Needs Assessment. J Nutr Educ Behav Elsevier Inc.; 2017;49:422-426.e1.

67. Buscemi J, Odoms-Young A, Stolley MR, Schiffer L, Blumstein L, Clark MH, et al. Comparative effectiveness trial of an obesity prevention intervention in EFNEP and SNAP-ED: Primary outcomes. Nutrients 2019;11.

68. Qin Y, Rivera RL, Zhang Y, Wang Q, Tooze JA, Abbott AR, et al. A Randomized Intervention of Supplemental Nutrition Assistance Program–Education Did Not Improve Dietary Outcomes Except for Vitamin D Among Lower-Income Women in Indiana. J Acad Nutr Diet Academy of Nutrition and Dietetics; 2022;123:284-298.e2.

69. U.S. Department of Agriculture Food and Nutrition Service. WIC Eligibility Requirements [Internet]. [cited 2023 Feb 16]. Available from: https://www.fns.usda.gov/wic/wic-eligibility-requirements

70. Zimmer MC, Vernarelli JA. Changes in nutrient and food group intakes among children and women participating in the Special Supplemental Nutrition Program for Women, Infants, and Children: Findings from the 2005-2008 and 2011-2014 National Health and Nutrition Examination Surveys. Public Health Nutr 2019;22:3309–14.

71. Hamad R, Batra A, Karasek D, Lewinn KZ, Bush NR, Davis RL, et al. The Impact of the Revised WIC Food Package on Maternal Nutrition during Pregnancy and Postpartum. Am J Epidemiol 2019;188:1493–502.

72. Odoms-Young AM, Kong A, Schiffer LA, Porter SJ, Blumstein L, Bess S, et al. Evaluating the initial impact of the revised Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) food packages on dietary intake and home food availability in African-American and Hispanic families. Public Health Nutr 2014;17:83–93.

73. Gibson D. Food stamp program participation is positively related to obesity in low income women. J Nutr 2003;133:2225–31.

74. Baum CL. The Effects of Food Stamps on Obesity. South Econ J 2011;77:623–51.

75. Gibson D. Long-Term Food Stamp Program Participation Is Positively Related to Simultaneous Overweight in Young Daughters and Obesity in Mothers. J Nutr 2006;136:1081–5.

76. Chen Z, Zhang Q. Nutrigenomics Hypothesis: Examining the Association Between Food Stamp Program Participation and Bodyweight Among Low-Income Women. J Fam Econ Issues 2011;32:508–20.

77. Ver Ploeg M, Mancino L, Lin BH, Wang CY. The vanishing weight gap: Trends in obesity among adult food stamp participants (US) (1976-2002). Econ Hum Biol 2007;5:20–36.

78. Zagorsky JL, Smith PK. Does the US Food Stamp Program contribute to adult weight gain? Econ Hum Biol 2009;7:246–58.

79. Webb AL, Schiff A, Currivan D, Villamor E. Food Stamp Program participation but not food insecurity is associated with higher adult BMI in Massachusetts residents living in low-income neighbourhoods. Public Health Nutr 2008;11:1248–55.

80. Meyerhoefer CD, Pylypchuk Y. Does participation in the food stamp program increase the prevalence of obesity and health care spending? Am J Agric Econ 2008;90:287–305.

81. Leung CW, Willett WC, Ding EL. Low-income supplemental nutrition assistance program participation is related to adiposity and metabolic risk factors. Am J Clin Nutr 2012;95:17–24.

82. Leung CW, Villamor E. Is participation in food and income assistance programmes associated with obesity in California adults? Results from a state-wide survey. Public Health Nutr 2011;14:645–52.

83. Fan M. Do food stamps contribute to obesity in low-income women? Evidence from the National Longitudinal Survey of Youth 1979. Am J Agric Econ 2010;92:1165–80.

84. Vartanian TP, Houser L. The Effects of Childhood SNAP Use and Neighborhood Conditions on Adult Body Mass Index. Demography 2012;49:1127–54.

85. Jilcott SB, Wall-Bassett ED, Burke SC, Moore JB. Associations between food insecurity, Supplemental Nutrition Assistance Program (SNAP) benefits, and body mass index among adult females. J Am Diet Assoc Elsevier Inc.; 2011;111:1741–5.

86. Zagorsky JL, Smith PK. Does the U.S. Food Stamp Program contribute to adult weight gain? Econ Hum Biol 2009;7:246–58.

87. Dollahite J, Olson C, Scott-Pierce M. The Impact of Nutrition Education on Food Insecurity among Low-Income.pdf. Fam Consum Sci Res J 2003;32:127–139.

CHAPTER 2. GRIT WAS ASSOCIATED WITH FOOD INSECURITY AMONG LOW INCOME, AT-RISK RURAL VETERANS

Qin Y, Sneddon D, Wadsworth SM, Topp D, Sterrett R, Eicher-Miller H. Grit but Not Help-Seeking Was Associated with Food Insecurity among Low Income, At-Risk Rural Veterans. Int J Environ Res Public Health 2022;20:2500.

The chapter was published as an original research article in *International Journal of Environmental Research and Public Health* and formatted according to the journal requirements. Multidisciplinary Digital Publishing Institute journals allow authors to retain the copyright of their work and, thus, to include their own articles in their dissertation.

2.1 Abstract

Rural veterans have poorer health, use healthcare services less often than their urban counterparts, and have more prevalent food insecurity than average U.S. households. Food insecurity and resource use may be influenced by modifiable psychological attributes such as grit and help-seeking behaviors, which may be improved through interventions. Grit and help-seeking have not been previously evaluated among rural veterans. Thus, this cross-sectional study evaluated the hypothesis that grit and help-seeking were associated with food insecurity and the use of resources. Food security, resource use, grit, and help-seeking behavior were assessed among rural veterans (≥18 years) from five food pantries in southern Illinois counties (n = 177) from March 2021 to November 2021. Adjusted multiple regression was used to estimate the relationship between the odds of food insecurity and the use of resources with grit and help-seeking scores. Higher grit scores were significantly associated with lower odds of food insecurity (OR = 0.5, p = 0.009). No other associations were detected. The results provided evidence to inform the content of future educational interventions to improve food insecurity and address health disparities among rural veterans by addressing grit. The enhancement of psychological traits such as grit is related to food security and has the potential to benefit other aspects of well-being.

2.2 Introduction

Over 4.7 million veterans live in rural areas of the U.S. (1). These veterans are in poorer health (2,3), disproportionately likely to have service-connected disability ratings above 50% (4), and have more severe mental health disorders (5) compared to their suburban and urban

counterparts. Despite poorer health conditions, rural veterans are less likely to use healthcare services, which is likely due to less access to resources from transportation barriers (4). Compared with 10.5% average household food security among U.S. adults (6) and 12.1% in rural areas (6), up to a quarter of U.S. veterans (7,8), representing 4.5 million people (9), were estimated to have inadequate access to enough food, known as food insecurity (10,11). Living in this situation has been associated with poor nutrient intake and increased risk for various chronic diseases such as diabetes, hypertension, and mental health disorders (12). Government assistance programs, such as the Supplemental Nutrition Assistance Program (SNAP) and Temporary Assistance for Needy Families (TANF), are designed to help those among the lower-income population by providing benefits for meeting basic needs (13). Unfortunately, rural veterans specifically and veterans overall face many barriers to using these resources, such as limited access to transportation, a high likelihood of disability, few years of education, low rates of employment, the stigma associated with seeking help, and concerns related to the reporting and recording of health problems (14,15).As a result, this at-risk population is less likely than non-veteran populations to utilize the assistance programs and healthcare resources that could help them improve their health conditions (16,17). The high burden of disease faced by rural veterans highlights the importance of assessing and improving help-seeking behavior, which is linked to motivation and performance (18) as well as grit, a learned behavior that is advantageous for facing adversities (19). Rates of help-seeking are low, especially among individuals suffering from psychiatric disorders (20), and low help-seeking is found in veteran populations who tend to underuse mental health services and are underserved in general (21–23). Other psycho-logical attributes, such as determination and perseverance for long-term goals, or "grit", may be linked to maintaining food security (24,25). Similar to resiliency, grit also captures prospective future planning (26). Furthermore, grit may be improved through interventions (19,27,28) to support preserving food security, yet only two studies have examined and found inverse associations between reported grit and food insecurity (25,29) and none have evaluated the link of help-seeking behavior with food insecurity.

Interventions targeting grit among individuals at risk for high stress and lacking protective resources tend to be effective over time (28). Similarly, interventions focusing on mental health and wellness promotion have increased help-seeking behaviors and intentions to seek help among adolescents (30) and adult college students (31). To our knowledge, no intervention program targeting food security improvement has focused on grit and help-seeking behavior, yet their

inclusion and fostering of these qualities may be a key link to health in veteran populations. The objectives of the current project were to examine the association of grit and help-seeking behavior with food insecurity and the use of resources among rural veterans from five food pantries in southern Illinois counties using a cross-sectional sample. The authors hypothesized that grit and help-seeking would each be linked to food insecurity and the use of resources.

2.2 Materials and Methods

2.2.1 Design and Participants

Rural veterans ≥18 years were recruited from March 2021 to November 2021 at five food pantries located in southern Illinois counties with high rurality scores (rurality scores ≥ 5 (32)) with large populations of low-income veterans (33). Baseline data and a cross-sectional design were used but the data were drawn from a larger, longitudinal community food pantry pilot intervention called Reaching Rural Veterans (RRV) to improve food security and resource use, of which a version was previously carried out in Indiana and Kentucky (34). Specifically, food pantries were selected from target counties based on several factors—rurality, need and sustainability, plans for sustained community partnerships, and budget to extend services to veterans, as described previously—and invited to participate in the project (34). Next, recruited food pantry staff and volunteers received training and education to improve their awareness and knowledge of veterans' needs and how to attract veterans to the pantry. The recruited pantries then implemented these marketing strategies to attract veterans to their food pantries at special veteran-targeted outreach events where veteran-relevant service organizations were represented. The outreach events were similar across the recruited pantry sites. At these events, the service organizations were represented by booths that veterans and their families could visit to learn about resources and their potential eligibility. Food pantry services were also offered at these events. Upon departure from these outreach events, food pantry patrons who self-identified as veterans were asked to fill out a questionnaire that included the measures discussed in more detail in the following section. The project team members screened the collected responses on site to ensure individuals met the inclusion criteria (≥18 years, served in the active or reserve U.S. military, can speak and read English, visit food pantries during the project period, and agreed to participate) to

be included in the sample for analysis. The project was reviewed and considered exempt from Human Subjects Research by Purdue University's Institutional Review Board.

2.2.2 Measures

Veteran participants were invited to self-complete or receive interviewer assistance from RRV staff, to complete questionnaires that queried demographic information and could be used to classify food security, assistance program and resource use, grit, and help-seeking behavior.

Missing responses were present among two of the independent variable assessments, grit and help-seeking, and for one of the outcome variable assessments, food security. Even though the project team adapted novel strategies to recruit and engage veterans, recruitment during the COVID-19 pandemic restrictions made it challenging to ensure adherence to protocols such as completing the surveys. For example, a portion of the surveys were taken home by the veterans and mailed back after completion with missing responses. Furthermore, onsite project staff received complaints about the length of the survey, which may have led to skipping questions among those who completed the surveys at the pantry. In order to utilize the available data collected from the current pilot project and retain statistical power, while making the best judgments to draw accurate conclusions, the imputation of certain missing data was completed to yield the most conservative outputs. Details of imputation are described below for each measure.

Grit was assessed using the (8-item) Short Grit Scale, which has been previously validated in adults (24). Specifically, the participants were presented with 8 statements to describe themselves, such as "setbacks don't discourage me" and "new ideas and projects sometimes distract me from previous ones," and were asked to select an answer from the 1 to 5 response choices ranging from "very much like me" to "not like me at all" (24). Scores of 1–5 were assigned to each response (4 of the 8 items were reverse scored), and the responses were averaged to generate the final score, which ranged from 1 to 5 (24). Higher scores indicated more grit (24). Participants with missing responses on the Grit Scale were few (n = 17). Consistent with other variables, grit mean scores were calculated for participants who responded to at least 75% of the items (6 items) on the Grit Scale (35). Given that our data were not missing at random, available item analysis (36) was the most appropriate tool. Mean scale scores could not be computed for 7 participants.

Help-seeking behavior was measured using the modified General Help-Seeking Questionnaire (GHSQ), a validated and widely utilized questionnaire in psychological research to capture help-seeking intentions (37). The GHSQ used a standard format of "If you were having [type of problem], how likely is it that you would seek help from the following people?", where the type of problem could be modified to fit the project purpose (37). We assessed 10 potential sources of help, such as "intimate partner," "friend," or "parent," and for each, participants were asked to select from a 7-point scale ranging from "extremely unlikely" to "extremely likely". The questionnaire administered in the current project included "having a personal or emotional problem" to assess the general help-seeking behaviors of these rural veterans. Participants with missing responses numbered 80. Scale averages were calculated for all participants who responded to at least 75% of the items (8 items); a higher score indicated more help-seeking behaviors. Scale means could not be calculated for 13 participants.

Food security was measured using the USDA 6-item Household Food Security Survey Module (HFSSM) [38]. Affirmative answers ("yes") were summed to generate raw scores, with a raw score of 0–1 categorized as "food secure" and 2–6 as "food insecure" [38]. The category "food insecure" was further broken down into low food security (raw score of 2–4), where the quality of food is less than in food-secure situations, and very low food security (raw score of 5–6), where the quality and quantity of food is less than in food-secure situations [38]. Most participants had missing items within the 6-item HFSSM (n = 107). Imputation was completed only on those with 1 missing response, following the USDA guidance for imputation for the 18-item scale [38] to yield a conservative classification. The questions were reordered based on severity. The missing responses were coded as "yes" or "no" based on the responses before and after the missing values [38]. When missing values were found after the last non-missing response, they were not allowed to be counted as "yes", and thus were not added to the raw score to calculate the food security level, potentially influencing the results towards a less severe range of food security.

Resource use was determined by type (yes or no for each resource) and tallied (total n of resources used) and included: Veterans Affairs healthcare (missing n = 36), disability payments (missing n = 21), Veteran Affairs disability benefits (missing n = 83), veteran pension (missing n = 11), employer pension/retirement fund (missing n = 13), social security benefits (missing n = 6), TANF (missing n = 15), employment compensation (missing n = 15), general assistance from the township trustee (missing n = 15), SNAP (missing n = 10), free meal/soup kitchens (missing n =

15), and free/reduced-price meals at school/childcare (missing n = 15). To be conservative, missing responses were coded as "No" when calculating the sum of program use.

2.2.3 Statistical Analysis

Characteristics (such as age, race, income, etc.) of the sample were described in numbers and percentages, and their relationships to each outcome variable, food security and the use of resources, were assessed using analysis of variance tests. Logistic and Poisson regression models were used to determine the relationship between food insecurity and the use of resources, respectively, with grit and help-seeking in the respective models. None of the characteristic variables were significantly related to either of the outcomes of interest. Multiple linear and logistic regression models created for the main results were adjusted for covariates age and sex, based on previous literature [39–42]. Model assumptions were evaluated and supported. The significance level was set as $\alpha < 0.05$.

2.3 Results

The socio-demographic characteristics and resource use of the sample are shown in Table 1. A total of 235 veterans visited the food pantries during the duration of the program and were invited to participate in the sample. The veterans who chose to complete the assessments and were included in the socio-demographic analysis numbered 177. After imputation, n = 162 for food security, n = 170 for grit, and n = 164 for help-seeking were included in each respective analysis. A high proportion of the sample was male (89%), white (92%), over 65 years (65%), with education below college (91%), unemployed or out of the labor force (85.2%), married or living with a partner (57%), without adult children (84%), with fewer than three adults in the household (89%), and with a 12-month household income of less than $30,000 (60%). The participants predominantly served in the Army (67%), did not serve in the Guard/Reserve (70%), and served for an average of 5.6 years.

The resource use of the sample is presented in Table 2. The majority of the sample used several veteran-related resources, such as Veterans Affairs healthcare (77%) and Veterans Affairs disability benefits (60%), and several social benefits, including disability payments (64%) and social security (59%). Few veterans used food assistance programs, such as SNAP (25%), free

meal/soup kitchens (12%), and free/reduced-price meals for their children at school or in childcare (6%). The sum of self-reported programs used ranged from 0 to 6, with half of the sample using no more than two types of resources. The majority of the sample was food secure (60%).

Grit and help-seeking scores are shown in Table 3. The mean grit score of the sample was 3.5 out of 5 and the mean help-seeking score was 3.5 out of 7.

Figure 1 shows the association between the odds of food insecurity with grit and help-seeking, respectively. The odds ratio of grit in the adjusted regression model was 0.47, indicating that one point higher in grit score was associated with 53% lower odds of being food insecure. There was no significant association found between the help-seeking score and the odds of being food insecure.

Lastly, the regression model results between resource use with grit and help-seeking, respectively, are presented in Table 4. Neither grit nor help-seeking were associated with resource use. Similarly, modeling with the original data without imputation did not generate significant results.

Table 2.1 Socio-demographics among rural southern Illinois veterans ≥18 years recruited from five food pantries from March 2021 to November 2021

Variables		N	% [1]
Age			
	18–44 years	16	9.0
	45–64 years	46	26.0
	≥65 years	115	65.0
Sex			
	Male	156	88.6
	Female	20	11.4
Race			
	White	162	92.0
	African American	7	4.0
	American Indian or Alaska Native	4	2.3
	Other	3	1.7
Education level			
	High school, equivalent or less	69	40.8
	Some post-high-school education but below college	85	50.3
	College and above	15	8.9
Employment status			
	Employed	26	14.8
	Unemployed	9	5.1
	Not in labor force	141	80.1
Marital status			
	Married/living with partner	100	56.5
	Widowed	20	11.3
	Divorced/separated	49	27.7
	Never married	8	4.5
Household type			
	With children <18 years	27	15.7
	Without children <18 years	145	84.3

Table 2.1 continued

Household size			
	1 adult	50	29.1
	2 adults	103	59.9
	≥3 adults	19	11.1
Household income in the last 12 month			
	≤$15,000	21	27.6
	$15,000–$30,000	25	32.9
	>$30,000	30	39.5
Military status			
	Veteran	156	91.8
	Non-active	13	7.7
	Active	1	< 1
Branch of military			
	Air Force	12	6.9
	Army	117	67.2
	Marine Corps	10	5.8
	Navy	32	18.4
	Multiple branches	3	1.7
Guard/Reserve Service			
	Yes	52	30.2
	No	120	69.8
Years served	mean (SD)	5.6 (5.8)	
Service-related Veterans Affairs-recognized disability			
	Yes	57	33.0
	No	116	67.0
Service-related non-Veterans Affairs-recognized disability			
	Yes	52	30.0
	No	121	69.9

[1] Totals may not add to total n and percentages may not add to 100 due to missing values and rounding.

Table 2.2 Resource use and food security status among rural Illinois veterans ≥18 years recruited from five food pantries from March 2021 to November 2021

	Status	N	%
Veterans Affairs healthcare			
	Yes	109	77.3
	No	32	22.7
Veteran Affairs disability benefits			
	Yes	56	59.6
	No	38	40.4
Veteran pension			
	Yes	35	21.1
	No	131	78.9
Disability payments			
	Yes	57	36.5
	No	99	63.5
Employer pension/retirement fund			
	Yes	37	22.6
	No	127	77.4
Social security			
	Yes	100	58.5
	No	71	41.5
TANF [1]			
	Yes	2	1.2
	No	160	98.8
Employment compensation			
	Yes	6	3.7
	No	156	96.3
General assistance from the township trustee			
	Yes	1	0.6
	No	161	99.4
SNAP [2]			
	Yes	42	25.2
	No	125	74.9
Free meals, soup kitchens			
	Yes	19	11.7
	No	143	88.3

Table 2.2 continued

Free/reduced-price meals at school/childcare			
	Yes	10	6.2
	No	152	94.8
Sum of all programs reported			
	0	21	11.9
	1	23	13.0
	2	40	22.6
	3	41	23.2
	4	25	14.1
	5	14	7.9
	6	13	7.3
Food security [3]			
	Food secure	97	59.9
	Food insecure	65	40.1
	Low food security [4]	30	46 [5]
	Very low food security [4]	35	54 [5]

[1] TANF, Temporary Assistance for Needy Families.
[2] SNAP, the Supplemental Nutrition Assistance Program.
[3] Food security results including imputed data are presented.
[4] Category "food insecure" was further broken into "low food security" and "very low food security".
[5] Percentage was calculated based on the number of participants categorized as "food insecure".

Table 2.3 Grit and help-seeking scores among rural Illinois veterans ≥18 years recruited from five food pantries from March 2021 to November 2021[1]

Variables	Scores (Mean ± SD)
Grit (1–5 score)	3.50 ± 0.67
Help-seeking (1–7 score)	3.48 ± 1.00

[1] Scores were calculated based on available data with imputation. Total sample size including imputed data: n = 170 for grit; n = 164 for help-seeking. The imputation was completed for those with missing values for less than 20% of the responses and the missing items were imputed as the mean of the available responses, for calculating the sum scores.

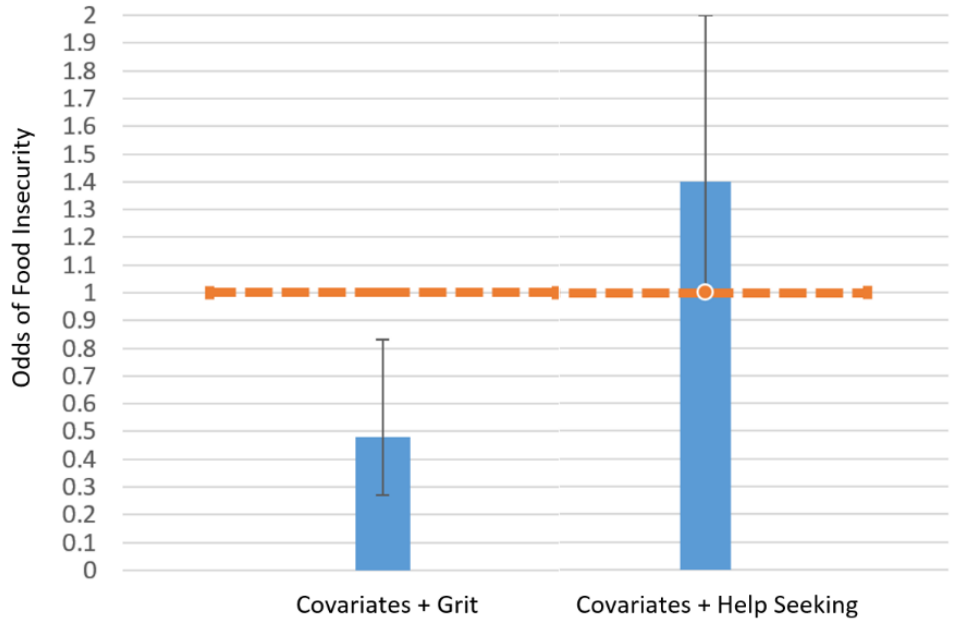

Figure 2.1 Grit, but not help-seeking, was inversely associated with the likelihood of being food insecure among rural Illinois veterans ≥18 years recruited from five food pantries from March 2021 to November 2021[1]

[1] Logistic regression models with imputed data were used and adjusted by age and sex; n = 162 for food security, n = 170 for grit, and n = 164 for help-seeking were included for analysis. Orange dashed line indicates an odds ratio of 1 as reference; orange box highlights significant results.

Table 2.4 Grit and help-seeking were not associated with resource use among rural Illinois veterans ≥18 years recruited from five food pantries from March 2021 to November 2021 [1]

Variable	Estimates ± SE	
	Covariates + Grit	Covariates + Help-seeking
Resource use (0–6 programs)	−0.023 ± 0.07	0.014 ± 0.05

[1] Poisson regression models with imputed data were used. Covariates adjusted included age and sex; n = 162 for food security, n = 170 for grit, and n = 164 for help-seeking were included for analysis.

2.4 Discussion

The sample of veterans in this study were primarily white, male, and over 65 years old. Around 40% were food insecure and more than half of the participants used two or fewer assistance programs or resources, indicating the success of the RRV program in reaching rural veterans with high needs. Higher grit was associated with less risk of being food insecure but not resource use, while help-seeking was not associated with either food security or resource use. Compared to the general veteran population [43], the current sample was similar in race and sex but different in other socio-demographic characteristics. The current sample had a higher percentage of veterans over 65 years, with lower education attained (college degree or above), higher service-related disabilities, and lower income compared to the general veteran population [43].

The 40% food insecurity rates found here were higher than the results of veteran groups documented in previous studies, which was expected considering the nature of RRV to engage with rural veterans of low resources. A previous study on veterans in wars in Iraq and Afghanistan [7] and another study designed for observing determining factors on the clinical outcomes of HIV infection among veterans [8] both found a food insecurity rate of around 25% among the veteran population assessed. Another study on working-age (18–59 years) veterans with children found that around 17% of veterans were food insecure [44]. These authors also reported that even though the odds of food insecurity were not higher among veterans, they were more likely to have more severe food insecurity associated with hunger compared to nonveterans [44]. The results in the present study similarly show high rates of very low food security, where the amount of food is reduced due to a lack of resources for food, at 54% among those with food insecurity in the sample. The high food insecurity rate and percentage with very low food security in the present study were likely a result of the recruitment at food pantries, where those with limited access to resources for food are more likely to visit. Additionally, this project featured a sample of rural veterans, where resources may be less available and also where only one previous project has specifically focused and reported on food security. The prior RRV pilot project reported a higher food insecurity rate (70%) among rural veterans in Indiana and Kentucky compared with the current sample [34]. Both studies highlighted the high risk of being food insecure among rural veterans using food pantries. The present study results were very similar to the 49% food insecurity reported among a sample of veterans from Veterans Administration Clinics [45]. The high prevalence estimates of food insecurity also documented the contribution of other risk factors to food insecurity, including poor

health conditions (i.e., diabetes and prediabetes) [45] and sociodemographic characteristics such as being women and/or racial or ethnic minorities [46].

Such few previous U.S. studies have importantly documented this under-studied topic of veteran food insecurity, a topic with even less prior investigation in countries outside of the U.S. Only one study from an international context, the United Kingdom (U.K.), evaluated food insecurity among veterans (median age group was over 55 years old) and found that around 10% were living in food-insecure households, while those with low income and disabilities were especially at risk for food insecurity [47], consistent with findings among the general population of U.S. veterans [46]. Such documentation provided evidence of the unmet needs of veterans outside of the U.S. and highlighted the need for further investigation of veteran food security and needs globally.

Despite the high rates of food insecurity, resource use among the sample in the present study was low, which was also consistent with the previous RRV pilot project [34]. Although a majority of the veterans reported using veteran-specific benefits and services, very few reported using food-related assistance programs such as SNAP, free meal/soup kitchens, and free/reduced-price meals at school/childcare. Specifically, the prevalence of using SNAP reported in the present sample was low (25%). This was consistent with a previous study on low-income veterans, where the authors estimated a 27% SNAP participation rate [48], but lower than what was reported in the previous RRV (33%) [34], while another report found around 22% SNAP participation among low-income veterans [49]. The SNAP income threshold for ages 60 and over is $2873 per month, which approximates $34,476 per year [50]. The characteristics of this sample where 65% are over 65 years show that 60% have an annual income below $30,000. Thus, a majority of the sample may likely be eligible for SNAP, and the reported low SNAP participation rate represents a potential gap between SNAP eligibility and participation among the sample, which may also be present among other rural veterans. Food pantries could serve as an important link to connect rural veterans who visit the pantry to SNAP, with the aim of encouraging SNAP enrollment and closing the potential eligibility-to-participation gap among this at-risk group.

Very limited research on veterans in other countries has supported the importance of connecting resources with veterans. A study on Chinese elderly veterans showed that poor health and inadequate income were the main reasons provided regarding life dissatisfaction and that existing social security and benefits were insufficient and required improvements [51]. On the

other hand, veterans in the U.K. had higher food security when receiving disability benefits compared to those without benefits [47]. This evidence indicated a potentially similar shared need among veterans globally and the importance of being connected with the resources they qualify for. Veteran outreach strategies to link veterans with resources, such as the RRV program, could be adapted and utilized in designing and delivering interventions and assistance programs for veterans in other countries, to improve veteran use of resources and quality of life.

The current investigation was carried out as a part of the RRV pilot intervention, a longitudinal project designed to test intervention methodologies to improve the connections and utilization of resources and food security status for rural low-resource veterans and family members through outreach events such as resource fairs and other interventions. The low participation in assistance programs such as SNAP reported in the current manuscript highlights the high need for connection to resources among this rural veteran population and justifies the necessity of RRV programs. The results also provide insight and guidance for future RRV interventions to focus on connecting veterans with these resources using food pantries as delivery sites. The resource use status assessed in the current project provides a baseline for resource use, which is aimed to be improved with RRV and would be valuable for RRV evaluation after the intervention is delivered.

Grit scores were inversely associated with the odds of food insecurity. This finding was consistent with previous studies [25,29] among non-veteran populations. Further explanation of this association is needed, as causation cannot be inferred from the cross-sectional design. It is not clear if high grit has led to a lower risk of food insecurity or if food security occurred before grit was developed, and perhaps experiences of food insecurity may lessen grit. Additionally, it is unknown if grit alone was impactful in this association or if grit is an indication of other potential beneficial qualities. Grit might be a marker for other personal traits or behaviors that are advantageous against adverse situations, such as food-obtaining behaviors, participation in assistance programs, the seeking and use of available resources, and budgeting. Individuals with these traits may be less likely to experience situations of need. Future research that explores these behaviors is needed to better understand the meaning of this association.

Previous studies among the general population of U.S. veterans have also found that food insecurity was associated with several psychological factors, including depression, suicidal thoughts, anxiety, and stigma related to COVID-19 infection [52,53]. Other studies reported

associations between food security with little sleep, medical and trauma-related comorbidities, and housing instability among veterans [46,54]. Not unique to the U.S., veterans worldwide tend to have chronic physical and mental conditions, as well as low income [47,51,55–59]. Veterans were more likely to suffer from chronic illnesses such as arthritis, depression, anxiety, post-traumatic stress disorder, and low general well-being in the U.S., Canada, Australia, the U.K., and China [47,51,55–59]. Health and well-being also tend to worsen over time since leaving military service [59]. Considering the interconnection of physical, mental, and social health [60] and the shared conditions among veterans internationally, more research is imperative to fully understand the psychological, health, and social factors associated with food insecurity among veterans to better address these needs among this at-risk population. The results reported here provide insights to inform tailored interventions and support for veterans.

Interestingly, help-seeking was not associated with either food security or resource use. As this was a self-reported measurement, veterans may feel stigma in reporting and/or performing help-seeking behaviors, which was one of the reported barriers to seeking help among veteran groups [15]. Additionally, the raw responses from the help-seeking questionnaire contained a large number of missing data. For example, field staff reported that many veterans left certain questions empty, such as the potential help sources, because individuals (i.e., parents) had passed away. Considering the age distribution of the current sample, the "parent" option might not be a suitable source to include in assessing the help-seeking behaviors of the sample, which contributed to some of the missing responses to this question. As mentioned, the authors imputed responses to retain the use of the data despite the missing entries for help-seeking, along with grit and food security. Yet, the conservative treatment of the imputation may have muted potential links of help-seeking with food security or resource use. Future studies should explore creative strategies and instruments that engage rural veterans and consider shorter questionnaires to improve completion rates.

There were limitations to the current study. As mentioned previously, there were a large amount of missing data for the outcome measurements. Although statistical power was retained with imputation, the conservative procedures could have biased the association to null. Future studies should focus on improving the clarity and conciseness of the survey questions, making sure field staff are available for answering questions, quality checking to ensure the completion of surveys, and reducing the amount of missing data. The current investigation also did not capture

purchasing and budgeting behaviors or attitudes and barriers to using assistance programs in the sample, which may be additional factors involved in the relationships between grit, help-seeking, and food security that may be important to adjust in the regression models and/or further explain the association between grit and food insecurity found in the current analysis. Future research on this topic should incorporate these variables. The sample was also recruited through food pantries, which may mean that the results are not generalizable to the broader rural veteran population. However, there is a lack of research on the food security of the rural veteran population and their resource-use status. Previous studies on help-seeking behaviors have been mostly focused on academic performance, mental health, or physical health conditions [15,18,20,22,23,61,62] and have not assessed the link to food security or resource use. Therefore, despite limitations, the results represent a first look at help-seeking in rural veterans. The current project could serve as a reference for future studies focusing on rural veteran populations and provide insights for better study designs and recruitment strategies.

The current results are the first to describe the psychological traits of grit and help-seeking with food insecurity and resource use among a sample of rural veterans of high need. These findings may inform future policies and proposals. For example, the determination of the association specifically between grit and food insecurity from the results supports the justification of the funding of future interventions or assistance programs to foster grit, for food security improvement and connecting veterans with health resources that they may be eligible for. Policymakers might also consider supporting intervention programs that include one-on-one coaching or group sessions to develop and strengthen a growth mindset and skills to help bolster persistence to improve grit [19,27,28]. The results also reveal the high needs among the rural veteran groups using food pantries. Resource fairs, such as RRV, where program representatives provide program information and offer assistance in the enrollment process are shown in these results to successfully attract the intended audience. Similar future events might be helpful in connecting veterans with resources they are eligible for but not currently using, promoting help-seeking behavior, and ultimately improving resource use. Such interventions are advantageous, as education may sustain impact and provide benefits in the long-term future after the intervention is over [63]. Enhancing psychological traits such as grit may improve the mental health of veterans and family members, improving their quality of life independently from food security and potentially supporting improvements of both physical and mental health that could ease the

healthcare burden on both the household and healthcare system. Therefore, the findings from the current project provide novel insights into rural veteran groups using food pantries and have important applications for future research, intervention development, and policies. In summary, salient applications are: 1. interventions that foster grit may also foster food security among rural veterans; 2. targeted outreach to rural veterans at food pantries can attract a group with high needs and low access to food and other resources; 3. determining and addressing the gap between eligibility and participation in assistance programs may inform future interventions to improve food security among rural veterans.

2.5 Conclusions

Grit was inversely associated with the odds of food insecurity among a cross-sectional sample of rural veterans. The results provided evidence to inform the content of future educational interventions to improve food insecurity and address health disparities among rural veterans by addressing grit. The enhancement of psychological traits such as grit might improve quality of life independently from food security and potentially benefit other aspects of well-being.

2.6 Acknowledgements

The authors would like to thank all of the food pantry staff who assisted in carrying out the project and the individuals who were willing to participate.

The authors' responsibilities were as follows: conceptualization, SMW, YQ, and HAE-M; methodology, YQ, DAS, SMW, DT, RAS, and HAE-M; formal analysis, YQ and DAS; data curation, YQ, DAS, and JRN; writing—original draft preparation, YQ; writing—review and editing, YQ, DAS, SMW, DT, RAS, and HAE-M; visualization, YQ; supervision, DAS, SMW, DT, and HAE-M; project administration, SMW, DT, RAS, and JRN; funding acquisition, YQ, SMW, RAS, DT, and HAE-M All authors have read and agreed to the published version of the manuscript.

2.7 References

1. RURAL VETERANS - Office of Rural Health [Internet]. [cited 2020 Nov 19]. Available from: https://www.ruralhealth.va.gov/aboutus/ruralvets.asp

2. Weeda ER, Bishu KG, Ward R, Axon RN, Taber DJ, Gebregziabher M. Joint effect of race/ethnicity or location of residence and sex on low density lipoprotein-cholesterol among veterans with type 2 diabetes: a 10-year retrospective cohort study. BMC Cardiovasc Disord [Internet] BioMed Central Ltd; 2020 [cited 2020 Nov 8];20. Available from: https://pubmed.ncbi.nlm.nih.gov/33059602/

3. Lynch CP, Strom JL, Egede LE. Disparities in diabetes self-management and quality of care in rural versus urban veterans. J Diabetes Complications [Internet] J Diabetes Complications; 2011 [cited 2020 Nov 8];25:387–92. Available from: https://pubmed.ncbi.nlm.nih.gov/21983152/

4. Weeks WB, Wallace AE, West AN, Heady HR, Hawthorne K. Research on rural veterans: An analysis of the literature. J Rural Heal [Internet] J Rural Health; 2008 [cited 2020 Nov 8];24:337–44. Available from: https://pubmed.ncbi.nlm.nih.gov/19007387/

5. National Organization of State Offices of Rural Health. ADDRESSING THE HEALTH CARE NEEDS OF RURAL VETERANS A GUIDE FOR STATE OFFICES OF RURAL HEALTH [Internet]. Available from: http://www.va.gov/directory/guide/division_flsh.asp?dnum=1

6. Coleman-Jensen A, Rabbitt MP, Gregory C, Singh A. Household Food Security in the United States in 2018. United States Dep Agric Econ 2019;

7. Widome R, Jensen A, Bangerter A, Fu SS. Food insecurity among veterans of the US wars in Iraq and Afghanistan. Public Health Nutr 2015;18:844–9.

8. Wang EA, McGinnis KA, Goulet J, Bryant K, Gibert C, Leaf DA, et al. Food insecurity and health: Data from the veterans aging cohort study. Public Health Rep 2015;130:261–8.

9. US Census Bureau. Those Who Served: America's Veterans From World War II to the War on Terror. [cited 2020 Dec 17]; Available from: https://www.census.gov/library/publications/2020/demo/acs-43.html

10. Office of Disease Prevention and Health Promotion. Food Insecurity | Healthy People 2020 [Internet]. [cited 2022 Jul 24]. Available from: https://www.healthypeople.gov/2020/topics-objectives/topic/social-determinants-health/interventions-resources/food-insecurity

11. Feeding America. What Is Food Insecurity? [Internet]. [cited 2022 Jul 24]. Available from: https://hungerandhealth.feedingamerica.org/understand-food-insecurity/

12. Gundersen C, Ziliak JP. Food insecurity and health outcomes. Health Aff [Internet] Project HOPE; 2015 [cited 2020 Dec 17];34:1830–9. Available from: https://pubmed.ncbi.nlm.nih.gov/26526240/

13. Purtell KM, Gershoff ET, Aber JL. Low income families' utilization of the Federal "Safety Net": Individual and state-level predictors of TANF and Food Stamp receipt. Child Youth Serv Rev [Internet] Child Youth Serv Rev; 2012 [cited 2020 Dec 17];34:713–24. Available from: https://pubmed.ncbi.nlm.nih.gov/22711951/

14. National Center for Veterans Analysis and Statistics. Characteristics of Rural Veterans: 2010 Data from the American Community Survey [Internet]. 2012. Available from: https://www.va.gov/vetdata/docs/SpecialReports/Rural_Veterans_ACS2010_FINAL.pdf

15. Porcari C, Koch EI, Rauch SAM, Hoodin F, Ellison G, McSweeney L. Predictors of help-seeking intentions in operation enduring freedom and operation Iraqi freedom veterans and service members. Mil Med 2017;182:e1640–7.

16. Cheney AM, Koenig CJ, Miller CJ, Zamora K, Wright P, Stanley R, et al. Veteran-centered barriers to VA mental healthcare services use. BMC Health Serv Res BMC Health Services Research; 2018;18:1–14.

17. Veterans benefits 2020: Most underused state benefit [Internet]. VAntage Point. [cited 2022 Aug 5]. Available from: https://blogs.va.gov/VAntage/76440/veterans-benefits-2020-underused-state-benefit/

18. Karabenick SA. Seeking help in large college classes: A person-centered approach. Contemp Educ Psychol 2003;28:37–58.

19. Credé M, Tynan MC, Harms PD. Much ado about grit: A meta-analytic synthesis of the grit literature. J Pers Soc Psychol [Internet] American Psychological Association Inc.; 2017 [cited 2020 Nov 8];113:492–511. Available from: https://pubmed.ncbi.nlm.nih.gov/27845531/

20. The International Consortium in Psychiatric Epidemiology. Cross-national comparisons of the prevalences and correlates of mental disorders. WHO International Consortium in Psychiatric Epidemiology. Bull World Health Organ [Internet] World Health Organization; 2000 [cited 2020 Dec 14];78:413–26. Available from: www.hcp.med.harvard.edu/icpe

21. Tanielian T, Jaycox LH. RAND Center for Military Health Policy Research. Invisible Wounds of War Psychological and Cognitive Injuries, Their Consequences, and Services to Assist Recovery [Internet]. Available from: www.rand.org

22. Stecker T, Fortney JC, Sherbourne CD. An Intervention to increase Mental Health Treatment Engagement among OIF veterans: A pilot trial. Mil Med [Internet] Association of Military Surgeons of the US; 2011 [cited 2020 Dec 14];176:613–9. Available from: https://pubmed.ncbi.nlm.nih.gov/21702376/

23. McFall M, Malte C, Fontana A, Rosenheck RA. Effects of an outreach intervention on use of mental health services by veterans with posttraumatic stress disorder. Psychiatr Serv 2000;51:369–74.

24. Duckworth AL, Quinn PD. Development and validation of the short Grit Scale (Grit-S). J Pers Assess 2009;91:166–74.

25. Nikolaus CJ, Schierer M, Ellison B, Eicher-Miller HA, Gundersen C, Nickols-Richardson SM. Grit is associated with food security among US parents and adolescents. Am J Health Behav 2019;43:207–18.

26. Adams J, Nettle D. Time perspective, personality and smoking, body mass, and physical activity: An empirical study. Br J Health Psychol [Internet] Br J Health Psychol; 2009 [cited 2020 Nov 8];14:83–105. Available from: https://pubmed.ncbi.nlm.nih.gov/18435866/

27. Paunesku D, Walton GM, Romero C, Smith EN, Yeager DS, Dweck CS. Mind-Set Interventions Are a Scalable Treatment for Academic Underachievement. Psychol Sci [Internet] SAGE Publications Inc.; 2015 [cited 2020 Nov 8];26:784–93. Available from: https://pubmed.ncbi.nlm.nih.gov/25862544/

28. Vanhove AJ, Herian MN, Perez ALU, Harms PD, Lester PB. Can resilience be developed at work? A meta-analytic review of resilience-building programme effectiveness. J Occup Organ Psychol [Internet] John Wiley and Sons Ltd.; 2016 [cited 2020 Nov 8];89:278–307. Available from: https://onlinelibrary.wiley.com/doi/full/10.1111/joop.12123

29. Myers CA, Beyl RA, Martin CK, Broyles ST, Katzmarzyk PT. Psychological mechanisms associated with food security status and BMI in adults: A mixed methods study. Public Health Nutr 2020;23:2501–11.

30. Lindow JC, Hughes JL, South C, Minhajuddin A, Gutierrez L, Bannister E, et al. The Youth Aware of Mental Health Intervention: Impact on Help Seeking, Mental Health Knowledge, and Stigma in U.S. Adolescents. J Adolesc Heal [Internet] Elsevier Inc.; 2020;67:101–7. Available from: https://doi.org/10.1016/j.jadohealth.2020.01.006

31. Wiljer D, Shi J, Lo B, Sanches M, Hollenberg E, Johnson A, et al. Effects of a Mobile and Web App (Thought Spot) on Mental Health Help-Seeking among College and University Students: Randomized Controlled Trial. J Med Internet Res 2020;22:1–13.

32. US Department of Agriculture Economics Research Service. Rural Classifications [Internet]. [cited 2022 Jul 20]. Available from: https://www.ers.usda.gov/topics/rural-economy-population/rural-classifications/

33. United States Census Beureau. Population and Housing Unit Estimates Datasets [Internet]. [cited 2022 Aug 10]. Available from: https://www.census.gov/programs-surveys/popest/data/data-sets.2019.List_1725564412.html

34. Wright B, MacDermid Wadsworth S, Wellnitz A, Eicher-Miller H. Reaching rural veterans: a new mechanism to connect rural, low-income US Veterans with resources and improve food security. J Public Health (Bangkok) 2019;41:714–23.

35. Smid WJ, Kamphuis JH, Wever EC, Van Beek DJ. A comparison of the predictive properties of nine sex offender risk assessment instruments. Psychol Assess 2014;26:691–703.

36. Parent MC. Handling Item-Level Missing Data: Simpler Is Just as Good. Couns Psychol 2013;41:568–600.

37. Wilson CJ, Deane FP, Ciarrochi J V, Rickwood D. Measuring help seeking intentions: Properties of the General Help-Seeking Questionnaire. Can J Couns [Internet] 2005;39:15–28. Available from: https://ro.uow.edu.au/hbspapers/1527/

38. Bickel G, Nord M, Price C, Hamilton W, Cook J. Guide to Measuring Household Food Security, Revised 2000. Alexandria VA; 2000.

39. Ma C, Ho SKM, Singh S, Choi MY. Gender Disparities in Food Security, Dietary Intake, and Nutritional Health in the United States. Am J Gastroenterol 2021;116:584–92.

40. National Canter for Equitable Care for Elders. Food Insecurity Among Older Adults. 2019;

41. Coleman-Jensen A, Rabbitt MP, Gregory C, Singh A. Household food security in the United States in 2020. U.S. Department of Agriculture, Economic Research Service. 2021.

42. Smith M. Fact Sheet Gender and Food Insecurity: The Burden on Poor Women.

43. U.S. Department of Veterans Affairs. Profile of Veterans : 2017 [Internet]. 2019. Available from: https://www.va.gov/vetdata/docs/SpecialReports/Profile_of_Veterans_2011.pdf

44. Kamdar N, Lester HF, Daundasekara SS, Greer AE, Hundt NE, Utech A, et al. Food insecurity: Comparing odds between working-age veterans and nonveterans with children. Nurs Outlook Elsevier Inc.; 2021;69:212–20. Available from: https://doi.org/10.1016/j.outlook.2020.08.011

45. O'Toole TP, Roberts CB, Johnson EE. Screening for food insecurity in six veterans administration clinics for the homeless, june-december 2015. Prev Chronic Dis 2017;14:1–4.

46. Cohen AJ, Dosa DM, Rudolph JL, Halladay CW, Heisler M, Thomas KS. Risk factors for Veteran food insecurity: Findings from a National US Department of Veterans Affairs Food Insecurity Screener. Public Health Nutr 2022;25:819–28.

47. Stretesky PB, Defeyter MA. Food Insecurity among UK Veterans. Armed Forces Soc 2022;in press.

48. Pooler JA, Srinivasan M, Miller Z, Mian P. Prevalence and Risk Factors for Food Insecurity Among Low-Income US Military Veterans. Public Health Rep SAGE Publications Ltd; 2021 [cited 2022 Jul 28];136:618–25. Available from: https://journals.sagepub.com/doi/abs/10.1177/0033354920974662

49. London AS, Heflin CM. Supplemental Nutrition Assistance Program (SNAP) Use Among Active-Duty Military Personnel, Veterans, and Reservists. Popul Res Policy Rev Springer Netherlands; 2015;34:805–26.

50. Illinois Department of Human Services. Supplemental Nutrition Assistance Program - SNAP [Internet]. [cited 2022 Jul 28]. Available from: https://www.dhs.state.il.us/page.aspx?item=30357

51. Zhao C, Guo J. Are Veterans Happy? Long-term Military Service and the Life Satisfaction of Elderly Individuals in China [Internet]. Journal of Happiness Studies. Springer Netherlands; 2022. 477–508 p. Available from: https://doi.org/10.1007/s10902-021-00410-4

52. Kamdar NP, Horning ML, Geraci JC, Uzdavines AW, Helmer DA, Hundt NE. Risk for depression and suicidal ideation among food insecure US veterans: data from the National Health and Nutrition Examination Study. Soc Psychiatry Psychiatr Epidemiol Springer Berlin Heidelberg; 2021;56:2175–84. Available from: https://doi.org/10.1007/s00127-021-02071-3

53. Brostow DP, Smith AA, Bahraini NH, Besterman-Dahan K, Forster JE, Brenner LA. Food Insecurity and Food Worries During the COVID-19 Pandemic: A Point-In-Time Study of Injured United States Veterans. J Hunger Environ Nutr Taylor & Francis; 2022;00:1–23. Available from: https://doi.org/10.1080/19320248.2022.2118564

54. Widome R, Jensen A, Fu SS. Socioeconomic disparities in sleep duration among veterans of the US wars in Iraq and Afghanistan. Am J Public Health 2015;105:e70–4.

55. Sweet J, Poirier A, Pound T, Van Til L. Well-Being of Canadian Regular Force Veterans: Findings from LASS 2019 Survey - Veterans Affairs Canada [Internet]. Veterans Affairs Canada. Research Directorate Technical Report - Veterans Affairs Canada. 2020. Available from: https://www.veterans.gc.ca/eng/about-vac/research/research-directorate/publications/reports/lass-well-being-2020%0Ahttp://publications.gc.ca/pub?id=9.889617&sl=0

56. O'Toole BI, Catts S V., Outram S, Pierse KR, Cockburn J. The physical and mental health of australian vietnam veterans 3 decades after the war and its relation to military service, combat, and post-traumatic stress disorder. Am J Epidemiol 2009;170:318–30.

57. Thompson JM, VanTil LD, Zamorski MA, Garber B, Dursun S, Fikretoglu D, et al. Mental health of Canadian Armed Forces Veterans: review of population studies. J Mil Veteran Fam Heal 2016;2:70–86.

58. VanTil LD, MacLean MB, Sweet J, McKinnon K. Understanding future needs of Canadian veterans. Heal Reports 2018;29:20–5.

59. Vogt D, Borowski SC, Godier-McBard LR, Fossey MJ, Copeland LA, Perkins DF, et al. Changes in the health and broader well-being of U.S. veterans in the first three years after leaving military service: Overall trends and group differences. Soc Sci Med Elsevier Ltd; 2022;294:114702. Available from: https://doi.org/10.1016/j.socscimed.2022.114702

60. Oster C, Morello A, Venning A, Lawn S. The health and wellbeing needs of veterans: A rapid review. BMC Psychiatry BMC Psychiatry; 2017;17:1–14.

61. Blanch S, Barkus E. Schizotypy and help-seeking for anxiety. Early Interv Psychiatry 2021;15.

62. Mann EG, VanDenKerkhof EG, Johnson A, Gilron I. Help-seeking behavior among community-dwelling adults with chronic pain. Can J Pain Taylor & Francis; 2019;3:8–19. Available from: https://doi.org/10.1080/24740527.2019.1570095

63. Eicher-Miller HA, Rivera RL, Sun H, Zhang Y, Maulding MK, Abbott AR. Supplemental Nutrition Assistance Program-Education Improves Food Security Independent of Food Assistance and Program Characteristics. Nutrients NLM (Medline); 2020;12.

CHAPTER 3. USUAL NUTRIENT INTAKES AND DIET QUALITY AMONG U.S. OLDER ADULTS PARTICIPATING IN THE SUPPLEMENTAL NUTRITION ASSISTANCE PROGRAM COMPARED TO INCOME ELIGIBLE NONPARTICIPANTS

Qin Y, Cowan AE, Bailey RL, Jun S, Eicher-Miller HA. Usual nutrient intakes and diet quality among U.S. older adults participating in the Supplemental Nutrition Assistance Program compared to income eligible nonparticipants. Accepted at Am. J. Clin. Nutr. March 9, 2023.

This chapter was accepted as an original research article to The American Journal of Clinical Nutrition and formatted according to the journal requirements. American Society for Nutrition journals provide the right for authors to include their own articles in their dissertation.

3.1 Abstract

Background:

The proportion of older adults with food insecurity at 8%, has increased faster than that of the general U.S. population 2001-2017. Many low-income food-insecure older adults rely on food assistance programs, such as the Supplemental Nutrition Assistance Program (SNAP), for meeting energy and nutrient needs, while others are eligible but do not participate. Neither updated nutrient intake estimates nor potential differences in meeting the Dietary Reference Intakes from foods alone and with dietary supplements (DS) among low-income older adults using or eligible for SNAP are known.

Objectives:

This study assessed and compared national estimates of usual nutrient adequacy and dietary quality of U.S. older adults using SNAP and income eligible nonparticipants.

Methods:

Usual dietary intake was estimated among older adults (≥60 years; *n*=2,582) of the 2007-2016 NHANES cross-sectional national survey. Data on food assistance participation and eligibility (poverty-income-ratio≤130%), DS use, and ≥24-hour dietary recalls were used. The National Cancer Institute method (Markov Chain Monte Carlo approach) was applied to estimate mean usual nutrient intakes, proportion of inadequate nutrient intake, and dietary quality using 2015 Healthy Eating Index.

Results:

Neither usual nutrient intake from dietary and total sources nor dietary quality differed between older adult SNAP participants and eligible nonparticipants. Low dietary quality and high percentage of inadequate intake for several nutrients was apparent among both groups especially from food sources alone, including vitamins A(56%), C(55%), D(97%), E(99%), calcium(73%), and magnesium(74%), but rates were attenuated when DS were also considered (i.e. 36% reduced risk for vitamin D inadequacy).

Conclusions:

Diet quality and usual nutrient intake among older adult SNAP participants and eligible nonparticipants were poor, but DS lowered the risk of nutrient inadequacy. Future policies and programs should focus on improving intake of vitamins A, C, D, E, calcium and magnesium, and dietary quality for all older adults.

3.2 Introduction

Nearly 8% of U.S. older adults (≥60 years) experienced food insecurity in 2017 (1), defined as an "economic or social condition of limited or uncertain access to adequate food" (2). The prevalence of food insecurity among this group increased more rapidly than that of the general U.S. population from 2001 to 2017, which has not been observed previously, and is likely to continue in the future (1,3,4). Older individuals may experience more nutritional risk when compared with those of younger ages due to decreased absorption and digestion related to aging (5–7) and many rely on food assistance programs (8); the largest being the federally funded Supplemental Nutrition Assistance Program (SNAP). SNAP provides benefits for participants to purchase foods that have the potential to contain critical energy and nutrients that are often under-consumed (9) among older adults and that can support healthy aging and disease prevention, including calcium, magnesium, zinc, vitamins A, B6, B12, C, D, E, and folate (10). Nutrient intakes of U.S. older adults by SNAP participation are addressed in a few earlier studies (10–15). However, nutrient intake estimates among older adults using SNAP, and those eligible but not using SNAP, that include recent data within the timeframe of food insecurity increases (2001-2017), remain unknown as do estimates of usual nutrient intake. Usual intake estimates reflect dietary intake over time, mitigating within-person random measurement error associated with self-

reported dietary intake, and more closely linking to health compared with estimates of intake on a single day, aligning with dietary recommendations to support health over the long term (16). Therefore, nutrient intake estimates that include the most recent data and that use rigorous methodology to estimate usual intake, are needed to address the fast-growing prevalence of food insecurity among older adults (1,4).

Dietary supplements (DS) are often excluded when examining nutrient intake but may represent a significant contribution to total nutrient intake, the summation of intake derived from both nutrients from dietary sources and from DS (8). Older adults are among the largest population subgroups to consume DS in the U.S. (17), with approximately 75% of all older adults over 71 years using DS. (17). DS can be costly as they are not covered by health insurance, presenting a barrier for low-income groups who generally use DS less prevalently; however, older adults with a household poverty-to-income ratio ≤ 130% also use DS at a rate of 66%, with the most common type being multivitamin-minerals, at a prevalence of 34% (17). Previous research has shown that up to 64% (vitamin D) of nutrient intake among food insecure adults ≥19 years comes from DS and that they make important contributions to meeting requirements for certain nutrients (8). The nutrients added by supplements are expected to be even greater for older adults as a group compared with all adults because of more widespread use among this life stage, but nutrient intakes from total sources remain unknown as does the proportion of low-income older adults using SNAP meeting nutrient requirements when total sources are considered.

The U.S. population is encouraged to meet nutrient needs through dietary sources as per the Dietary Guidelines for Americans (DGA) while for certain at-risk groups, such as older adults, DS use might be appropriate (18). Yet, critical information for evaluation and making policy decisions and recommendations with regard to SNAP concerning DS use among older U.S. adults are currently missing, including: their dietary quality, usual nutrient intake from dietary and total sources and proportion meeting Dietary Reference Intake (DRI) recommendations. Thus, the objectives of this study were to: 1) characterize the prevalence of SNAP participation and income eligible (≤130% family poverty-to-income ratio) nonparticipation and associated characteristics including household/adult food security; 2) estimate mean *usual* nutrient intake and the proportion meeting requirements from dietary and total sources, and dietary quality; and, 3) compare the dietary outcomes in objective 2 between SNAP participants and income eligible nonparticipants, all among U.S. older adults. The authors hypothesized that characteristics between the two groups

would be different and SNAP participants would have higher usual nutrient intake (both dietary and total), less risk of inadequacy and higher dietary quality compared to eligible nonparticipants.

3.3 Research Methods

3.3.1 Study Design and Survey Measures Collected

The current cross-sectional study was a secondary analysis of U.S. older adults (≥60y) using data from the 2007-2016 NHANES. This nationally representative survey is ongoing, among the non-institutionalized civilian U.S. population, and uses a stratified, multistage probability sampling design (19). The study design and survey measures collected in NHANES have been approved by the National Center for Health Statistics Research Ethics Review Board.

Data are collected in three phases in NHANES: 1) in the household interview, 2) the health examination at the mobile examination center, and 3) during a telephone follow-up. First, an in-person household interview collected information on socio-demographic and health-related characteristics, household and adult food security status (using the U.S. Household Food Security Survey Module (20)), and food assistance program participation (whether a participant received: SNAP; emergency food from church, food pantry, food bank or soup kitchen; community/government meal delivery or meals at senior center) over the past 12 months. During the household interview, a frequency-based DS and Prescription Medicine Questionnaire (DSMQ) was also administered to gather information on DS use in the previous 30-days (21). For each DS reported, participants showed supplement containers to trained interviewers and reported on frequency, duration and amount taken. About 3 weeks later, in the mobile examination center, a health examination including an in-person 24-hour dietary recall was completed to gather information on reported intake from foods and DS over the previous day. Lastly, about 3-10 days after the first 24-hour dietary recall, a second dietary recall was completed by telephone. Both dietary recalls were collected by trained professionals using the USDA's automated multiple-pass method (22) to record food, beverage, and DS intake. Nutrient conversion of the recorded foods and beverages in the dietary recalls were completed using the USDA Food and Nutrient Database for Dietary Studies and DS data was converted using the NHANES DS database, where trained professionals at the National Center for Health Statistics reviewed the collected data, acquired product labels and incorporating detailed DS information to derive nutrients in application of the

NHANES DS database (23,24). SNAP participants were categorized as those who reported receiving SNAP benefits in the past 12 months, while income eligible nonparticipants were those that reported not receiving SNAP benefits in the past 12 months and had a family poverty-to-income ratio ≤ 130% of the federal poverty level, the financial eligibility cutoff for SNAP (25,26). Use of emergency food was categorized as reporting of have received emergency food from a church, a food pantry or a food bank, or ate in a soup kitchen in the past 12 months.

For the current analysis, data from 2007-2016 were combined as the most updated appropriate analytic sample with all necessary components (n=50,588). Sixty years or older were used as criteria for older adults because this was used to define "senior" in food assistance programs (27). Those who were <60 years of age (n=40,828), without at least one reliable 24-hour dietary recall (n=1,162), without family poverty-to-income ratio information (n=6,017) and without DSMQ (n=0), were excluded, resulting in a final analytic sample of 2,581 U.S. older adults (**Supplemental Figure 1**).

3.3.2 Statistical Analysis

Nutrients of public health concern, nutrients at a high risk for under-consumption, and those with an Estimated Average Requirement (EAR) were selected as outcomes, including calcium, magnesium, zinc, vitamins A, B6, B12, C, D, E, and folate (28,29). Means and distributions of usual nutrient intakes, and proportion meeting the Estimated Average Requirement (EAR), from foods and beverages alone and from food, beverages, and DS (except for vitamins A and E, whose summary variables for nutrient intake from DS are not available in NHANES) were estimated using an adaptation of the National Cancer Institute (NCI) method macros (16,30–32). Standard errors for usual nutrient intakes were approximated via Fay's Modified Balanced Repeated Replication technique (33). The distributions of usual nutrient intake for the U.S. older adult population were estimated, accounting for covariates and mitigating within-person variation from a small number of repeated 24-hour dietary recalls for dietary intake and approximate normality at group level utilizing the NCI method (16,30–32). In addition, information from DS use reported on the DSMQ were also used for total usual intakes. Estimates were produced using a "shrink then add" approach (31). Extensive details surrounding the NCI method can be found elsewhere (31). Day of the week of the recall day, interview sequence, and DS use were adjusted as covariates in the usual intake models. Although socio-demographic characteristics and food

security status showed differences between compared groups (education, household food security, adult food security, emergency food use), they were not adjusted for in the usual intake models to avoid multi-collinearity. Race and ethnicity (i.e. Hispanic origin) were significantly different between the SNAP participants and income eligible nonparticipants but a sensitivity analysis using the usual intake models showed these characteristics had little impact on the usual intake results. To avoid over-adjusting the models and to be consistent across analysis for all comparisons, race and ethnicity were not adjusted in the final usual intake analysis. Subgroup analyses were performed using categorical variables for SNAP participation status, sex and age. All comparisons were analyzed by full sample and with stratification of sex and age, separately, where sample was large enough to accommodate. The sample was sufficient to detect meaningful differences in nutrient intake and dietary quality using α=0.05 and β=0.80 (34). Bonferroni-corrected *p*-values (0.05/10, 0.05/8, 0.05/13) were applied based on the number of comparisons for each outcome (35,36).

The 2015 Healthy Eating Index (HEI-2015) is a density based score that quantifies dietary conformance with the 2015 DGA (37), and is the summation of scores for 13 food and nutrient components, including nine adequacy components: total fruit, whole fruit, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins; and four components to be consumed in moderation: fatty acids, refined grains, sodium, added sugars and saturated fats, which were reverse scored (37–39). The HEI-2015 has a maximum score of 100, with higher scores indicating better diet quality. High HEI scores have been shown to be inversely related to risk of major chronic disease, overweight and obesity, and all-cause mortality (40,41). Total and component mean HEI-2015 scores were estimated using a Markov Chain Monte Carlo approach (42), an extension of the NCI method, enabling simultaneous modeling of multiple food groups and nutrients. The selection of covariates for the HEI analysis was consistent with the usual intake analysis described above except race and ethnicity were impactful on the HEI results and were added. As a result, covariates included in the analysis included interview recall day of the week, sequence of dietary recall, and race and ethnicity. The study sample generated a limited sample size for several episodically consumed foods after stratification. In order to meet the sample size recommendations for using the Markov Chain Monte Carlo approach, the HEI analysis was not stratified by sex or age. Like usual nutrient intake, standard errors for HEI-2015 total and

component scores were obtained by performing Fay's Modified Balanced Repeated Replication (33).

Comparison of differences in percentages, means for usual nutrient intakes and HEI-2015 scores between older adults participating in SNAP and not participating, but eligible for SNAP were determined using pairwise t-tests with a Bonferroni-adjusted *p*-value, based on different number of comparisons for each outcome measurement. Satterthwaite-adjusted Wald Chi-square tests for categorical variables compared socio-demographic characteristics and food security status among SNAP participants and income eligible nonparticipants with a two-sided p-value of <0.05. All analyses were completed using SAS software, version 9.4 (SAS Institute Inc., Cary, NC, USA)

3.4 Results

SNAP participants were younger (60-70 years), less likely to be non-Hispanic white and more likely to be non-Hispanic black, had lower educational attainment (less than high school), lower household and adult food security, more likely to use emergency food, and were less likely to take a DS in a 30-day period, when compared with income-eligible SNAP nonparticipants (**Table 1).**

Usual nutrient intake compared to the EAR reflected inadequate intake for most of the group who were SNAP participants and for the group who were income-eligible for SNAP but not participating (**Table 2-7**). Specifically, when only intake from foods and beverages were considered, over 90% did not meet the EAR for vitamins D and E, over 70% did not meet the EAR for calcium and magnesium, and over 50% did not meet the EAR for vitamins A and C. However, when intake from DS was considered, the risk of not meeting the EAR was lower across all nutrients. For some nutrients, this reduction in the risk of inadequacy with the inclusion of DS was especially notable; among both SNAP participants and eligible nonparticipants, about 60% had total intakes below the EAR for magnesium and vitamin D, and about 50% had total intakes below the EAR for calcium, while less than 50% of the group had total intakes below the EAR for all other nutrients assessed: zinc, folate and vitamins A, B6, B12, C, and E.

No significant differences in usual nutrient intake were observed between older adult SNAP participants and income eligible nonparticipants, regardless of stratification by age and sex; this was apart from total usual vitamin D intake ($P = 0.004$) (**Table 5**). More specifically, total

usual vitamin D intake among male SNAP participants was significantly lower than that of income eligible SNAP nonparticipants (9.5 vs. 16.3 µg/d).

The dietary quality of older adult SNAP participants and eligible nonparticipants was reflected by total HEI-2015 scores of 60 (SNAP participants) and 59 (eligible nonparticipants) out of 100 (**Table 8**). No significant differences regarding HEI-2015 total and component scores were found between SNAP participants and eligible nonparticipants.

Table 3.1 Sociodemographic characteristics and comparison of U.S. low-income older adult Supplemental Nutrition Assistance Program (SNAP) participants and SNAP eligible nonparticipants over 60 years drawn from NHANES during 2007 - 2016[1]

		SNAP participants (n=713)		SNAP eligible nonparticipants (n=1868)		
Characteristics		n	%	n	%	*P* – Value[2]
Sex						0.08
	Male	304	35.6	882	39.5	
	Female	409	64.4	986	60.5	
Age						**0.0006**
	60-70	460	63.9	1008	52.6	
	70+	253	36.1	860	47.4	
Race and Ethnicity						**0.0001**
	Non-Hispanic white	185	45.5	745	61.7	
	Non-Hispanic black	255	26.2	358	13.3	
	Hispanic	221	19.8	639	17.8	
	Other	52	8.4	126	7.1	
Education						**0.0063**
	Less than high school	420	51.5	929	41.6	
	High School Grad/GED	134	22.7	430	26.6	
	Some college or associate degree	121	20.5	364	23.7	
	College or above	36	5.3	141	8.1	
Poverty-income-ratio						0.74
	0% to 50%	79	10.0	222	9.6	
	50% to 100%	307	44.9	827	42.6	
	above 100%	264	45.1	819	47.9	
Household Food Security						**<.0001**
	Secure	326	49.8	1112	65.2	
	Low	280	36.1	547	24.9	
	Very low	104	14.1	208	9.8	
Adult Food Security						**<.0001**
	Secure	327	49.8	1116	65.3	
	Low	273	35.8	531	23.9	
	Very low	110	14.3	220	10.8	

Table 3.1 continued

Emergency Food						**0.040**
	Yes	176	23.4	320	17.5	
	No	537	76.6	1546	82.5	
Community Meals/Meal Deliveries						0.32
	Yes	90	12.6	267	14.7	
	No	623	87.4	1601	85.3	
Dietary Supplement Use (in the past 30 days)						**0.022**
	Yes	347	52.9	1034	59.7	
	No	366	47.1	834	40.3	

[1]NHANES, National Health and Nutrition Examination Survey. Age≥60 years. [2]Rao-Scott F adjusted chi-square tests were used to compare socio-demographic and food security status among food assistance groups with two-sided p-value of <0.05. [3]Federal poverty line.

Table 3.2 Usual intake from food among Supplemental Nutrition Assistance Program (SNAP) participants and eligible nonparticipants in U.S. low-income older adults over 60 years as drawn from NHANES during 2007 - 2016 [1]

		Usual Intake from food					
Nutrient	Estimated Average Requirement (EAR)	Mean (SE)			% not meeting EAR (SE)		
		SNAP users (N=713)	SNAP eligible non-users (N=1868)	p-value[2]	SNAP users (N=713)	SNAP eligible non-users (N=1868)	p-value [2]
Calcium, mg[3]	800-1,000	787.3 (27.7)	792.7 (15.3)	0.90	72.0 (3.4)	73.0 (1.8)	0.85
Magnesium, mg[4]	265-350	242.9 (6.0)	253.0 (3.1)	0.27	73.8 (2.4)	71.1 (1.2)	0.46
Zinc, mg[5]	6.8-9.4	9.3 (0.2)	9.4 (0.2)	0.80	35.1 (2.9)	37.4 (1.7)	0.61
Vitamin A, mcg[6]	500-625	552.2 (23.5)	592.5 (15.8)	0.30	56.0 (3.6)	53.0 (2.2)	0.60
Folate, mcg	320	443.2 (14.6)	459.8 (9.4)	0.48	23.2 (3.7)	21.7 (3.0)	0.82
Vitamin B6, mg[7]	1.3-1.4	1.6 (0.04)	1.7 (0.03)	0.14	33.8 (3.5)	32.8 (1.9)	0.85
Vitamin B12, mcg	2	4.3 (0.2)	4.2 (0.1)	0.74	6.3 (2.4)	7.9 (1.7)	0.69
Vitamin C, mg[8]	60-75	71.0 (4.5)	71.0 (2.1)	1.0	54.7 (3.9)	55.1 (2.0)	0.95
Vitamin D, mcg	10	4.3 (0.2)	4.4 (0.1)	0.74	95.7 (1.4)	97.0 (0.7)	0.54
Vitamin E, mg	12	6.0 (0.3)	6.8 (0.2)	0.10	98.9 (0.8)	94.4 (1.0)	0.01

[1]NHANES, National Health and Nutrition Examination Survey. Age ≥60. [2]Statistical significance was determined as $p<0.005$ using a Bonferroni adjustment. [3]EAR of calcium is 800mg for men 60-70 years of age and 1,000mg for women years of age and adults over 70 years of age. [4]EAR of magnesium is 350mg for men over 60 years and 265mg for women over 60 years. [5]EAR of zinc is 9.4mg for men over 60 years and 6.8mg for women over 60 years. [6]EAR of vitamin A is 625mcg for men over 60 years and 500mcg for women over 60 years. [7]EAR of vitamin B6 is 1.4mg for men over 60 years and 1.3mg for women over 60 years. [8]EAR of vitamin C is 75mg for men over 60 years and 60mg for women over 60 years.

Table 3.3 Total usual intake from diet and supplements among Supplemental Nutrition Assistance Program (SNAP) participants and eligible nonparticipants of U.S. low-income older adults over 60 years as drawn from NHANES during 2007 - 2016 [1]

		Total usual nutrient intake					
Nutrient	Estimated Average Requirement (EAR)	Mean (SE)			% not meeting EAR (SE)		
		SNAP users (N=713)	SNAP eligible non-users (N=1868)	p-value[2]	SNAP users (N=713)	SNAP eligible non-users (N=1868)	p-value[2]
Calcium, mg[3]	800-1,000	938.8 (29.6)	985.2 (17.4)	0.32	58.0 (3.1)	56.0 (1.7)	0.68
Magnesium, mg[4]	265-350	263.1 (8.2)	285.3 (4.7)	0.084	67.8 (2.4)	62.3 (1.3)	0.14
Zinc, mg[5]	6.8-9.4	12.5 (0.5)	14.8 (0.4)	0.01	29.8 (2.8)	29.2 (1.5)	0.89
Vitamin A, mcg[6]	500-625	--	--	--	--	--	--
Folate, mcg	320	629.5 (25.9)	680.0 (15.8)	0.22	18.0 (3.3)	17.0 (2.3)	0.85
Vitamin B6, mg[7]	1.3-1.4	4.2 (0.7)	4.7 (0.4)	0.65	28.3 (3.2)	25.7 (1.6)	0.59
Vitamin B12, mcg	2	62.5 (14.1)	91.6 (11.0)	0.23	5.0 (2.0)	6.0 (1.3)	0.76
Vitamin C, mg[8]	60-75	134.6 (12.6)	173.6 (11.2)	0.089	43.0 (3.2)	40.0 (2.1)	0.56
Vitamin D, mcg	10	11.6 (1.1)	20.0 (2.0)	0.0070	66.4 (2.4)	60.8 (1.9)	0.18
Vitamin E, mg	12	--	--	--	--	--	--

[1]NHANES, National Health and Nutrition Examination Survey. Age ≥60 years. [2]Statistical significance was determined as $p<0.00625$ using a Bonferroni adjustment. [3]EAR of calcium is 800mg for men 60-70 years of age and 1,000mg for women years of age and adults over 70 years of age. [4]EAR of magnesium is 350mg for men over 60 years and 265mg for women over 60 years. [5]EAR of zinc is 9.4mg for men over 60 years and 6.8mg for women over 60 years. [6]EAR of vitamin A is 625mcg for men over 60 years and 500mcg for women over 60 years. [7]EAR of vitamin B6 is 1.4mg for men over 60 years and 1.3mg for women over 60 years. [8]EAR of vitamin C is 75mg for men over 60 years and 60mg for women over 60 years.

Table 3.4 Usual intake from food among Supplemental Nutrition Assistance Program (SNAP) participants and eligible nonparticipants in U.S. low-income older adults over 60 years **by sex** as drawn from NHANES during 2007 - 2016[1]

		Usual Intake from food					
Nutrient	Estimated Average Requirement (EAR)	Mean (SE)			% not meeting EAR (SE)		
		SNAP users	SNAP eligible non-users	p-value[2]	SNAP users	SNAP eligible non-users	p-value[2]
Male							
Calcium, mg[3]	800-1000	912.0 (70.5)	850.7 (27.3)	0.55	52.0 (5.9)	38.0 (3.2)	0.12
Magnesium, mg	350	260.6 (27.1)	267.1 (20.7)	0.89	76.2 (4.7)	75.7 (6.8)	0.96
Zinc, mg	9.4	10.9 (0.5)	11.0 (0.3)	0.90	37.7 (6.1)	39.1 (3.1)	0.88
Vitamin A, mcg	625	543.6 (44.4)	610.3 (26.4)	0.34	67.0 (5.2)	60.0 (3.2)	0.40
Folate, mcg	320	503.6 (31.0)	513.1 (15.5)	0.84	17.0 (4.7)	12.0 (3.3)	0.52
Vitamin B6, mg	1.4	1.81 (0.09)	1.99 (0.07)	0.24	28.8 (5.4)	25.4 (3.1)	0.69
Vitamin B12, mcg	2	4.9 (0.3)	4.7 (0.3)	0.73	4.0 (2.5)	4.5 (2.0)	0.91
Vitamin C, mg (EAR)	60	82.2 (8.1)	76.6 (4.7)	0.66	58.0 (5.3)	57.9 (4.3)	0.99
Vitamin D, mcg	10	5.0 (0.5)	4.7 (0.2)	0.68	91.1 (3.1)	96.4 (1.1)	0.23
Vitamin E, mg	12	6.7 (0.5)	7.6 (0.3)	0.25	98.5 (2.1)	93.4 (2.2)	0.21

Table 3.4 continued

Female							
Calcium, mg	1000	722.9 (21.6)	755.1 (17.2)	0.39	85.0 (2.5)	82.0 (2.5)	0.54
Magnesium, mg	265	224.5 (6.8)	234.8 (3.3)	0.32	75.4 (3.9)	69.2 (1.6)	0.28
Zinc, mg	6.8	8.5 (0.3)	8.4 (0.2)	0.84	30.1 (4.8)	33.2 (2.9)	0.69
Vitamin A, mcg	500	555.9 (31.0)	580.1 (21.6)	0.64	48.0 (6.1)	48.0 (3.0)	1.0
Folate, mcg	320	411.3 (16.3)	425.5 (11.1)	0.60	26.4 (5.3)	27.9 (3.5)	0.86
Vitamin B6, mg	1.3	1.5 (0.06)	1.5 (0.04)	1.0	36.3 (6.9)	37.3 (2.9)	0.92
Vitamin B12, mcg	2	4.0 (0.2)	3.9 (0.1)	0.74	7.1 (4.0)	9.2 (2.3)	0.74
Vitamin C, mg	75	65.5 (4.7)	67.4 (2.9)	0.80	52.5 (4.9)	53.7 (2.6)	0.87
Vitamin D, mcg	10	4.0 (0.2)	4.2 (0.1)	0.51	98.1 (0.9)	97.5 (0.7)	0.70
Vitamin E, mg	12	5.6 (0.3)	6.4 (0.2)	0.11	99.3 (0.6)	95.2 (1.0)	0.010

[1]NHANES, National Health and Nutrition Examination Survey. Age ≥60. [2]Statistical significance was determined as $p<0.005$ using a Bonferroni adjustment. [3]EAR of calcium is 800mg for men 60-70 years of age and 1,000mg for adults over 70 years of age.

Table 3.5 Total usual intake from diet and supplements among Supplemental Nutrition Assistance Program (SNAP) participants and eligible nonparticipants of U.S. low-income older adults over 60 years **by sex** as drawn from NHANES during 2007 - 2016 [1]

		Total usual nutrient intake					
Nutrient	Estimated Average Requirement (EAR)	Mean (SE)			% not meeting EAR or exceeding AI (SE)		
		SNAP users	SNAP eligible non-users	p-value[2]	SNAP users	SNAP eligible non-users	p-value[2]
Male							
Calcium, mg[3]	800-1000	1008.6 (77.3)	962.1 (31.7)	0.68	45.0 (6.1)	49.0 (3.2)	0.67
Magnesium, mg	350	277.6 (23.5)	295.7 (15.9)	0.64	70.7 (5.4)	66.6 (6.4)	0.72
Zinc, mg	9.4	13.3 (0.7)	15.7 (0.6)	0.054	34.1 (5.6)	31.4 (2.5)	0.74
Vitamin A, mcg	625	--	--	--	--	--	--
Folate, mcg	320	650.9 (45.0)	705.8 (23.8)	0.42	15.0 (4.5)	9.0 (2.6)	0.39
Vitamin B6, mg	1.4	3.7 (0.7)	5.1 (0.7)	0.30	26.9 (5.0)	20.6 (2.3)	0.40
Vitamin B12, mcg	2	47.7 (19.4)	86.0 (18.3)	0.29	4.0 (2.2)	4.0 (1.6)	1.0
Vitamin C, mg	60	142.5 (22.4)	152.6 (13.0)	0.77	48.8 (5.1)	44.0 (4.1)	0.59
Vitamin D, mcg	10	9.5 (0.9)	16.3 (1.5)	**0.0042**	69.9 (4.3)	65.1 (2.5)	0.47
Vitamin E, mg	12	--	--	--	--	--	--

Table 3.5 continued

Female							
Calcium, mg	1000	904.6 (25.2)	1000.6 (22.8)	0.040	67.0 (2.6)	61.0 (2.0)	0.18
Magnesium, mg	265	248. 2 (10.3)	271.9 (6.5)	0.16	66.8 (3.8)	59.5 (1.6)	0.20
Zinc, mg	6.8	12.1 (0.8)	14.3 (0.5)	0.088	25.4 (4.5)	26.0 (2.4)	0.93
Vitamin A, mcg	500	--	--	--	--	--	--
Folate, mcg	320	619.2 (33.9)	663.7 (19.5)	0.41	20.0 (4.8)	21.0 (2.8)	0.90
Vitamin B6, mg	1.3	4.4 (1.1)	4.4 (0.5)	1.0	28.8 (5.6)	28.8 (2.4)	1.0
Vitamin B12, mcg	2	70.8 (20.6)	95.2 (11.5)	0.45	6.0 (3.0)	6.0 (1.7)	1.0
Vitamin C, mg	75	130.9 (15.7)	187.4 (15.1)	0.058	40.0 (4.0)	38.0 (2.5)	0.76
Vitamin D, mcg	10	12.8 (1.6)	22.4 (2.9)	0.59	64.3 (3.6)	58.2 (2.3)	0.30
Vitamin E, mg	12	--	--	--	--	--	--

[1]NHANES, National Health and Nutrition Examination Survey. Age ≥60 years. [2]Statistical significance was determined as $p<0.00625$ using a Bonferroni adjustment. [3]EAR of calcium is 800mg for men 60-70 years of age and 1,000mg for adults over 70 years of age.

Table 3.6 Usual intake from food among Supplemental Nutrition Assistance Program (SNAP) participants and eligible nonparticipants in U.S. low-income older adults over 60 years **by age group** as drawn from NHANES during 2007 - 2016[1]

		Usual Intake from food					
Nutrient	Estimated Average Requirement (EAR)	Mean (SE)			% not meeting EAR or exceeding AI (SE)		
		SNAP users	SNAP eligible non-users	p-value[2]	SNAP users	SNAP eligible non-users	p-value[2]
60-70 years							
Calcium, mg[3]	800-1,000	814.2 (37.4)	815.4 (23.6)	0.98	67.0 (4.0)	66.0 (2.8)	0.88
Magnesium, mg[4]	265-350	251.9 (8.7)	268.4 (6.0)	0.25	71.2 (3.1)	66.3 (2.1)	0.34
Zinc, mg[5]	6.8-9.4	9.4 (0.3)	10.0 (0.3)	0.30	34.9 (3.4)	35.0 (2.1)	0.99
Vitamin A, mcg[6]	500-625	567.2 (31.2)	567.1 (24.6)	1.0	56.0 (4.2)	58.0 (2.8)	0.77
Folate, mcg	320	452.0 (19.1)	478.2 (15.1)	0.43	22.9 (3.9)	21.0 (4.6)	0.82
Vitamin B6, mg[7]	1.3-1.4	1.6 (0.06)	1.8 (0.06)	0.084	32.3 (4.5)	32.2 (2.7)	0.99
Vitamin B12, mcg	2	4.2 (0.3)	4.3 (0.2)	0.84	7.7 (2.7)	10.0 (2.4)	0.64
Vitamin C, mg[8]	60-75	70.0 (6.0)	68.0 (3.4)	0.83	56.8 (4.9)	58.8 (3.3)	0.80
Vitamin D, mcg	10	4.2 (0.3)	4.3 (0.2)	0.84	95.5 (1.7)	96.9 (1.1)	0.61
Vitamin E, mg	12	6.1 (0.4)	7.2 (0.3)	0.11	99.0 (0.7)	92.2 (1.8)	0.0099

Table 3.6 continued

70+ years							
Calcium, mg	1,000	748.5 (29.2)	770.9 (20.0)	0.64	82.0 (4.7)	81.0 (2.9)	0.89
Magnesium, mg [4]	265-350	228.7 (6.9)	236.5 (4.1)	0.47	79.8 (3.0)	77.0 (1.9)	0.56
Zinc, mg[5]	6.8-9.4	9.3 (0.5)	8.9 (0.2)	0.58	34.0 (4.7)	40.3 (2.9)	0.40
Vitamin A, mcg[6]	500-625	531.3 (36.7)	619.7 (21.5)	0.12	55 (8.2)	47 (2.9)	0.49
Folate, mcg	320	432.1 (25.3)	440.0 (11.8)	0.83	19.9 (7.9)	23.5 (4.2)	0.76
Vitamin B6, mg[7]	1.3-1.4	1.5 (0.07)	1.6 (0.04)	0.36	34.0 (5.7)	33.9 (3.3)	0.99
Vitamin B12, mcg	2	4.5 (0.2)	4.2 (0.2)	0.43	3.5 (2.8)	6.1 (2.6)	0.61
Vitamin C, mg[8]	60-75	74.0 (5.9)	74.8 (3.1)	0.93	50.1 (5.3)	51.2 (2.7)	0.89
Vitamin D, mcg	10	4.6 (0.3)	4.4 (0.2)	0.68	96.9 (2.1)	97.0 (0.9)	0.97
Vitamin E, mg	12	5.9 (0.3)	6.5 (0.2)	0.22	98.5 (1.5)	96.0 (1.1)	0.32

[1]NHANES, National Health and Nutrition Examination Survey. Age ≥60 years. [2]Statistical significance was determined as $p<0.005$ using a Bonferroni adjustment. [3]EAR of calcium is 800mg for men 60-70 years of age and 1,000mg for women years of age and adults over 70 years of age. [4]EAR of magnesium is 350mg for men over 60 years and 265mg for women over 60 years. [5]EAR of zinc is 9.4mg for men over 60 years and 6.8mg for women over 60 years. [6]EAR of vitamin A is 625mcg for men over 60 years and 500mcg for women over 60 years. [7]EAR of vitamin B6 is 1.4mg for men over 60 years and 1.3mg for women over 60 years. [8]EAR of vitamin C is 75mg for men over 60 years and 60mg for women over 60 years.

Table 3.7 Total usual intake from diet and supplements among Supplemental Nutrition Assistance Program (SNAP) participants and eligible nonparticipants of U.S. low-income older adults over 60 years **by age group** as drawn from NHANES during 2007 - 2016 [1]

		Total usual nutrient intake					
Nutrient	Estimated Average Requirement (EAR)	Mean (SE)			% not meeting EAR or exceeding AI (SE)		
		SNAP users	SNAP eligible non-users	p-value[2]	SNAP users	SNAP eligible non-users	p-value[2]
60-70 years							
Calcium, mg[3]	800-1,000	960.0 (42.4)	976.4 (28.8)	0.81	54.0 (3.8)	53.0 (2.6)	0.87
Magnesium, mg[4]	265-350	275.5 (11.7)	296.8 (7.5)	0.26	65.3 (3.0)	58.7 (2.1)	0.19
Zinc, mg[5]	6.8-9.4	12.4 (0.6)	14.1 (0.6)	0.14	30.0 (3.3)	28.2 (2.1)	0.74
Vitamin A, mcg[6]	500-625	--	--	--	--	--	--
Folate, mcg	320	648.0 (32.5)	688.3 (23.1)	0.46	19.0 (3.8)	16.0 (3.6)	0.67
Vitamin B6, mg[7]	1.3-1.4	4.0 (0.6)	4.4 (0.5)	0.71	27.3 (4.2)	25.2 (2.2)	0.75
Vitamin B12, mcg	2	57.2 (14.0)	80.0 (17.0)	0.45	7.0 (2.2)	8.0 (1.9)	0.80
Vitamin C, mg[8]	60-75	120.7 (11.3)	160.0 (17.7)	0.16	44.0 (4.4)	45.0 (3.4)	0.90
Vitamin D, mcg	10	12.4 (1.6)	17.7 (1.7)	0.096	66.7 (3.0)	63.9 (2.9)	0.62
Vitamin E, mg	12	--	--	--	--	--	--

Table 3.7 continued

70+ years							
Calcium, mg	1,000	909.9 (28.8)	998.5 (24.7)	0.084	66.0 (4.3)	61.0 (2.2)	0.44
Magnesium, mg[4]	265-350	242.8 (7.5)	273.0 (7.8)	0.039	73.2 (2.8)	66.8 (1.9)	0.16
Zinc, mg[5]	6.8-9.4	12.8 (1.0)	15.6 (0.7)	0.089	28.2 (3.9)	30.8 (2.3)	0.67
Vitamin A, mcg[6]	500-625	--	--	--	--	--	--
Folate, mcg	320	601.2 (30.0)	671.3 (21.2)	0.16	14.0 (5.9)	18.0 (2.8)	0.65
Vitamin B6, mg[7]	1.3-1.4	4.4 (1.2)	5.0 (0.7)	0.75	28.0 (4.3)	26.8 (2.4)	0.86
Vitamin B12, mcg	2	71.9 (32.8)	104.6 (14.6)	0.50	3.0 (2.0)	4.0 (1.8)	0.78
Vitamin C, mg[8]	60-75	160.5 (36.3)	189.0 (13.9)	0.58	40.0 (4.0)	36.0 (2.4)	0.52
Vitamin D, mcg	10	10.2 (0.7)	22.6 (3.4)	0.0091	66.2 (3.5)	57.5 (2.3)	0.12
Vitamin E, mg	12	--	--	--	--	--	--

[1]NHANES, National Health and Nutrition Examination Survey. Age ≥60 years. [2]Statistical significance was determined as $p<0.00625$ using a Bonferroni adjustment. [3]EAR of calcium is 800mg for men 60-70 years of age and 1,000mg for women years of age and adults over 70 years of age. [4]EAR of magnesium is 350mg for men over 60 years and 265mg for women over 60 years. [5]EAR of zinc is 9.4mg for men over 60 years and 6.8mg for women over 60 years. [6]EAR of vitamin A are 625mcg for men over 60 years and 500mcg for women over 60 years. [7]EAR of vitamin B6 is 1.4mg for men over 60 years and 1.3mg for women over 60 years. [8]EAR of vitamin C is 75mg for men over 60 years and 60mg for women over 60 years.

Table 3.8 Mean Healthy Eating Index-2015 (HEI-2015) total and component scores among U.S. older adult Supplemental Nutrition Assistance Program (SNAP) participants and eligible nonparticipants over 60 years as drawn from the NHANES 2007–2016[1]

	SNAP participants (n=713)		SNAP eligible nonparticipants (n=1868)		
HEI-2015 component (maximum score)	Mean	SE	Mean	SE	*P* – Value[2]
Total Score (100)	59.4	0.9	58.6	0.8	0.51
Total Fruits (5)	3.2	0.2	3.0	0.08	0.35
Whole Fruits (5)	3.7	0.1	3.3	0.1	0.0047
Total Vegetables (5)	3.8	0.1	3.7	0.09	0.46
Greens and Beans (5)	3.3	0.6	3.0	0.3	0.65
Whole Grains (10)	3.2	0.04	3.4	0.2	0.33
Dairy (10)	5.7	0.3	5.4	0.2	0.41
Total Protein Foods (5)	4.8	0.06	4.9	0.03	0.14
Seafood and Plant Proteins (5)	4.3	0.2	4.2	0.2	0.72
Fatty Acids (10)	4.8	0.3	4.9	0.2	0.78
Refined Grains (10)	5.8	0.3	6.0	0.2	0.58
Sodium (10)	3.5	0.2	3.7	0.2	0.48
Added Sugars (10)	7.2	0.3	7.0	0.2	0.58
Saturated Fats (10)	6.2	0.3	6.3	0.2	0.78

[1]NHANES, National Health and Nutrition Examination Survey. Age≥60 years. [2]Statistical significance for total score was set as $P < 0.05$. Statistical significance for component scores was determined as $P < 0.00385$ to adjust for multiple comparisons using Bonferroni method.

3.5 Discussion

Dietary intake and quality of both SNAP participants and eligible nonparticipants was very poor. The hypothesized expectation for a difference in nutrient intake and dietary quality among older adult SNAP participants and eligible nonparticipants was not observed in the findings. These results were somewhat unexpected based on previous research showing SNAP decreases food insecurity (43–48) and that SNAP benefits were mostly spent on vegetables, fruits, grains, meat and meat alternatives (49,50). SNAP benefits also increased household food expenditure, which is positively associated with minimal but increased dietary quality (49–51). However, nutrient intake and dietary quality differences may be difficult to observe cross-sectionally due to the effect of a self-selection bias among SNAP participants. Previous investigations have shown that those who were most at-risk nutritionally and food insecure were least likely to meet recommendations but most likely to participate in SNAP among the SNAP-eligible population (45,52). Thus, the use of SNAP to purchase additional foods and beverages may equalize diets among those eligible and using SNAP (44,46,48,53,54). The present analysis is based on the assumption that self-reported SNAP participation is accurate. However, previous research has suggested underreporting of SNAP participation remains an issue (53), which could attenuate the differences between the self-reported SNAP participants and eligible nonparticipants and bias the results toward null. Future longitudinal studies not reliant on SNAP self-report may strengthen evidence of SNAP participation on dietary outcomes.

When stratified by sex, male SNAP participants had lower total usual intake of vitamin D compared to eligible nonparticipants. The result was only observed for usual intake from total and not dietary sources and thus was likely linked to DS use. DS use and consequently total nutrient intake are closely related to socio-demographic characteristics and health status (17,55). DS users are more likely to be women, older adults, with higher income, food secure, SNAP eligible nonparticipants, and in a better health condition (17,55). Considering the potential self-selection bias of at-risk households being more likely to participate in SNAP (46), male SNAP participants in the current study may have been less likely to be health conscious because of existing stressors or to use DS compared to eligible nonparticipants (17), contributing to observed differences in total usual intake of vitamin D. Nevertheless, risk of inadequate nutrient intake appeared to be lower after DS was examined in the current study, which has been consistently found across

multiple studies. Nutrients where DS use made the most difference, such as calcium and vitamin D, were those commonly included in multivitamins or consumed as single-nutrient DS (11).

Previous studies focusing on usual nutrient intake of all U.S. older adults of all income levels found high risk of inadequacy for magnesium, and vitamins D and E (34). The current analysis found consistent results for these nutrients and additional risk for other nutrients, including calcium, and vitamins A and C among U.S. older adults eligible for SNAP. These nutrients have important functions in maintaining health and disease prevention among older adults. Calcium is critical in maintaining bone health, and preventing fractures and osteoporosis, which could help maintain older adults' ability to meet nutrient requirements (56). Vitamin D not only has important roles in calcium homeostasis and bone health but also in immune function (56,57). Older adults have less ability to produce vitamin D compared with younger age groups, which leads to decreased absorption of calcium from the diet and higher risk of inadequate intake or even deficiency (58). Magnesium supports muscle and nerve function, blood pressure regulation, and immune function (59); older adults may have high risk of inadequate intake of magnesium due to changes in gastrointestinal functions and medication use (60). Vitamin A is essential for immune function, cell growth and vision, and is especially important in preventing certain age-related eye diseases (61). Vitamin E possesses antioxidant properties, and is involved in immune and anti-inflammatory function and disease prevention such as cancer, eye disorders and cognitive decline, which are common among older adults (62). Lastly, vitamin C is also an antioxidant with anti-inflammatory properties that are important in the immune response, and prevention and treatment of some chronic diseases (63).

Total dietary quality for both groups in the study was below 60 with a maximum of 100. If 100 is considered as a letter grade of A+ (64–66), the scores for dietary quality among older adults eligible for SNAP in this study would have received a grade of F. Although receiving a failing grade, older adults generally have better dietary quality compared to the average American population (score of 58) and younger age groups (67). Looking at dietary components, scores for dairy, fatty acids, and sodium were particularly low for all groups. Dairy is a nutrient dense food and a good source of high quality protein linked to improved bone health and nutrient intake (18,68), as well as calcium and vitamin D, outcomes for which older adults are already at high risk of not achieving. Maintaining a healthy ratio of unsaturated and saturated fats is also important in the context of chronic disease; evidence suggests that replacing saturated fats with unsaturated fats

is linked with lower risk of CVD and improved blood lipid profile (18). Lastly, consuming a diet low in sodium is beneficial for blood pressure, and therefore reduced risk for CVD (18). Low scores on dairy, fatty acids, and sodium dietary quality components among the older adults eligible for SNAP show that meeting the DGA recommendations for these particular dietary components are a challenge that could contribute to adverse dietary and health outcomes.

Previous research by Leung et al. compared dietary outcomes for US adult (20-65 years) SNAP participants and eligible nonparticipants and found SNAP participants had lower diet quality using the alternative HEI scoring but no difference using the HEI scoring system compared to nonparticipants (9). Similarly, the current study did not find any differences in overall dietary quality among older adults participating and not participating, but eligible for SNAP via HEI scores. Another study documenting total dietary quality for all U.S. older adults showed that the HEI-2015 scores ranged from 58 to 68 out of 100 by weight status (34) , which is very similar compared with results in this study for both SNAP participants and eligible nonparticipants.

To our knowledge, the present study is the first to compare dietary outcomes of SNAP participants with eligible nonparticipants among older adults. Strengths of the current study are the novelty of focusing on dietary outcomes of older adults by SNAP participation and estimation of usual intake from food and total sources using rigorous methods. The adapted NCI method used in the current study reduced the effects of within-person variance and generated habitual intake of nutrients from up to two 24 hour dietary recalls for the population (16,31). There were also limitations of the current study. DS contributions to vitamin A and E were not available for the included survey years of NHANES to estimate total intake. Additionally, the small sample size limited stratification by age and sex for some comparisons. Causality cannot be inferred from the results of this study due to the cross-sectional study design, but the associations discovered are critical to understanding current SNAP contributions to nutrient intake and dietary quality.

The findings of this study highlight critical nutrients for senior health to inform local food assistance programs, such as food pantries and senior meal delivery programs to ensure the inclusion of foods rich in these nutrients and to close these nutrient gaps. For example, policies that recommend or require inclusion of certain foods in menus that are dense in one or more of these nutrients (calcium, magnesium, vitamins A, C, D, and E) or that achieve certain nutrient totals for menus may be justified by these results. Recent provisions to the farm bill would allow SNAP benefits to be used to purchase DS such as multivitamins (69,70). The results of this study

show that supplements may indeed contribute to meeting nutrient requirements, however, DS do not supply energy needs similarly as food and may contribute to excess nutrient intake in a proportion of the group that was not evaluated in this study. Therefore, multiple nutritional considerations should be weighted. The findings provided by this study may also be integrated to nutrition education programs like SNAP-Education (71–73) to inform low-income adults of foods they should particularly emphasize in their diets and optimizing resources to meet nutrient needs overall. For example, the importance of nutrition to health, interpretation of dietary recommendations, meal planning and preparation skills to meet these recommendations, financial literacy to adapt healthy diets on limited budgets, as well as inclusive approaches that accommodate cultural backgrounds, health conditions, and food preferences are essential knowledge to be included in education programs. Additionally, supporting self-regulation techniques and promoting self-motivation and habit forming in addition to nutrition and health information could also lead to dietary behavioral changes and sustained long term improvements in dietary intake (74,75). Furthermore, SNAP-Ed could also feature education on DS for low-income consumers to explain the risks and potential benefits, how DS are regulated differently from foods, potential cost-effectiveness in DS use and healthcare expenses and the importance of additional healthy habits. Further research on the characteristics of older U.S. adults who are eligible for SNAP and how they manage resources for foods and DS are needed to better understand the role of DS in meeting nutrient requirements. The higher percentage of DS use among nonparticipants might indicate this group to be more health conscious (more likely to practice healthy behaviors) than SNAP participants (17), suggesting SNAP participants might be a more at-risk group. However, limits on SNAP are the topic of other recent policy proposals (76,77). If passed, such proposals may disproportionally harm low income elderly as over a quarter of households with older adults could potentially experience a decrease in SNAP benefits compared to 19% of general SNAP recipients (78,79). Despite the associational evidence limited by the cross-sectional survey design of this study, these results may imply that older adult SNAP participants would have even worse nutrient and dietary intake if not participating in SNAP and receiving SNAP benefits or participation in other food assistance programs (80). If so, the results may suggest that further restrictions to SNAP eligibility may be likely to result in more challenges to meeting nutrient requirements and decreased quality of life among low-income U.S. older adults along with increasing gaps to receive assistance benefits and food insecurity. Rather than imposing

restrictions on SNAP income eligibility, potential incentives for purchasing healthy foods with SNAP benefits show promise in improving healthy food consumption and dietary intake, as previous research has shown incentives to be effective in motivating the low-income population to make healthy food choices (81,82).

3.6 Conclusions

Nutrient intake and dietary quality were poor among U.S. older adults participating in SNAP and income eligible nonparticipants. Risks for inadequate intake of nutrients were lower after intake from DS was included. Future policies should focus on improving intake of vitamins A, C, D, and E, calcium and magnesium, and dietary quality for older adult participants of food assistance programs.

3.7 Acknowledgment

This project was supported with a research contract from the University of Kentucky Center for Poverty Research through funding by the U.S. Department of Agriculture, Food and Nutrition Service, Contract Number 12319819C0006. The findings and conclusions in this publication are those of the author(s) and should not be construed to represent UKCPR and any official USDA or U.S. Government determination or policy. The authors declare no conflict of interests. HAEM and RLB designed research; YQ and AEC analyzed data; YQ and HAEM wrote the paper; HAEM had primary responsibility for final content; AEC, RLB and SJ provided critical review and insights presented. All authors read and approved the final manuscript.

3.8 References

1. Ziliak JP, Gundersen C. The State of Senior Hunger in America in 2017. 2019.
2. U.S. Department of Agriculture Economic Research Service. Definitions of Food Security [Internet]. [cited 2021 Jun 4]. Available from: https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/definitions-of-food-security.aspx
3. Coleman-Jensen A, Rabbitt MP, Gregory C, Singh A. Household Food Security in the United States in 2018. United States Dep Agric Econ 2019;

4. Ziliak JP, Gundersen C, Haist M. The causes, consequences, and future of senior hunger in America. 2008;88. Available from: http://nfesh.org/wp-content/uploads/causes-consequences-senior-hunger-2008-full-report.pdf

5. Russell RM. Factors in aging that effect the bioavailability of nutrients. Journal of Nutrition. [Internet] American Institute of Nutrition; 2001 [cited 2021 Jun 9]. p. 1359–61. Available from: https://academic.oup.com/jn/article/131/4/1359S/4686879

6. Barbagallo M, Belvedere M, Dominguez LJ. Magnesium homeostasis and aging. Magnes Res [Internet] Magnes Res; 2009 [cited 2021 Jun 9];22:235–46. Available from: https://pubmed.ncbi.nlm.nih.gov/20228001/

7. Veldurthy V, Wei R, Oz L, Dhawan P, Jeon YH, Christakos S. Vitamin D, calcium homeostasis and aging [Internet]. Bone Research. Sichuan University; 2016 [cited 2021 Jun 9]. p. 1–7. Available from: www.nature.com/boneres

8. Cowan AE, Jun S, Tooze JA, Eicher-Miller HA, Dodd KW, Gahche JJ, et al. Total usual micronutrient intakes compared to the dietary reference intakes among U.S. adults by food security status. Nutrients 2020;12:38.

9. Leung CW, Ding EL, Catalano PJ, Villamor E, Rimm EB, Willett WC. Dietary intake and dietary quality of low-income adults in the Supplemental Nutrition Assistance Program. Am J Clin Nutr 2012;96:977–88.

10. Condon E, Drilea S, Jowers K, Lichtenstein C, Mabli J, Madden E, et al. Diet Quality of Americans by SNAP Participation Status: Data from the National Health and Nutrition Examination Survey, 2007–2010. 2015.

11. Cole N, Fox MK. Diet Quality of Americans by Food Stamp Participation Status: Data from the National Health and Nutrition Examination Survey, 1999-2004. U.S. Department of Agriculture, Food and Nutrition Service, Office of Research, Nutrition and Analysis. 2008.

12. Fey-Yensan N, English C, Pacheco HE, Belyea M, Schuler D. Elderly food stamp participants are different from eligible nonparticipants by level of nutrition risk but not nutrient intake. J Am Diet Assoc 2003;103:103–7.

13. Posner BM, Ohls JC, Morgan JC. The impact of food stamps and other variables on nutrient intake in the elderly. J Nutr Elder 1987;6:3–16.

14. Butler JS, Raymond JE. The effect of the food stamp program on nutrient intake. Econ Inq 1996;34:781–98.

15. Butler JS, Ohls JC, Posner B. The Effect of the Food Stamp Program on the Nutrient Intake of the Eligible Elderly. J Hum Resour 1985;20:405–20.

16. Tooze JA, Midthune D, Dodd KW, Freedman LS, Krebs-Smith SM, Subar AF, et al. A New Statistical Method for Estimating the Usual Intake of Episodically Consumed Foods with Application to Their Distribution. J Am Diet Assoc 2006;106:1575–87.

17. Cowan AE, Jun S, Gahche JJ, Tooze JA, Dwyer JT, Eicher-Miller HA, et al. Dietary supplement use differs by socioeconomic and health-related characteristics among U.S. adults, NHANES 2011–2014. Nutrients. 2018. p. 1114.

18. U.S. Department of Health and Human Services and U.S. Department of Agriculture. 2015–2020 Dietary Guidelines for Americans. 8th Edition [Internet]. 2015. Available from: http://health.gov/dietaryguidelines/2015/guidelines/

19. National Center for Health Statistics. NHANES [Internet]. [cited 2021 May 5]. Available from: https://www.cdc.gov/nchs/nhanes/index.htm

20. U.S. Department of Agriculture Economic Research Service. Survey Tools [Internet]. [cited 2021 Aug 22]. Available from: https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/survey-tools/#household

21. National Center for Health Statistics. NHANES - National Health and Nutrition Examination Survey [Internet]. [cited 2021 May 11]. Available from: https://www.cdc.gov/nchs/nhanes/index.htm

22. Blanton CA, Moshfegh AJ, Baer DJ, Kretsch MJ. The USDA automated multiple-pass method accurately estimates group total energy and nutrient intake. J Nutr 2006;136:2594–9.

23. NHANES NYFS: Dietary Supplement Database: Product Information Data Documentation, Codebook, and Frequencies [Internet]. [cited 2021 Dec 18]. Available from: https://wwwn.cdc.gov/Nchs/Nnyfs/DSPI.htm

24. United States Department of Agriculture Agricultural Research Service. Food and Nutrient Database for Dietary Studies [Internet]. [cited 2021 Jun 9]. Available from: https://www.ars.usda.gov/northeast-area/beltsville-md-bhnrc/beltsville-human-nutrition-research-center/food-surveys-research-group/docs/fndds/

25. Poverty Guidelines | ASPE [Internet]. [cited 2021 Oct 26]. Available from: https://aspe.hhs.gov/topics/poverty-economic-mobility/poverty-guidelines

26. SNAP Eligibility | USDA-FNS [Internet]. [cited 2020 Sep 29]. Available from: https://www.fns.usda.gov/snap/recipient/eligibility

27. Meals on Wheels America. Meals on Wheels America [Internet]. [cited 2023 Jan 30]. Available from: https://www.mealsonwheelsamerica.org/

28. U.S. Department of Agriculture and U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2020–2025. 9th Edition [Internet]. DietaryGuidelines.gov. 2020 [cited 2021 Nov 3]. p. 139. Available from: DietaryGuidelines.gov

29. Cowan AE, Jun S, Tooze JA, Eicher-Miller HA, Dodd KW, Gahche JJ, et al. Total usual micronutrient intakes compared to the dietary reference intakes among U.S. adults by food security status. Nutrients [Internet] MDPI AG; 2020 [cited 2020 Nov 19];12. Available from: /pmc/articles/PMC7019721/?report=abstract

30. National Cancer Institute. Usual Dietary Intakes [Internet]. [cited 2021 May 11]. Available from: https://epi.grants.cancer.gov/diet/usualintakes/

31. Bailey RL, Dodd KW, Gahche JJ, Dwyer JT, Cowan AE, Jun S, et al. Best Practices for Dietary Supplement Assessment and Estimation of Total Usual Nutrient Intakes in Population-Level Research and Monitoring Regan. J Nutr 2019;149:181–97.

32. Dodd KW, Guenther PM, Freedman LS, Subar AF, Kipnis V, Midthune D, et al. Statistical Methods for Estimating Usual Intake of Nutrients and Foods: A Review of the Theory. J Am Diet Assoc 2006;106:1640–50.

33. Rao JNK, Shao J. Modified balanced repeated replication for complex survey data. Biometrika 1999;86:403–15.

34. Jun S, Cowan A, Bhadra A, Dodd K, Dwyer J, Eicher-Miller H, et al. Nutritional Status of Older Adults Who Are Overweight or Obese Compared to Those with a Healthy Weight, NHANES 2011–2014. Curr Dev Nutr [Internet] Oxford University Press (OUP); 2019 [cited 2021 May 5];3. Available from: /pmc/articles/PMC6574524/?report=abstract

35. Shaffer JP. Multiple Hypothesis Testing. 1995;46:561–84.

36. Streiner DL. Best (but oft-forgotten) practices: the multiple problems of multiplicity-whether and how to correct for many statistical tests. Am J Clin Nutr [Internet] Am J Clin Nutr; 2015 [cited 2022 Oct 7];102:721–8. Available from: https://pubmed.ncbi.nlm.nih.gov/26245806/

37. Krebs-Smith SM, Pannucci TE, Subar AF, Kirkpatrick SI, Lerman JL, Tooze JA, et al. Update of the Healthy Eating Index: HEI-2015. J Acad Nutr Diet 2018;118:1591–602.

38. National Cancer Institute. Developing the Healthy Eating Index [Internet]. [cited 2021 May 5]. Available from: https://epi.grants.cancer.gov/hei/developing.html#2015

39. U.S. Department of Agriculture Center for Nutrition Policy and Promotion. Healthy Eating Index [Internet]. [cited 2021 May 5]. Available from: https://www.fns.usda.gov/healthy-eating-index-hei

40. Guo X, Warden BA, Paeratakul S, Bray GA. Healthy eating index and obesity. Eur J Clin Nutr 2004;58:1580–6.

41. Ford ES, Zhao G, Tsai J, Li C. Low-Risk lifestyle behaviors and all-cause mortality: Findings from the national health and nutrition examination survey III mortality study. Am J Public Health 2011;101:1922–9.

42. Zhang S, Midthune D, Guenther PM, Kipnis V, Dodd KW, Carroll RJ. A NEW MULTIVARIATE MEASUREMENT ERROR MODEL WITH ZERO-INFLATED DIETARY DATA, AND ITS APPLICATION TO DIETARY ASSESSMENT. Ann Appl Stat 2011;5:1456–87.

43. Gundersen C, Waxman E, Crumbaugh AS. An Examination of the Adequacy of Supplemental Nutrition Assistance Program (SNAP) Benefit Levels: Impacts on Food Insecurity. Agric Resour Econ Rev 2019;48:433–47.

44. Gundersen C, Kreider B, Pepper J V. Partial identification methods for evaluating food assistance programs: A case study of the causal impact of snap on food insecurity. Am J Agric Econ 2017;99:875–93.

45. Mabli J, Ohls J, Dragoset L, Castner L, Santos B. Measuring the Effect of Supplemental Nutrition Assistance Program (SNAP) Participation on Food Security. Prep by Math Policy Res US Dep Agric Food Nutr Serv 2013;

46. Ratcliffe C, McKernan SM, Zhang S. How much does the supplemental nutrition assistance program reduce food insecurity? Am J Agric Econ 2011;93:1082–98.

47. Yen ST, Andrews M, Chen Z, Eastwood DB. Food stamp program participation and food insecurity: An instrumental variables approach. Am J Agric Econ 2008;90:117–32.

48. Mykerezi E, Mills B. The impact of food stamp program participation on household food insecurity. Am J Agric Econ 2010;92:1379–91.

49. Cohen B, Ohls J, Andrews M, Ponza M, Moreno L, Zambrowski A, et al. Food Stamp Participants ' Food Security and Nutrient Availability. 1999;1–286.

50. Fox MK, Hamilton W, Lin B-H. Effects of Food Assistance and Nutrition Programs on Nutrition and Health. Volume 4, Executive Summary of the Literature Review. Rep Submitt to US Dep Agric Econ Res Serv 2004;

51. Mabli J, Castner L, Ohls J, FOx MK, Crepinsek MK, Condon E. Food Expenditures and Diet Quality Among Low-Income Household and Individuals. 2010;

52. Kreider B, Pepper J V., Gundersen C, Jolliffe D. Identifying the effects of SNAP (Food Stamps) on child health outcomes when participation is endogenous and misreported. J Am Stat Assoc 2012;107:958–75.

53. Meyer BD, Mok WKC, Sullivan JX. The Under-Reporting of Transfers in Household Surveys: Its Nature and Consequences. Cambridge, MA; 2009 [cited 2021 Oct 15]; Available from: https://www.nber.org/papers/w15181

54. Gundersen CG, Kreider B. Food stamps and food insecurity: What can be learned in the presence of nonclassical measurement error? J Hum Resour 2008;43:352–82.

55. Eicher-Miller HA, Park C, Bailey R. Chapter 2: Identifying Nutritional Gaps among Americans. In: Wallace TC, editor. Dietary Supplements in Health Promotion. 1st ed. Boca Raton, Florida: CRC Press; 2015. p. 17–53.

56. Institute of Medicine. Dietary Reference Intakes for Adequacy: Calcium and Vitamin D. In: Ross AC, Taylor CL, Yaktine AL, Valle HB Del, editors. Dietary Reference Intakes for Calcium and Vitamin D. Washington (DC): National Academies Press (US); 2011.

57. Aranow C. Vitamin D and the immune system. Journal of Investigative Medicine. [Internet] BMJ Publishing Group; 2011 [cited 2021 Jun 9]. p. 881–6. Available from: /pmc/articles/PMC3166406/

58. Bullamore JR, Wilkinson R, Gallagher JC, Nordin BEC, Marshall DH. EFFECT OF AGE ON CALCIUM ABSORPTION. Lancet [Internet] Elsevier; 1970 [cited 2021 Jun 9];296:535–7. Available from: http://www.thelancet.com/article/S0140673670913449/fulltext

59. National Insitutes of Health Office of Dietary Supplements. Magnesium - Health Professional Fact Sheet [Internet]. [cited 2021 Jun 9]. Available from: https://ods.od.nih.gov/factsheets/Magnesium-HealthProfessional/

60. Costello RB, Moser-Veillon PB. A review of magnesium intake in the elderly. A cause for concern? Magnes Res [Internet] 1992 [cited 2021 Jun 9];5:61–7. Available from: https://pubmed.ncbi.nlm.nih.gov/1591145/

61. National Insitutes of Health Office of Dietary Supplements. Vitamin A - Health Professional Fact Sheet [Internet]. [cited 2021 Jun 9]. Available from: https://ods.od.nih.gov/factsheets/VitaminA-HealthProfessional/

62. National Insitutes of Health Office of Dietary Supplements. Vitamin E - Health Professional Fact Sheet [Internet]. [cited 2021 Jun 9]. Available from: https://ods.od.nih.gov/factsheets/VitaminE-HealthProfessional/

63. National Insitutes of Health Office of Dietary Supplements. Vitamin C - Health Professional Fact Sheet [Internet]. [cited 2021 Jun 9]. Available from: https://ods.od.nih.gov/factsheets/VitaminC-HealthProfessional/

64. Krebs-Smith SM, Pannucci TE, Subar AF, Kirkpatrick SI, Lerman JL, Tooze JA, et al. Update of the Healthy Eating Index: HEI-2015. J Acad Nutr Diet [Internet] J Acad Nutr Diet; 2018 [cited 2021 Oct 27];118:1591–602. Available from: https://pubmed.ncbi.nlm.nih.gov/30146071/

65. Kirkpatrick SI, Reedy J, Krebs-Smith SM, Pannucci TRE, Subar AF, Wilson MM, et al. Applications of the Healthy Eating Index for Surveillance, Epidemiology, and Intervention Research: Considerations and Caveats. J Acad Nutr Diet [Internet] Elsevier B.V.; 2018 [cited 2020 Dec 19];118:1603–21. Available from: /pmc/articles/PMC6730554/?report=abstract

66. Guenther PM, Kirkpatrick SI, Reedy J, Krebs-Smith SM, Buckman DW, Dodd KW, et al. The healthy eating Index-2010 is a valid and reliable measure of diet quality according to the 2010 dietary guidelines for Americans. J Nutr [Internet] J Nutr; 2014 [cited 2020 Oct 20];144:399–407. Available from: https://pubmed.ncbi.nlm.nih.gov/24453128/

67. U.S. Department of Agriculture Food and Nutrition Service. HEI Scores for Americans [Internet]. [cited 2023 Feb 3]. Available from: https://www.fns.usda.gov/hei-scores-americans

68. Hess JM, Cifelli CJ, Iii VLF. Energy and Nutrient Intake of Americans according to Meeting Current Dairy Recommendations. Nutrients 2020;12.

69. H.R.2-Agriculture Improvemet Act of 2018, 115th Congress (2017-2018) [Internet]. [cited 2021 May 6]. Available from: https://www.congress.gov/bill/115th-congress/house-bill/2/text/eh

70. Wolkomir E. Letting SNAP Participants Buy Dietary Supplements With Their Benefits Could Leave Them Hungry | Center on Budget and Policy Priorities [Internet]. [cited 2021 May 6]. Available from: https://www.cbpp.org/blog/letting-snap-participants-buy-dietary-supplements-with-their-benefits-could-leave-them-hungry

71. Rivera RL, Maulding MK, Abbott AR, Craig BA, Eicher-Miller HA. SNAP-Ed (supplemental nutrition assistance program-education) increases long-term food security among Indiana households with children in a randomized controlled study. J Nutr [Internet] American Society for Nutrition; 2016 [cited 2020 Oct 20];146:2375–82. Available from: https://pubmed.ncbi.nlm.nih.gov/27683869/

72. Rivera RL, Dunne J, Maulding MK, Wang Q, Savaiano DA, Nickols-Richardson SM, et al. Exploring the association of urban or rural county status and environmental, nutrition- and lifestyle-related resources with the efficacy of SNAP-Ed (Supplemental Nutrition Assistance Program-Education) to improve food security. Public Health Nutr [Internet] Cambridge University Press; 2018 [cited 2020 Oct 20];21:957–66. Available from: https://pubmed.ncbi.nlm.nih.gov/29199629/

73. SNAP-Ed Connection [Internet]. [cited 2021 Oct 2]. Available from: https://snaped.fns.usda.gov/

74. Stadler G, Oettingen G, Gollwitzer PM. Intervention Effects of Information and Self-Regulation on Eating Fruits and Vegetables Over Two Years. Heal Psychol 2010;29:274–83.

75. Mullan B, Olivier C, Thøgersen-Ntoumani C. Mind the gap: Habit and self-determined motivation predict health behaviours in middle-aged and older adults. Br J Health Psychol 2021;26:1095–113.

76. U.S. Department of Agriculture Food and Nutrition Service. Revision of Categorical Eligibility in the Supplemental Nutrition Assistance Program (SNAP), proposed July 24, 2019 [Internet]. [cited 2021 May 6]. Available from: https://www.fns.usda.gov/snap/fr-072419

77. U.S. Department of Agriculture. President's Budget, Food and Nutrition Service, proposed FY 2019 [Internet]. [cited 2021 May 6]. Available from: https://www.usda.gov/obpa/home

78. Kenneth Terrell. Changes to Food Stamps Could Hurt Many Older Adults. AARP Politics & Society. [Internet] 2019 [cited 2022 Aug 19]; Available from: https://www.aarp.org/politics-society/advocacy/info-2019/food-stamps-snap-benefits.html

79. U.S. Department of Agriculture Food and Nutrition Service. Revision of Categorical Eligibility in the SNAP - Withdrawal [Internet]. 2021 [cited 2022 Aug 19]. Available from: https://www.fns.usda.gov/snap/fr-061021

80. Andreyeva T, Tripp AS, Schwartz MB. Dietary Quality of Americans by Supplemental Nutrition Assistance Program Participation Status A Systematic Review. J Acad Nutr Diet 2015;49:594–604.

81. Lindsay S, Lambert J, Penn T, Hedges S, Ortwine K, Mei A, et al. Monetary matched incentives to encourage the purchase of fresh fruits and vegetables at farmers markets in underserved communities. Prev Chronic Dis 2013;10:1–10.

82. Polacsek M, Moran A, Thorndike AN, Boulos R, Franckle RL, Greene JC, et al. A Supermarket Double-Dollar Incentive Program Increases Purchases of Fresh Fruits and Vegetables Among Low-Income Families With Children: The Healthy Double Study. J Nutr Educ Behav [Internet] Elsevier Inc.; 2018;50:217-228.e1. Available from: https://doi.org/10.1016/j.jneb.2017.09.013

CHAPTER 4. NEITHER FOOD ASSISTANCE NOR NUTRITION EDUCATION WERE LINKED WITH BODY MASS INDEX CHANGES OVER ONE YEAR AMONG LOWER INCOME WOMEN IN INDIANA

Qin Y, Craig BA, Bailey RL, Abbott AR, Connelly BA, Eicher-Miller HA. Neither food assistance nor nutrition education were linked with body mass index changes over one year among lower income women in Indiana. Submitted for JAND. March 10, 2023.

This chapter was submitted as an original research article to Journal of the Academy of Nutrition and Dietetics and formatted according to the journal requirements. The Journal of Academy of Nutrition and Dietetics provides the right for authors to include their own articles in their dissertation.

4.1 Abstract

Background: Low-resource groups experience a higher burden of obesity, a public health concern, compared with the general U.S. population. Therefore, food assistance programs and nutrition education through the Supplemental Nutrition Assistance Program Education (SNAP-Ed) are aimed to improve access to food and promote healthy lifestyles. Long-term relationships of these programs on body mass index (BMI) are unclear.

Objective: Objectives were to determine long-term links of participation in a SNAP-Ed intervention, food assistance programs, and their combination on BMI.

Design: The study was a secondary analysis of data from a longitudinal nutrition education intervention, with 1-year follow-up.

Subject/setting: Indiana SNAP-Ed eligible women (≥18 years) willing to receive nutrition education were recruited and randomized to receive SNAP-Ed (n=59) or not (n=47) from August 2015 to May 2016.

Intervention: SNAP-Ed was delivered to the intervention group following baseline assessment.

Main outcome measures: Participants completed baseline and 1-year follow-up assessments including socio-demographic information and participation in SNAP and WIC. Trained

paraprofessionals measured height and weight of each participant 3 times which were averaged to calculate BMI at each time point.

Statistical analyses performed: Mixed linear models compared the change in BMI over time for each comparison.

Results: Most of the sample (over 60%) were obese at both time points. No differences in long-term BMI were detected by receiving SNAP-Ed or not, receiving food assistance or not, or combinations of the programs (*P*-values from 0.07 to 0.85).

Conclusions: BMI did not differ in the long-term based on receiving SNAP-Ed, food assistance programs, or their combination. Yet, the high prevalence of obesity highlights a need for healthy weight and lifestyle interventions.

4.2 Introduction

Overweight and obesity are prevalent health risks in the U.S. Based on the latest available national data from 2020, four out of ten adults were obese (1), a 10% increase compared with two decades prior (2). The high and quickly growing prevalence of obesity is of public health concern, as obesity is associated with numerous chronic diseases, including but not limited to diabetes mellitus, cardiovascular disease, non-alcoholic fatty liver disease, hypertension and dyslipidemia (3,4). Increased risk of obesity is linked with low-income (5,6), as well as food insecurity, defined as having inadequate access to food for active and healthy lives (7), with most numerous studies showing this relationship among adult women compared with men (8,9). Food insecurity is also associated with poor diet quality, which is a modifiable risk factor for obesity and weight management (10–12).

To improve food access and security of low-income households, the U.S. Department of Agriculture Food and Nutrition Service provides food assistance through several programs, including the Supplemental Nutrition Assistance Program (SNAP) and the Special Supplemental Nutrition Program for Women Infants and Children (WIC). SNAP, previously known as the food stamp program, is the largest federal nutrition assistance program and is aimed to alleviate food insecurity by improving access to healthy foods through benefits to U.S. households (13). SNAP provides financial assistance to households with a monthly gross income less than or equal to 130%

of the federal poverty line to purchase foods. The Supplemental Nutrition Assistance Program Education (SNAP-Ed) is a federal nutrition education program that compliments SNAP and provides nutrition education to the SNAP-eligible group (household income ≤ 130% of the federal poverty line or poverty income ratio; PIR) (14,15) to promote a healthy lifestyle and behaviors aligned with the Dietary Guidelines for Americans (16). Whereas, WIC is a federally funded nutrition assistance program with the goal of improving food access for pregnant, breastfeeding, or non-breastfeeding postpartum women, infants, toddlers, and children under the age of five years in households with gross incomes at or below 185% of the PIR, by providing monthly monetary benefits to purchase supplemental foods (17,18). WIC food packages were revised in 2009 to promote closer alignment to updated nutrition science and infant feeding guidelines among participants (19).

The food assistance eligible low-income population is at high health and nutrition risk, and experience a great burden of chronic conditions and poor dietary intakes (11,20–23). Previous studies have demonstrated that SNAP participation improves food security status (24,25), but mixed results have been shown for diet quality (26–31) and weight status (32–38). Several cross-sectional and longitudinal studies have results indicating a higher likelihood of weight gain and obesity among SNAP participants, especially for women (32–37), while others did not find associations between weight gain and obesity with short or long term SNAP participation (38). Nutrition education through SNAP-Ed has improved food insecurity but not dietary or nutrient intake in the long-term (22,39–41). Few studies assessed weight status among SNAP-Ed participants (42,43). However, these studies did not use a rigorous randomized control design and did not assess the long-term impact of SNAP-Ed on weight status. A large proportion of low-income households (around 73%) used food assistance programs in addition to nutrition education, which is often voluntary (39,44,45). Yet, evidence on the long-term impact of SNAP-Ed, SNAP and/or WIC and their combination on weight status among SNAP-Ed participants remains largely unknown.

Thus, the objectives of the present study were to determine the potential long-term (1 year) relationships on body mass index (BMI of 1) direct, adult-focused vs. no direct, adult-focused SNAP-Ed intervention; 2) SNAP participation vs. no SNAP participation; 3) SNAP participation only vs. SNAP and WIC participation collectively; and 4) SNAP-Ed and SNAP and/or WIC vs. no SNAP-Ed but with SNAP and/or WIC or SNAP-Ed with neither SNAP nor WIC, respectively.

To the authors knowledge, this was the first attempt in examining the association of participation in SNAP, WIC and SNAP-Ed separately and in combination with weight status on non-pregnant adult women participating in either program. The authors hypothesized that BMI changes over time would not be different for SNAP-Ed intervention and control groups; BMI changes over time were expected to be larger for SNAP participants compared to non-participants(i.e., increase); BMI changes over time were expected to be the larger for SNAP only participants (increase) compared to SNAP and WIC participants; and finally, BMI changes over time were expected to not be different for those receiving a combination of food assistance and education compared to those that did not receive education with food assistance.

4.3 Methods

4.3.1 Study Population and Design

The present study was a pilot investigation carried out using a secondary analysis of data from the Indiana SNAP-Ed Long-term Study, a longitudinal randomized controlled trial with a nutrition education intervention; complete details of the study can be found elsewhere (22). Briefly, participants were recruited from Indiana by county-level SNAP-Ed nutrition educators from Purdue University's Health and Human Science Cooperative Extension Nutrition Education Program. The SNAP-Ed education paraprofessionals screened study eligibility of participants and randomized eligible participants into intervention (i.e., immediate lessons) and control or delayed lessons at 1 year groups at a ratio of around 1:1. Participants that were eligible for SNAP-Ed (15), did not receive SNAP-Ed lessons in the year prior to recruitment, were able to read English, were Indiana residents and were willing to wait for 1 year to receive the nutrition lessons, were recruited. A random number generator was used to assign the first participant (or group) into intervention or control group to prevent knowledge of treatment assignment. Subsequent participants (or groups) were assigned to alternating treatment groups. All participants provided written informed consent and the Purdue Institutional Review Board approved the trial protocol, which was registered at www.clinicaltrials.gov as NCT03436589.

4.3.2 SNAP-Ed Intervention

The intervention consisted of 4 core lessons (out of 10) in the "Small Steps to Health" Indiana SNAP-Ed curriculum (22), addressing United States Department of Agriculture (USDA) key behavioral outcomes. Specifically, the lessons encouraged use of USDA MyPlate (46) and food labels to build balanced diets, and highlighted the importance of whole grains, fruits and vegetables and encouraged incorporation of these food groups to make healthy food choices aligning with federal guidelines (15,16).

4.3.3 Measures

All participants completed a baseline assessment with a basic characteristics questionnaire including, socio-demographic variables, and food assistance program use at recruitment from August 2015 to May 2016 and at one year follow-up, from August 2016 to May 2017. SNAP and WIC use were collected with questions "Do you currently receive food stamps or SNAP" and "Do you currently receive WIC benefits?" at both baseline and one year follow-up. The SNAP-Ed paraprofessionals were trained to measure height and weight of the participants using protocols developed by the National Health and Nutrition Examination Survey (47) at both baseline and follow-up assessments. At each assessment, height and weight were measured three separate times. The average heights and weights for each participant at each timepoint were calculated and used to calculate BMI at baseline and at follow-up. BMI were categorized into underweight (BMI<18.50), normal (18.5≤ BMI<25), overweight (25≤BMI<30) and obese (BMI≥30) (48).

4.3.4 Statistical Analysis

A total of 106 participants (n=47 control and n=59 intervention) were included in the analysis (**Figure 1**). Participants were excluded from analysis (n=6 control and n=15 intervention) for incomplete survey data (n=3), being male (n=6), and pregnancy at any time during the study (n=8) because of inherent BMI changes. Chi-square tests were used to compare socio-demographic characteristics for each of the comparison groups to identify potential confounding variables to adjust in the models. Mixed linear regression models, using BMI as the response, were used to compare changes in BMI from baseline to one year follow-up across the various comparison groups. Several covariates were included in the model with Group, Time, and their interaction as

fixed effects and Subject as a random effect. Change of food assistance program status over 1 year was identified as a factor that may have a relationship to the BMI comparison of food assistance program participants vs nonparticipants. A variable was constructed to account for this factor using the self-reported SNAP and WIC status at baseline and follow-up assessments and categorized as "no change", "changed out of the program" and "changed into the program" for SNAP and WIC respectively. A small number of participants (n=22 for SNAP, n=13 for WIC) had changes in SNAP and/or WIC program participation status over the 1 year of the study and a sensitivity analysis where these participants were removed from the analysis (data not shown) did not change the linear regression results. Therefore, the participants were retained for final analysis. SNAP-Ed treatment group assignment and the variable created to capture change in assistance program status were adjusted in comparisons 2 (SNAP participants vs nonparticipants), 3 (SNAP only vs SNAP and WIC participants) and 4 (SNAP-Ed and SNAP and/or WIC vs. no SNAP-Ed, but not in SNAP and/or WIC or SNAP-Ed with no SNAP or WIC). Chi-square tests indicated no differences between the SNAP-Ed intervention and comparison groups (Table 1). Thus, only changes of SNAP and WIC use over time were adjusted in comparison 1 (SNAP-Ed intervention vs control). A few characteristics were different for comparisons 2-4 (Supplementary Table 1-3). All characteristics (those different or not different between comparison groups) not correlated with main independent variables were examined in the model and those that contributed to predictivity of model were included as covariates in their final respective models. Specifically, age was adjusted in comparison 2. The power to detect a difference at significance level of 0.05 were confirmed based on mean difference in BMI and SD from a previous study (effect size 0.59, power 80%) (49). All analyses were performed using SAS software, version 9.4 (50).

4.4 Results

The sample was predominately non-Hispanic white women. A majority of the sample were over 30 years old, with educational attainment below bachelor's degree, living in households with at least 1 other adult and with children for both intervention and control groups (**Table 1**).

The BMI was high (both SNAP-Ed intervention and control group) at each time point, with over 60% of the group being obese (**Table 1**). Mean BMI for all comparison groups were classified as obese or overweight (**Table 2-5**). There were no differences in change of BMI over time between the SNAP-Ed intervention group vs. control group (**Table 2**), SNAP participants vs.

nonparticipants (**Table 3**), SNAP only participants and SNAP and WIC participants (**Table 4**) or SNAP-Ed and SNAP and/or WIC vs. no SNAP-Ed but in SNAP and/or WIC or SNAP-Ed with neither SNAP nor WIC (**Table 5**).

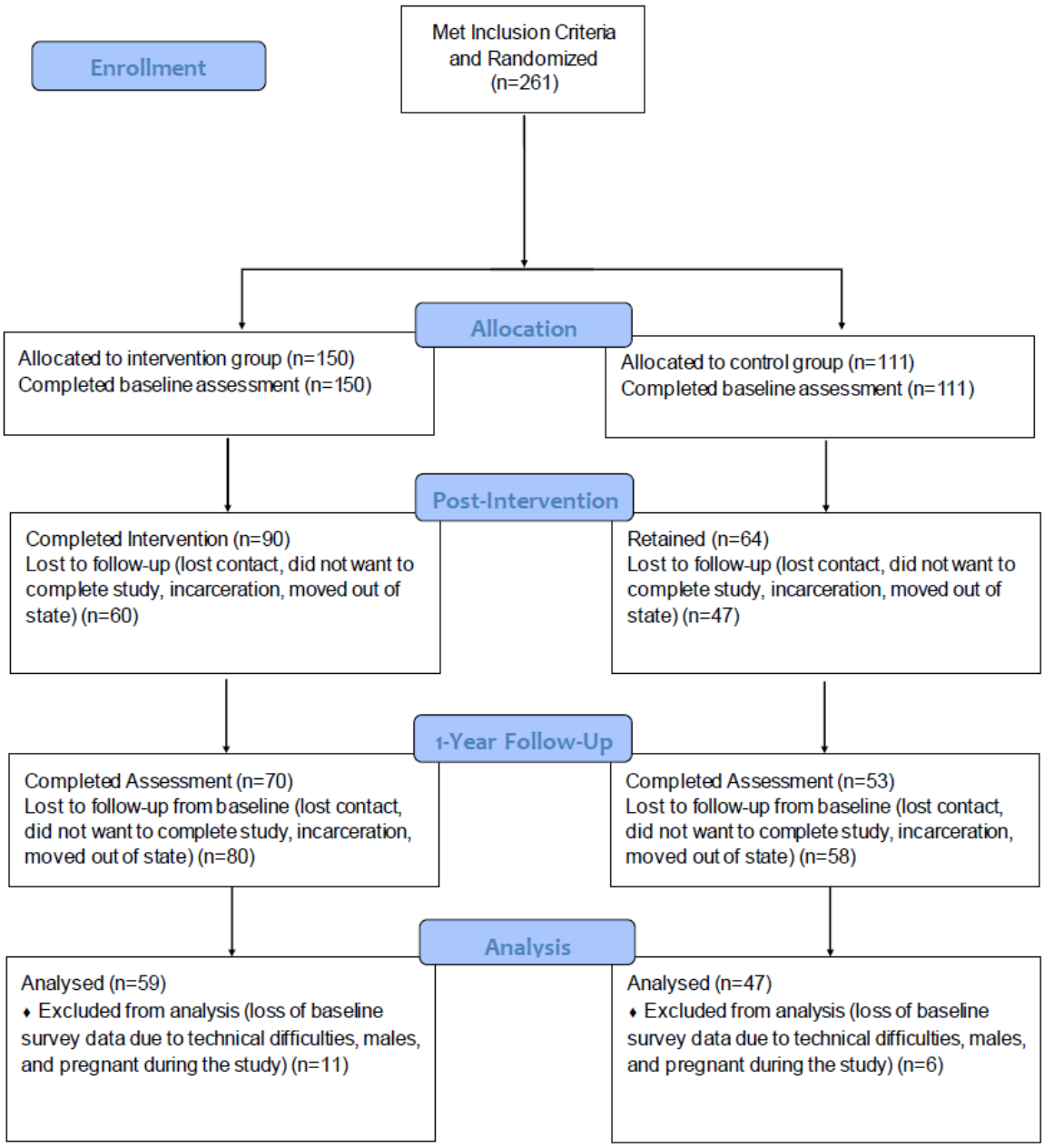

Figure 4.1 Participant flow chart for loss to follow-up and assessment completion among adult women Indiana Supplemental Nutrition Assistance Program-Education eligible participants during 2015 to 2016

Table 4.1 Baseline sociodemographic characteristics by Supplemental Nutrition Assistance Program-Education (SNAP-Ed) intervention or control group and Body Mass Index (BMI) status at baseline and over time among adult Indiana SNAP-Ed-eligible female participants from 2015 to 2016[a]

		Control		SNAP-Ed Intervention		
Characteristics		n	%	n	%	P-*value*
Total (n=106)		47	46	59	54	
Age group (years)						0.20
	18-30	18	38	19	32	
	31-50	21	45	21	36	
	51 or older	8	17	19	32	
Race and Ethnicity						0.76
	Non-Hispanic White	43	91	54	93	
	Other	4	9	4	7	
Household Education						
	No HS[b] Diploma	12	26	8	14	0.24
	HS Diploma/GED[c]	13	28	24	41	
	Some College	14	30	16	27	
	Associate Degree	4	9	9	15	
	Bachelor's Degree or more	4	9	2	3	
Marital Status						0.66
	Never Married	11	23	10	17	
	Married w/ Partner	22	47	28	47	
	Separated/Divorced/Widowed	14	30	21	36	
Number of other Household Adults						0.081
	None	6	13	18	31	
	1 Additional	21	45	20	34	
	2 Additional	8	17	13	22	
	3 or More Additional	12	26	8	14	
Number of Household Children						0.49
	0	12	26	17	29	
	1-2	18	38	27	46	
	3 or more	17	36	15	25	
Employed in Last 12 Months						0.91
	No	26	55	32	54	
	Yes	21	45	27	46	
	Part-Time	12	60	12	44	0.29
	Full-Time	8	40	15	56	

Table 4.1 continued

Other Household Adult Employment in the Last 12 Months						0.29
	No	19	40	29	51	
	Yes	28	60	28	49	
	Part-Time	7	26	6	22	0.75
	Full-Time	20	74	21	78	
Monthly Income ($)						0.29
	0-1265	12	27	25	42	
	1266-1705	12	27	9	15	
	1706-2144	7	16	10	17	
	2145 and above	14	31	15	25	
SNAP[d] Participation						0.60
	Yes	31	66	36	61	
	No	16	34	23	39	
WIC[e]						0.74
	Yes	19	40	22	37	
	No	28	60	37	63	
Emergency Food Assistance Participation (Food Pantry)						0.21
	No	26	55	25	41	
	Yes	21	45	33	59	
	Less Than Once Per Month	5	24	3	9	0.50
	One Time Per Month	10	48	18	55	
	1-3 Times a Month	5	24	9	27	
	One Time or More Per Week	1	5	3	9	
BMI[a] at baseline (kg/m-2)						
	Underweight	2	4	0	0	
	Normal	7	15	9	16	
	Overweight	8	17	13	22	
	Obese	30	6	35	61	
BMI at follow-up (kg/m-2)						
	Underweight	2	4	0	0	
	Normal	9	19	7	12	
	Overweight	7	15	16	28	
	Obese	29	62	34	60	

Table 4.1 continued

[a] Data were number of participants and percent. Chi-Square tests were used to compare the characteristics. Statistical significance at $P< 0.05$. All data were self-reported. Total numbers do not always add up to sample size because of missing values; percentages do not always add up to 100 because of rounding.

[b] HS = high school.

[c] GED = General Educational Development Test.

[d] SNAP = Supplemental Nutrition Assistance Program; SNAP participation reference time period was the previous 30 days.

[e] WIC = Special Supplemental Nutrition Program for Women, Infants, and Children; WIC participation reference time period was the previous 30 days.

Table 4.2 Long-term difference in differences in Body Mass Index (BMI) between Supplemental Nutrition Assistance Program-Education (SNAP-Ed) intervention and control groups among adult women SNAP-Ed-eligible study participants[a]

	Control (n=47)		SNAP-Ed Intervention (n=59)		Difference in Differences		
	Baseline	1-year Follow-up	Baseline	1-year Follow-up	ΔSNAP-Ed Intervention - Δ Control	*P* - Value	95% CI
Least Square Means ± SEs							
BMI ($kg/(m^2)$)	32.9 ± 7.7	32.6 ± 7.7	38.7 ± 6.9	37.3 ± 6.9	-1.0 ± 0.9	0.23	-2.8 to 0.8

[a] Data were presented as Least Squares Means ± Standard Error of the Mean (SE). Outcomes were controlled for changes in Supplemental Nutrition Assistance Program (SNAP) and Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) participation over time. Difference in differences were mean difference of BMI in control group from 1-year follow-up and baseline subtracted from the mean difference in intervention group at 1-year follow-up and baseline. 95% confidence intervals were for difference in differences. Δ, difference in differences. Significance levels were $P<0.05$.

Table 4.3 Long-term difference in differences in Body Mass Index (BMI) between Supplemental Nutrition Assistance Program (SNAP) participants and nonparticipants among adult women Supplemental Nutrition Assistance Program-Education (SNAP-Ed)-eligible study participants[a]

	SNAP participants (n=67)		SNAP nonparticipants (n=39)		Difference in Differences		
	Baseline	1-year Follow-up	Baseline	1-year Follow-up	ΔSNAP participants - Δ SNAP nonparticipants	*P* - Value	95% CI
Least Square Means ± SEs							
BMI (kg/m^2)	40.4 ± 7.8	40.0 ± 7.7	35.9 ± 7.8	33.9 ± 7.8	-1.7 ± 0.9	0.07	-3.5 to 0.1

[a] Data were presented as Least Squares Means ± Standard Error of the Mean (SE). Outcomes were controlled for age, changes in SNAP and Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) participation over time and SNAP-Ed treatment group assignment. Difference in differences were mean difference of BMI among SNAP participants from 1-year follow-up and baseline subtracted from the mean difference among SNAP nonparticipants at 1-year follow-up and baseline. 95% confidence intervals were for difference in differences. Outcomes were controlled for SNAP-Ed treatment group assignment, change in SNAP status over time (no change, changed out of SNAP or changed into SNAP), change in WIC status over time (no change, changed out of WIC or changed into WIC) and age. Δ, difference in differences. Significance levels were $P<0.05$.

Table 4.4 Long-term difference in differences in Body Mass Index (BMI) between Supplemental Nutrition Assistance Program (SNAP) only (no Special Supplemental Nutrition Program for Women, Infants, and Children, WIC) participants and both SNAP and WIC participants among adult women Supplemental Nutrition Assistance Program-Education (SNAP-Ed)-eligible study participants[a]

		SNAP only (n=38)		Both SNAP and WIC (n=29)		Difference in Differences	
	Baseline	1-year Follow-up	Baseline	1-year Follow-up	ΔSNAP only - Δ Both SNAP and WIC	*P* - Value	95% CI
Least Square Means ± SEs							
BMI ($kg/(m^2)$)	40.9 ± 2.8	40.4 ± 2.8	38.4 ± 2.7	38.1 ± 2.6	0.2 ± 1.1	0.83	-2.0 to 2.4

[a] Data were presented as Least Squares Means ± Standard Error of the Mean (SE). Outcomes were controlled for changes in SNAP and WIC participation over time and SNAP-Ed treatment group assignment. Difference in differences were mean difference of BMI among SNAP only participants from 1-year follow-up and baseline subtracted from the mean difference among SNAP and WIC participants at 1-year follow-up and baseline. 95% confidence intervals were for difference in differences. Outcomes were controlled for SNAP-Ed treatment group assignment and change in SNAP status over time (no change, changed out of SNAP/WIC or changed into SNAP/WIC). Δ, difference in differences. Significance levels were $P<0.05$.

Table 4.5 Long-term difference in differences in Body Mass Index (BMI) between any food assistance program (Supplemental Nutrition Assistance Program, SNAP and/or Special Supplemental Nutrition Program for Women, Infants, and Children, WIC) participation with Supplemental Nutrition Assistance Program-Education (SNAP-Ed) intervention and no food assistance program participation and/or no SNAP-Ed intervention among adult women SNAP-Eda-eligible study participants[a]

	Comparison Group 1[b] (n=41)		Comparison Group 2[c] (n=65)		Difference in Differences		
	Baseline	1-year Follow-up	Baseline	1-year Follow-up	Δ Comparison Group 1- Δ Comparison Group 2	P - Value	95% CI
Least Square Means ± SEs							
BMI (kg/(m2))	29.2 ± 9.0	28.4 ± 9.0	38.0 ± 7.1	37.0 ± 7.1	-0.2 ± 0.9	0.85	-2.0 to 1.6

[a] Data were presented as Least Squares Means ± Standard Error of the Mean (SE). Outcomes were controlled for SNAP-Ed treatment group assignment and change in SNAP status over time (no change, changed out of SNAP/WIC or changed into SNAP/WIC). Difference in differences were mean difference of BMI among SNAP only participants from 1-year follow-up and baseline subtracted from the mean difference among SNAP and WIC participants at 1-year follow-up and baseline. 95% confidence intervals were for difference in differences. Δ, difference in differences. Significance levels were $P<0.05$.

[b] Group 1: SNAP with SNAP and/or WIC.

[c] Group 2: no SNAP-Ed with SNAP and/or WIC; or SNAP-Ed with neither SNAP nor WIC.

4.5 Discussion

Results from the present analysis showed high obesity among SNAP-Ed eligible Indiana women, with mean BMI over 30 indicating obesity for all comparison groups, at all time points except for those participating in both education and food assistance. The present findings demonstrated higher mean BMI (28.4-40.9) and prevalence of obesity (60-64%) among this sample of Indiana SNAP-Ed-eligible women compared to a those reported by a previous study (42) that featured SNAP-Ed participants in Georgia, 30.4 and 42%, respectively. The previous study (42) included both women and men, sampled from a different state, a larger sample size (n=270) and older population (mean age 60 years) compared with the current study, which might contribute to the differences in the BMI results. The prevalence of obesity from the current sample was also higher compared to that of US women in general (42%) and of low-income (42%) (51,52) that indicated higher health risks among the Indiana SNAP-Ed-eligible women featured in the present analysis.

Results also showed no differences in changes in BMI over time for any of the comparisons featured in the current study. In comparison 1, specifically, differences in BMI changes over time between SNAP-Ed intervention and control group were not observed. SNAP-Ed goals include the promotion of healthy behaviors and a healthy weight along with improving diet quality (15) and to this end, participants were successful in not gaining weight over time. The Indiana SNAP-Ed curriculum delivered through the intervention did not include lessons that directly addressed weight, but rather, they focus on the promotion of healthful lifestyles through dietary choices and regular activity (53). Shifts to include more fruits, vegetables, whole grains, and low-fat dairy and protein and less added sugars, sodium, and saturated fats, encourage dietary quality changes but not necessarily decreases in total energy. However, simultaneous increases in physical activity through the direct education or other SNAP-Ed components (i.e. community resources and facilities) could theoretically support weight reduction. A prior study using a longitudinal controlled evaluation of the Indiana SNAP-Ed program did not improve long-term dietary or nutrient intake (except for vitamin D) (22) and a similar longitudinal evaluation of physical activity using a rigorous study design is unknown. Therefore, it was not surprising that SNAP-Ed did not have a differential impact on long-term BMI status between intervention and control groups. Although there were no statistically significant changes over time, it is interesting to note that both groups generally maintained or decreased BMI over the study period. Especially among the SNAP-

Ed intervention group, there was a 1.4 kg/m^{-2} decrease in BMI over 1 year, which was a biologically meaningful change in BMI that could be impactful on health outcomes (54,55). Besides individual level direct education, SNAP-Ed also includes community-level initiatives, such as working with community stakeholders to encourage the building of sidewalks, walking trials, parks and other facilities in low-income communities. SNAP-Ed plan guidance (15) promotes physical activity at the community-level as Policy, System and Environmental Approaches to reflect the Social-Ecological Model (SEM) theoretical framework that SNAP-Ed is based on. One possible explanation of the observed potentially biologically meaningful BMI decrease among the SNAP-Ed intervention group was that those who were assigned to this group, may have been able to utilize the direct SNAP-Ed intervention and the community level initiatives to slightly decrease BMI over time, but not enough to be statistically different from the control group. Nonetheless, the high prevalence of obesity observed in the present analysis makes salient that initiatives are needed to support physical activity and maintain healthy weight.

Similarly, in comparison 2 where BMI changes over time were compared between SNAP participants and nonparticipants, no differences detected. In contrast, previous literature (33–37,56) has shown current and long-term participation in SNAP was associated with weight gain and obesity. In the present study, similar to comparison 1, the authors found a decrease in BMI (2.0 kg/m^{-2}) over time among SNAP nonparticipants with magnitude that may be biologically meaningful (54,55), which were not observed among SNAP participants and not statistically significant. Although mean BMIs for both groups at baseline and follow-up still belong to the obesity categories, the potentially impactful decease in BMI among SNAP nonparticipants might indicate overall better financial situation to secure healthful diets and engage in healthful practices, and food security and health literacy that might ultimately contribute to better health compared to SNAP participants. Those participating in SNAP might be in a worse financial situation, experiencing more stress and facing greater needs compared to those that not participating in SNAP. SNAP participation was a self-selected process and cannot be randomized due to ethical reasons, making the mechanisms behind SNAP participation/nonparticipation and weight gain and obesity difficult to entangle.

The comparison 3 between those using only SNAP compared to those that used both SNAP and WIC over time also showed no differences in BMI changes over time. Although there are a lack of prior studies that examined WIC participation with weight status, evidence has shown WIC

participation was linked to improved nutrient intake and diet quality among women (57–59), which could help maintain a healthy weight over time, while participation in SNAP has been associated with increased weight (33–37,56). Yet, the present results suggest that participating in either or both programs did not have a relationship on weight status changes over time. The associations between BMI and different combinations of food assistance programs over time are novel and should be further investigated with future studies with larger sample.

In comparison 4, the authors compared the unique combination of SNAP-Ed and SNAP and/or WIC to those that had no SNAP-Ed, but were in SNAP and/or WIC or SNAP-Ed with those who were neither in SNAP nor received WIC benefits. No difference in BMI changes over time between the groups were observed. Referring to the results from comparison 1 and 2, SNAP-Ed intervention and not participating in SNAP seemed to have protective effects on BMI status (although not statistically significant) as biological meaningful BMI decreases were observed among these two groups. Thus, in each of the comparison 4 groups, the two potentially protective factors were distributed into opposite groups, which could explain the absence of BMI changes over time and differences between the groups. No prior studies have assessed the combination of SNAP and SNAP-Ed on weight status among participants, highlighting a critical gap in evaluation, as the two programs are designed to complement each other with the aim to improve both the access and quality of food, and ultimately health, among the low-income groups. Due to limited sample size in the present study, the analysis could not be further broken down by comparison groups. Future research with a larger sample size is needed to explore various combinations of food assistance and nutrition education participation, such as separate evaluation of groups by: food assistance only, food assistance and nutrition education, nutrition education only, and neither food assistance nor nutrition education, on BMI to evaluate and identify the potential synergic effects of these programs on BMI outcomes. These analyses could identify potential risk factors associated with obesity among various low-income population and inform interventions addressing obesity. Since different populations might respond differently to different programs and have differential impacts on a spectrum of health outcomes, understanding such joint and potential interacting effects of different types of programs among each specific population could help better tailor obesity prevention interventions towards target populations. Additionally, such investigations could inform the possibility to deliver interventions using existing program

frameworks in various combinations, which might result in added effectiveness and reduced implementation cost.

There are limitations of the present study. There was a high attrition rate from the baseline to the follow-up assessments, which is common for longitudinal studies. Nonetheless, the study used a randomized controlled study design that was rigorous in examining cause-and-effect relationships to evaluate impact of SNAP-Ed intervention on outcomes. Evaluation and scientific investigation of the SNAP-Ed program are limited by funding for rigorous evaluation. Additional financial and labor resources should be allocated to the evaluation of nutrition education programs to better understand the direct and underlying impacts among low-income at-risk groups. Furthermore, this present research may be viewed as a pilot investigation. The secondary analysis was exploratory and potentially challenged by sample size to detect a statistically significant difference in the expected effect size of BMI change over time between comparison groups. The study sample had much larger variations in BMI and standard deviations compared with the prior research (49) upon which the sample size calculation was based, likely due to the differences in the study populations and sample sizes. An estimated sample size of around 4,900 might be needed to achieve a power of 80% calculated using effect size from the present sample. This sample size might not be feasible without substantial financial support and cross-state or nation-wide collaborations. Although this analysis was exploratory, the results provide important insights on the weight status of food assistance program and nutrition education participants, highlighting the urgent need for attention, intervention and resources addressing weight loss and management, and potentially overall health among this population. Furthermore, the study was an important first step in assessing the complex relationships and mechanisms between various food assistance program use and nutrition education intervention with BMI. The results also provide example of a rigorous study design and methodology for future evaluations with longer follow-up period than the current study (1 year) or on more intensive interventions (more lessons and monitoring on lesson completion).

The high prevalence of obesity observed in the study may lead to chronic health conditions that further worsen already poor financial situations and place additional burden on the healthcare system. Poor body weight status and body shape have negative impacts on health and social status, which in turn affect income (60); while low-income has been associated with high prevalence of obesity (5,6), forming a vicious cycle. Additionally, low-income groups are less likely to utilize

and engage in weight loss programs and more likely to have poor weight outcomes compared with higher income groups presenting challenges for weight management interventions (61,62). Direct SNAP-Ed lessons are not focused on weight loss or management but could include content that educates on BMI calculation and health risks associated with weight categories. Along with the existing nutrition education, content that operationalizes physical activity in the community environment could be encouraged. These strategies might empower participants to become self-motivated to make changes promoting healthy lifestyles. At a community level, accessible walking trials, parks and residential greenness could also support physical activity (15). Easy access to local YMCA or other exercise facilities (i.e. free/reduced cost memberships) could also be offered to increase movement, and shown to be effective (63–65). Other strategies towards individual or groups, such as; providing behavioral and psychological counseling in goal-setting, self-monitoring, self-regulation, and emotion management; and offering financial incentives for adherence to positive behavioral changes, may help support health to mediate the high risk of obesity (66–70).

The current study was the first to examine long-term impact of a nutrition education intervention, and food assistance programs individually and in combination on BMI. Future studies with robust power are needed to strengthen the evidence of association and underlying mechanism among groups that have low-resources and to inform customized interventions that address obesity, potentially utilizing combinations of various programs through existing program structures. The present findings highlighted the severe obesity concern among low-income groups.

4.6 Conclusion

There were no differences in change in BMI over time by receipt of food assistance and a nutrition education intervention separately or in combination.

4.7 References

1. Bryan S, Afful J, Carroll M, Te-Ching C, Orlando D, Fink S, et al. National Health and Nutrition Examination Survey 2017–March 2020 Pre-pandemic Data Files. Natl Health Stat Report 2021;2021. Available from: https://stacks.cdc.gov/view/cdc/106273

2. Centers for Disease Control and Prevention. Adult Obesity Facts [Internet]. [cited 2023 Jan 19]. Available from: https://www.cdc.gov/obesity/data/adult.html

3. Must A, Spadano J, Coakley EH, Field AE, Colditz G, Dietz WH. The disease burden associated with overweight and obesity. J Am Med Assoc 1999;282:1523–9.

4. Ogden CL, Yanovski SZ, Carroll MD, Flegal KM. The Epidemiology of Obesity. Gastroenterology 2007;132:2087–102.

5. Campbell AD, Baker EH. Do income inequalities in higher weight status depend on social integration? Soc Sci Res 2019;83:102301.

6. Kim TJ, Von Dem Knesebeck O. Income and obesity: What is the direction of the relationship? A systematic review and meta-analysis. BMJ Open 2018;8.

7. Coleman-Jensen A, Rabbitt MP, Gregory C, Singh A. Household Food Security in the United States in 2018. United States Dep Agric Econ 2019;

8. Townsend MS, Peerson J, Love B, Achterberg C, Murphy SP. Food insecurity is positively related to overweight in women. J Nutr 2001;131:1738–45.

9. Martin KS, Ferris AM. Food Insecurity and Gender are Risk Factors for Obesity. J Nutr Educ Behav 2007;39:31–6.

10. Seligman HK, Laraia BA, Kushel MB. Food insecurity is associated with chronic disease among low-income NHANES participants. J Nutr 2010;140:304–10.

11. Leung CW, Epel ES, Ritchie LD, Crawford PB, Laraia BA. Food Insecurity Is Inversely Associated with Diet Quality of Lower-Income Adults. J Acad Nutr Diet Elsevier Inc; 2014;114:1943-1953.e2.

12. Laraia B. Food Insecurity and Chronic Disease. Am Soc Nutr Adv Nutr 2013;4:203–12.

13. U.S. Department of Agriculture Food and Nutrition Service. Supplemental Nutrition Assistance Program (SNAP) | USDA-FNS [Internet]. [cited 2020 Sep 29]. Available from: https://www.fns.usda.gov/snap/supplemental-nutrition-assistance-program

14. SNAP Eligibility | USDA-FNS [Internet]. [cited 2020 Sep 29]. Available from: https://www.fns.usda.gov/snap/recipient/eligibility

15. U.S. Department of Agriculture SNAP-Ed Connection. SNAP-Ed Plan Guidance and Templates [Internet]. [cited 2022 May 2]. Available from: https://snaped.fns.usda.gov/program-administration/snap-ed-plan-guidance-and-templates

16. U.S. Department of Agriculture and U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2020–2025. 9th Edition [Internet]. DietaryGuidelines.gov. 2020 [cited 2021 Nov 3]. p. 139. Available from: DietaryGuidelines.gov

17. Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) | USDA-FNS [Internet]. [cited 2020 Sep 29]. Available from: https://www.fns.usda.gov/wic

18. WIC Eligibility Requirements|USDA-FNS [Internet]. [cited 2020 Sep 29]. Available from: https://www.fns.usda.gov/wic/wic-eligibility-requirements

19. Food and Nutrition Service. Department of Agriculture, Food and Nutrition Service Special Supplemental Nutrition Program for Women, Infants and Children (WIC): Revisions in the WIC Food Packages; Final Rule. 2014;79:1–74.

20. Gundersen C, Seligman HK. Food insecurity and health outcomes. Econ Voice 2017;14.

21. Lee JS, Gundersen C, Cook J, Laraia B, Johnson MA. Food insecurity and health across the lifespan. Advances in Nutrition. 2012 [cited 2020 Oct 20]. p. 744–5. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/pmid/22983862/?tool=EBI

22. Qin Y, Rivera RL, Zhang Y, Wang Q, Tooze JA, Abbott AR, et al. A Randomized Intervention of Supplemental Nutrition Assistance Program–Education Did Not Improve Dietary Outcomes Except for Vitamin D Among Lower-Income Women in Indiana. J Acad Nutr Diet Academy of Nutrition and Dietetics; 2022;123:284-298.e2.

23. Rivera RL, Zhang Y, Wang Q, Maulding MK, Tooze JA, Wright BN, et al. Diet quality and associations with food security among women eligible for Indiana supplemental nutrition assistance program-education. J Nutr Oxford University Press; 2020 [cited 2020 Oct 20];150:2191–8. Available from: https://doi.org/10.1093/jn/nxaa171.

24. Kennedy E, Guthrie JF. Nutrition Assistance Programs: Cause or Solution to Obesity. Curr Obes Rep Current Obesity Reports; 2016;5:176–83. Available from: http://dx.doi.org/10.1007/s13679-016-0207-x

25. Tiehen L, Ploeg M Ver. SNAP Benefits Alleviate the Incidence and Intensity of Poverty, Washington, DC: Economic Research Service, US Department of Agriculture. 2012;

26. Cole N, Fox MK. Diet Quality of Americans by Food Stamp Participation Status: Data from the National Health and Nutrition Examination Survey, 1999-2004. U.S. Department of Agriculture, Food and Nutrition Service, Office of Research, Nutrition and Analysis. 2008.

27. Nguyen BT, Shuval K, Njike VY, Katz DL. The Supplemental Nutrition Assistance Program and dietary quality among US adults: findings from a nationally representative survey. Mayo Clinic proceedings. 2014. p. 1211–9.

28. Leung CW, Ding EL, Catalano PJ, Villamor E, Rimm EB, Willett WC. Dietary intake and dietary quality of low-income adults in the Supplemental Nutrition Assistance Program. Am J Clin Nutr 2012;96:977–88.

29. Leung C, Cluggish S, Villamor E, Catalano P, Willett W, Rimm E. Few changes in food security and dietary intake from short-term participation in the Supplemental Nutrition Assistance Program among low-income Massachusetts adults. J Nutr Educ Behav 2014 2014;46:68–74.

30. Gregory CA, Ver Ploeg M, Andrews M, Coleman-Jensen A. Supplemental nutrition assistance program (SNAP) participation leads to modest changes in diet quality. United States Department of Agriculture Economic Research Service Economic Research Report Number 147. 2013.

31. Fox MK, Hamilton W, Lin B-H. Effects of Food Assistance and Nutrition Programs on Nutrition and Health, Volume 3, Literature Review. Food Assistance and Nutritiion Research Report Number 19-3. 2004.

32. Leung CW, Willett WC, Ding EL. Low-income supplemental nutrition assistance program participation is related to adiposity and metabolic risk factors. Am J Clin Nutr 2012;95:17–24.

33. Zagorsky JL, Smith PK. Does the U.S. Food Stamp Program contribute to adult weight gain? Econ Hum Biol 2009;7:246–58.

34. Baum CL. The Effects of Food Stamps on Obesity. South Econ J 2011;77:623–51.

35. Gibson D. Long-Term Food Stamp Program Participation Is Positively Related to Simultaneous Overweight in Young Daughters and Obesity in Mothers. J Nutr 2006;136:1081–5.

36. Dinour LM, Bergen D, Yeh MC. The Food Insecurity-Obesity Paradox: A Review of the Literature and the Role Food Stamps May Play. J Am Diet Assoc 2007;107:1952–61.

37. DeBono NL, Ross NA, Berrang-Ford L. Does the Food Stamp Program cause obesity? A realist review and a call for place-based research. Heal Place Elsevier; 2012;18:747–56. Available from: http://dx.doi.org/10.1016/j.healthplace.2012.03.002

38. Fan M. Do food stamps contribute to obesity in low-income women? Evidence from the National Longitudinal Survey of Youth 1979. Am J Agric Econ 2010;92:1165–80.

39. Rivera RL, Maulding MK, Abbott AR, Craig BA, Eicher-Miller HA. SNAP-Ed (supplemental nutrition assistance program-education) increases long-term food security among Indiana households with children in a randomized controlled study. J Nutr American Society for Nutrition; 2016;146:2375–82.

40. Eicher-Miller HA, Mason AC, Abbott AR, McCabe GP, Boushey CJ. The Effect of Food Stamp Nutrition Education on the Food Insecurity of Low-income Women Participants. J Nutr Educ Behav J Nutr Educ Behav; 2009;41:161–8.

41. Rivera RL, Maulding MK, Eicher-Miller HA. Effect of Supplemental Nutrition Assistance Program-Education (SNAP-Ed) on food security and dietary outcomes. Nutr Rev Oxford University Press; 2019 [cited 2020 Oct 20];77:903–21. Available from: https://pubmed.ncbi.nlm.nih.gov/31077323/

42. Bailey C, Lee JS. Overweight and Obesity, Weight Perception, and Weight Management Practices Among Supplemental Nutrition Assistance Program–Education (SNAP-Ed) Participants in Georgia: A Needs Assessment. J Nutr Educ Behav Elsevier Inc.; 2017;49:422-426.e1.

43. Buscemi J, Odoms-Young A, Stolley MR, Schiffer L, Blumstein L, Clark MH, et al. Comparative effectiveness trial of an obesity prevention intervention in EFNEP and SNAP-ED: Primary outcomes. Nutrients 2019;11.

44. Dollahite J, Olson C, Scott-Pierce M. The Impact of Nutrition Education on Food Insecurity among Low-Income.pdf. Fam Consum Sci Res J 2003;32:127–139.

45. Eicher-Miller HA, Rivera RL, Sun H, Zhang Y, Maulding MK, Abbott AR. Supplemental Nutrition Assistance Program-Education Improves Food Security Independent of Food Assistance and Program Characteristics. Nutrients NLM (Medline); 2020;12.

46. U.S. Department of Agriculture. USDA MyPlate [Internet]. [cited 2023 Jan 20]. Available from: https://www.myplate.gov/

47. Centers for Disease Control and Prevention. National Health and Nutrition Examination Survey (NHANES): Anthropometry Procedures Manual. 2016.

48. Center for Disease Control and Prevention. Defining Adult Overweight & Obesity [Internet]. [cited 2023 Feb 8]. Available from: https://www.cdc.gov/obesity/basics/adult-defining.html

49. Islam MT, Möller J, Zhou X, Liang Y. Life-course trajectories of body mass index and subsequent cardiovascular risk among Chinese population. PLoS One 2019;14:1–14.

50. SAS. Version 9.4. SAS Institute Inc; 2013.

51. National Instituite of Diabetes and Digestive and Kidney Diseases. Overweight & Obesity Statistics [Internet]. [cited 2023 Feb 5]. Available from: https://www.niddk.nih.gov/health-information/health-statistics/overweight-obesity

52. Ogden CL, Lamb MM, Carroll MD, Flegal KM. Obesity and socioeconomic status in adults: United States, 2005-2008. NCHS data brief n0 50. 2010.

53. Maulding M. Small Steps to Health [Internet]. 2015. Available from: https://snaped.fns.usda.gov/library/materials/small-steps-health

54. Covassin N, Sert-Kuniyoshi F, Singh P, Romero-Corral A, Davison D, Lopez-Jimenez F, et al. Experimental Weight Gain Increases Ambulatory Blood Pressure in Healthy Subjects: Implications of Visceral Fat Accumulation. Mayo Clin Proc 2018;93:618–26.

55. Wimmelmann CL, Hegelund ER, Folker AP, Just-ØStergaard E, Osler M, Mortensen EL, et al. Prospective Associations of the Short Form Health Survey Vitality Scale and Changes in Body Mass Index and Obesity Status. J Obes 2018;2018.

56. Leung CW, Villamor E. Is participation in food and income assistance programmes associated with obesity in California adults? Results from a state-wide survey. Public Health Nutr 2011;14:645–52.

57. Zimmer MC, Vernarelli JA. Changes in nutrient and food group intakes among children and women participating in the Special Supplemental Nutrition Program for Women, Infants, and Children: Findings from the 2005-2008 and 2011-2014 National Health and Nutrition Examination Surveys. Public Health Nutr 2019;22:3309–14.

58. Hamad R, Batra A, Karasek D, Lewinn KZ, Bush NR, Davis RL, et al. The Impact of the Revised WIC Food Package on Maternal Nutrition during Pregnancy and Postpartum. Am J Epidemiol 2019;188:1493–502.

59. Odoms-Young AM, Kong A, Schiffer LA, Porter SJ, Blumstein L, Bess S, et al. Evaluating the initial impact of the revised Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) food packages on dietary intake and home food availability in African-American and Hispanic families. Public Health Nutr 2014;17:83–93.

60. Li P, Chen X, Yao Q. Body mass and income: Gender and occupational differences. Int J Environ Res Public Health 2021;18.

61. Volz K, Wyckoff E, Medina TH, Denmat Z, Field C, LaRose J, et al. Impact of income and perceived stress on engagement and weight loss outcomes in an online behavioral weight loss program. J Behav Med Springer US; 2021;44:853–9. Available from: https://doi.org/10.1007/s10865-021-00238-6

62. Kakinami L, Gauvin L, Barnett TA, Paradis G. Trying to lose weight: The association of income and age to weight-loss strategies in the U.S. Am J Prev Med Elsevier; 2014;46:585–92. Available from: http://dx.doi.org/10.1016/j.amepre.2014.01.022

63. Colom A, Mavoa S, Ruiz M, Wärnberg J, Muncunill J, Konieczna J, et al. Neighbourhood walkability and physical activity: moderating role of a physical activity intervention in overweight and obese older adults with metabolic syndrome. Age Ageing 2021;50:963–8.

64. Villeneuve PJ, Jerrett M, Su JG, Weichenthal S, Sandler DP. Association of residential greenness with obesity and physical activity in a US cohort of women. Environ Res 2018;160:372–84.

65. Annesi JJ, Johnson PH, Porter KJ. Bi-Directional Relationship Between Self-Regulation and Improved Eating: Temporal Associations With Exercise, Reduced Fatigue, and Weight Loss. J Psychol J Psychol; 2015 [cited 2023 Feb 1];149:535–53. Available from: https://pubmed.ncbi.nlm.nih.gov/26047256/

66. Wadden TA, Tronieri JS, Butryn ML. Lifestyle modification approaches for the treatment of obesity in adults. Am Psychol 2020;75:235–51.

67. Beutel M, Thiede R, Wiltink J, Sobez I. Effectiveness of behavioral and psychodynamic in-patient treatment of severe obesity--first results from a randomized study. Int J Obes Relat Metab Disord Int J Obes Relat Metab Disord; 2001 [cited 2023 Feb 1];25 Suppl 1:S96–8. Available from: https://pubmed.ncbi.nlm.nih.gov/11466599/

68. Riva G, Bacchetta M, Cesa G, Conti S, Castelnuovo G, Mantovani F, et al. Is severe obesity a form of addiction? Rationale, clinical approach, and controlled clinical trial. Cyberpsychol Behav Cyberpsychol Behav; 2006 [cited 2023 Feb 1];9:457–79. Available from: https://pubmed.ncbi.nlm.nih.gov/16901250/

69. Molinari E, Baruffi M, Croci M, Marchi S, Petroni ML. Binge eating disorder in obesity: comparison of different therapeutic strategies. Eat Weight Disord Eat Weight Disord; 2005 [cited 2023 Feb 1];10:154–61. Available from: https://pubmed.ncbi.nlm.nih.gov/16277137/

70. Beutel ME, Dippel A, Szczepanski M, Thiede R, Wiltink J. Mid-term effectiveness of behavioral and psychodynamic inpatient treatments of severe obesity based on a randomized study. Psychother Psychosom Psychother Psychosom; 2006 [cited 2023 Feb 2];75:337–45. Available from: https://pubmed.ncbi.nlm.nih.gov/17053334/

CHAPTER 5. CONCLUSION

Low-income populations experience high burden of food insecurity, poor dietary and obesity related health conditions. The analyses included in this dissertation addressed three aspects of a conceptualized model created to identify gaps that could inform interventions designed to mitigate the health risks of this population. Specifically, the dissertation chapters assessed links between 1) self-efficacy and food insecurity; 2) SNAP participation and dietary outcomes; and 3) food assistance and nutrition education program participation and weight status.

The analysis of cross-sectional data from the sample of rural veteran food pantry clients in Southern Illinois aged 18 years and over assessed the traits related to self-motivation and efficacy, at the individual level of the conceptualized model, and their links to food security and resource use. The analysis showed an inverse association between grit score and risk of food insecurity. Surprisingly, there were no other significant associations identified, such as between help-seeking behaviors and resource use. This could be due to limited sample size. Future research investigating the relationships between the self-efficacy related psychological traits and food insecurity and resource use with adequate sample size and longitudinal data is needed to better understand these associations and potential underlying mechanisms. Nonetheless, the findings provided evidence for future interventions targeting food insecurity improvement to include education and resources that address and improve self-efficacy among these low-income populations to improve overall health outcomes directly or through addressing food security or use of resources.

There were no differences in current usual nutrient intake, from dietary or total sources, or dietary quality low-income U.S. older adults at least 60 years by SNAP participation, a form of external temporary support in the conceptualized model. The usual nutrient intake estimates revealed high risk for inadequacy from dietary sources among both groups for vitamins A, C, D, E, calcium, and magnesium. The incorporation of DS in nutrient estimation was novel and showed that DS helped reduced the risk for inadequate intake, especially for calcium, magnesium and vitamin D. The results highlighted needs for continued efforts in SNAP to improve nutrient and dietary intake, such as continued support for SNAP-Ed. Additionally, education on DS regulation, potential risk and benefits associated with DS use should also be provided to guide low-income older adults using DS to acquire nutrients difficult to get from dietary sources alone. Studies with rigorous design, such as randomized trials would identify a causal relationship between SNAP and

dietary outcomes but would not be ethical. One possible solution would be to take advantage of natural experiments when available, to achieve stronger evidence that that provided through cross-sectional studies in evaluating dietary impacts of SNAP, without violating ethical standards.

Participation in nutrition education and food assistance program separately and in combination was not linked to long-term changes in weight status among a sample of low-income Indiana women eligible for SNAP-Ed. This study focused on the two types of external support, including nutrition education that could be internalized to have long lasting impact on self-efficacy or health outcomes, and temporary financial assistance. This was also the first study that assessed food assistance and education program in combination with longitudinal weight status. Future analyses with robust sample size and perhaps with a longer longitudinal component are needed to fully investigate these links for potential opportunities to deliver obesity prevention interventions using existing program framework to support healthy lifestyles.

The studies included in this dissertation contributed new knowledge to inform existing gaps at individual and societal level featured in the conceptualized model to mediate health risks among the low-income population. The findings provided novel insights for targeted interventions to address food insecurity, dietary and health outcomes from internal motivation and self-sufficiency, and external support in the forms of financial assistance and nutrition education programs.

VITA

Yue Qin

Education

Purdue University Expected: May 2023

Ph.D. in Nutrition Science (Nutrition Epidemiology and Public Health) Cumulative GPA: 3.81/4.00

University of Illinois at Urbana-Champaign May 2018

B.S. in Food Science and Human Nutrition (Human Nutrition) Cumulative GPA:3.96/4.00

Minor in Chemistry

Fields of Interest

Nutrition Epidemiology, Population Science, Public Health, Community Nutrition, Food Policy and Program Evaluation, Interdisciplinary Nutrition, Complex Survey Design

Research Projects

Purdue University, West Lafayette, IN

Graduate Research Assistant

MEAL-DM Pilot Study, West Lafayette, IN February 2021 – Present

- Design, implement and monitor a clinical trial that examine the dietary intake and patterns for healthy population and insulin takers by creating of study protocols and informed consent documents, acquiring of Institutional Review Board (IRB) approval
- Create study materials, and tracking and communication strategies, collaborate with cross-functional team (engineers, statisticians, healthcare professionals, etc.) to complete project goals within set timeline and metrics, and present project updates to multiple stakeholders

Reaching Rural Veterans Project (RRV), West Lafayette, IN August 2020 – Present

- Secure grant ($10,000) from Purdue Pharmacy, Center for Health Equity and Innovation Research and propose analysis plan to evaluation the RRV outreach program by studying the association of grit and help-seeking behavior with food insecurity and use of resources among rural veterans
- Communicate and manage multiple stakeholders and collaborate with several partner departments (Military Family Research Institute, Human Development and Family Studies) in developing survey instruments and administrations
- Review and clean the collected data, and complete model building and data analysis
- Interpret the results and apply their meaning in dissemination of research in publications and conferences

NHANES Project, West Lafayette, IN February 2020 – Present

- Study the structure and design of the multi-year survey data with complex, stratified, multistage probability sampling design (National Health and Nutrition Examination Survey), identify the data cycles for inclusion of analysis, create variables of interest and prepared the dataset for dietary analysis
- Determine and compare usual nutrient intake (from foods alone and with dietary supplements) and risk of inadequate intake of lower income older adults by food assistance program participation with complex survey data by implementing the adapted National Cancer Institute (NCI) method to inform policy

SNAP-Ed longitudinal Project, West Lafayette, IN January 2020 – Present

- Determined and compared long term impact of SNAP-Ed intervention on usual intake of key nutrients and food groups among Indiana SNAP-Ed-eligible participants using NCI method to inform policy
- Determined and compared long-term impact of SNAP-Ed intervention on dietary quality among the study sample using the healthy eating index
- Determined links of participation in food assistance and nutrition education program separately and in combination with long-term changes (1 year) in BMI among Indiana SNAP-Ed eligible women

Literature Review, West Lafayette, IN January 2020 – April 2021

- Reviewed literature of dietary aspects relevant for dietary assessment for diabetes management and prevention
- Gathered relevant research articles for narrative review

Food Policy White Paper, West Lafayette, IN August 2020 – December 2020

- Created white paper on providing grocery delivery service for at risk population to reduce food insecurity
- Presented white paper in front of members from FDA, USDA and Congress for potential policy proposals

University of Illinois at Urbana-Champaign, Urbana, IL

Undergraduate Researcher

Individual Honors Research Project, Urbana, IL November 2015 – May 2018

- Performed DNA isolation of intestinal microbiota for Ikid and Nestle Study which studies how feeding different formulas to infants/piglets affects their gut microbiota by analyzing DNA content from stool samples using QIAamp Fast DNA Stool Mini Kit
- Analyzed DNA profile from extracted samples, utilizing lab techniques such as DNA measurement, gel electrophoresis and qPCR
- Conducted individual project studying association of food allergy and gut microbiota as part of the STRONG Kids 2 using Real-Time qPCR to determine microbiome status in infants

Publications

- **Qin Y**, Aqeel M, Zhu F, Delp EJ, Eicher–Miller HA. Dietary Aspects to Incorporate in the Creation of a Mobile Image–Based Dietary Assessment Tool to Manage and Improve Diabetes. Nutrients. 2021 Apr. 2;13(4):1179.
- **Qin Y**, Rivera RL, Zhang Y, Wang Q, Tooze JA, Abbott AR, Maulding MK, Craig BA, Bailey RL, Eicher–Miller

HA. A Randomized Intervention of Supplemental Nutrition Assistance Program–Education Did Not Improve Dietary Outcomes Except for Vitamin D Among Lower-Income Women in Indiana. Journal of the Academy of Nutrition and Dietetics. 2022 Jun. 30: S2212–2672(22)00402–6.

- **Qin Y**, Cowan AE, Bailey RL, Jun S, Eicher–Miller HA. Usual Nutrient Intake and Dietary Quality of Low–income U.S. Older Adults. Applied Economic Perspectives and Policy. 2022 Oct. 7. https://doi.org/10.1002/aepp.13328
- **Qin Y**, Sneddon DA, MacDermid Wadsworth S, Topp D, Sterrett RA, Newton JR, Eicher–Miller HA. Grit was Associated with Food Insecurity among Low Income, At-risk Rural Veterans Grit but Not Help-Seeking Was Associated with Food Insecurity among Low Income, At-Risk Rural Veterans. International Journal of Environmental Research and Public Health. 2023; 20(3):2500.
- **Qin Y**, Cowan AE, Bailey RL, Jun S, Eicher–Miller HA. Usual nutrient intakes and diet quality among U.S. older adults participating in the Supplemental Nutrition Assistance Program compared to income eligible nonparticipants (under review at the American Journal of Clinical Nutrition).
- **Qin Y**, Cifelli CJ, Agarwal S, Fugoni VL. Dairy Food Consumption is Beneficially Linked with Iodine Status in US Children and Adults: NHANES 2001 – 2018 (under review at Public Health Nutrition).
- Lin L, He J, Cowan A, **Qin Y**, Zhu F; Delp E, Eicher-Miller H. The Development of a Food Image Database for Food Identification (under review at Journal of Food Composition and Analysis)

Peer Review Experience

- Serving as an expertise in food insecurity and peer reviewed a manuscript submitted to the Journal of Nutrition
- Reviewed a manuscript on food security and agriculture for International Journal of Agricultural Science and Food Technology

Presentations

- **Qin Y**, Cowan AE, Bailey RL, Jun S, Eicher–Miller HA. Usual Nutrient Intake of Older Adults in the U.S. Is Lower Among SNAP Participants Compared to Income-Eligible Non–Participants. Poster Presentation at: American Society for Nutrition Annual Meeting. June 7-10, 2021, online.
- **Qin Y**, Cowan AE, Bailey RL, Jun S, Eicher–Miller HA. Usual Nutrient Intake of U.S. Older Adults among SNAP Participants and Income–Eligible Nonparticipants. Poster Presentation at: National Institutes of Health "Food Insecurity, Neighborhood Food Environment, and Nutrition health Disparities: State of the Science Workshop". September 21-23, 2021, online.
- **Qin Y,** Sneddon DA, MacDermid Wadsworth S, Topp D, Sterrett RA, Eicher-Miller HA. Grit was Associated with Food Insecurity among Low Income, At-risk Rural Veterans. Poster Presentation at: Purdue University College of Health and Human Sciences Spring Research Event. March 25, 2022, West Lafayette, Indiana.
- **Qin Y,** Sneddon DA, MacDermid Wadsworth S, Topp D, Sterrett RA, Eicher–Miller HA. Grit was Associated with Food Insecurity among Low Income, At-risk Rural Veterans. Poster Presentation at: Purdue University

Office of Interdisciplinary Graduate Programs' Spring Reception. May 4, 2022, West Lafayette, Indiana.

- **Qin Y**, Sneddon DA, MacDermid Wadsworth S, Topp D, Sterrett RA, Eicher–Miller HA. Grit was Associated with Food Insecurity among Low Income, At-risk Rural Veterans. Poster Presentation at: American Society for Nutrition Annual Meeting. June 14–16, 2022, online.
- **Qin Y**, Cifelli CJ, Agarwal S, Fugoni VL. Association between total dairy and individual dairy foods and iodine status in the U.S. population. Poster Presentation at: American Society for Nutrition Annual Meeting. June 14–16, 2022, online.
- **Qin Y**, Shao Z, Vinod G, He J, Mao R, Lin L, Zhu F, Delp E, Eicher-Miller HA. Piloting a Mobile Image-Based Dietary Assessment Tool for Diabetes Management. Poster Presentation at: Connected Solutions. August 17, 2022. Indianapolis, Indiana.
- **Qin Y.** Usual nutrient intake and diet quality of U.S. older adults with low-incomes using various food assistance programs. Seminar Presentation at: Interdepartmental Nutrition Research Seminar Series. November 11, 2022, West Lafayette, Indiana.

Research Grants and Honors

- *Food Insecurity, Neighborhood Food Environment, and Nutrition Health Disparities: State of the Science Workshop*" Poster Award (National Institutes of Health) September 2021
- Center for Health Equity and Innovation Research Grant *"Examining Grit and Help–seeking Behavior in Relationship to Food Insecurity among Low–income, Homeless and at–risk Veterans in Rural Areas"* (Purdue) May 2021
- Ross Fellowship (Purdue) August 2018 – August 2019
- Mary E. Fuqua Graduate Scholarship (Purdue) August 2018 – May 2020
- James Scholar Honors Program (UIUC) January 2015 – May 2018
- Bronze Tablet Highest Institutional Honors (UIUC) May 2018
- JBT/ACES Undergraduate Research Award (UIUC) December 2017 – May 2018
- Merit Scholarship (UIUC) January 2018 – May 2018
- Dean's List (UIUC) December 2014 – May 2018

Teaching Experience

Purdue University, West Lafayette, IN August 2019 – December 2019, August 2020 – December 2020

NUTR303 "Fundamentals of Nutrition" Instructor through Teaching Assistantship

- Taught fundamental nutrition knowledge through explanation of complex concepts such as dietary guidelines and dietary reference intake recommendations to large class (over 180) of students from non-nutrition backgrounds
- Mentored and helped students with progressing in the course and received positive feedback from students and co-instructors

- Gave lectures and led in-class group activities in recitation sessions to promote communication and teamwork skills of the students
- Graded weekly activity worksheets and individual projects to enhance understanding of the course content

Professional Membership

American Society for Nutrition (ASN) 2019 – Present

- Student Interest Group
- Research Interest Sections (RIS): Nutrition Epidemiology; Community and Public Health; Nutrition Education and Behavioral Sciences; Aging and Chronic Disease; and Obesity

Leaderships and Activities

American Society for Nutrition (ASN) Student Interest Group (SIG) July 2021 – Present

Awards Chair

- Coordinate the SIG 3-Minute-Thesis (3MT) Award, organized by ASN SIG
    - Oversee application submission, review and scoring process and determination of finalists
    - Recruit and invited judges for the 3MT competition
    - Invite finalists to the SIG 3MT Award Competition during the annual meeting
    - Chair the 3MT Award Competition Event
    - Announce the Competition Award winners
- Co-host professional development activities with over 1500 global members, such as webinars on science communication and diverse career paths with nutrition degree

Nutrition Science Graduate Student Organization (NSGSO), West Lafayette, IN July 2021 – Present

Vice President (July 2022 - Present), Social Committee Member (July 2021 – June 2022)

- Compile the weekly Tuesday Toast email blast
- Assist with presidential duties in the president's absence or as needed
- Serve as a faculty graduate student liaison and represent of the graduate students and NSGSO during faculty meetings
- Plan professional and social events with executive board members
- Implement social events within and between the departments to facilitate interactions and connections of graduate students

Purdue Graduate Student Government (PGSG), West Lafayette, IN February 2021 – Present

Nutrition Science Department Senator July 2021 – July 2022

- Represented Nutrition Science graduate students as an advocating and legislative voice in the Purdue graduate student community

- Reflected issues and difficulties from nutrition graduate students to PGSG to bring attention and prompt improvement for professional, academic developments and daily life
- Communicated discussion topics and policy decisions made at PGSG to Nutrition Science department

Grant Review and Allocation Committee, Travel Grant Vice Chair July 2021 – July 2022

- Strengthened the communications between GRAC and the graduate students to connect resources and funding for conference related expenses to students in need
- Worked closely with all reviewers to improve communication and ensure fairness, smoothness and organization of the travel grant reviewing procedures

Grant Review and Allocation Committee, Grant Reviewer February 2021 – Present

- Review various types of grants including travel, professional, graduate student organization and symposium grants provided by PGSG
- Communicate with fellow grant reviewers and provide feedback to collectively make funding decisions for grant applicants by utilizing resource allocation and management strategies

La Milonguera Argentine Tango Club, West Lafayette, IN August 2019 – December 2022

Vice President (December 2021 – December 2022), Treasurer (August 2019 – December 2021)

- Organize club activities, including advertising for club information session, reserving rooms for weekly classes, scheduling with instructors, completing all additional COVID related paperwork to ensure approval
- Manage budgets for club events such as workshops, field trips, milonga parties and performances
- Connect and collaborate with other student organizations and performed at various events, such as Latinx Heritage Show and World Dance Party

Office of Interdisciplinary Graduate Programs (OIGP), West Lafayette, IN August 2019 – July 2020

Student Advisory Board, Department Representative

- Represented Interdepartmental Nutrition Program (INP) as a student voice to and provided feedback for OIPG
- Promoted and attended OIGP professional and social events to represent the interdisciplinary community members and broaden my knowledge outside of my field

Global Connection Café (GCC) at Purdue Wesley Foundation, West Lafayette, IN June 2019 – Present

Board Member

- Plan and discuss with other members in the planning team to determine cultural themes, activities and menu items for weekly GCC
- Prepare and lead the weekly event by facilitating cross-cultural conversations and promoting ideas among event participants

UIUC REACT Program, Urbana-Champaign, IL January 2015 – December 2015

Volunteer Instructor

- Taught basic chemistry to and lead experiments for local elementary students
- Assisted in preparation and ensured organization of the chemistry experiment showcase event for interested students and families

Professional Experiences

Dairy Management Inc. | National Dairy Council, Rosemont, IL June 2021 – August 2021

Scientific Affairs Outreach and Nutrition Research Intern

- Authored manuscript determining association of dairy food intake and iodine status in U.S. population using a nationally representative sample and submitted to top nutrition science journals and presented study findings at American Society for Nutrition annual meeting
- Created infographics to present and compare nutrition values and prices of dairy foods to fruits and vegetables for strategic planning and decision making of Feeding America
- Reviewed and summarized high-impact dairy-related nutrition research on associations between lactose intolerance and health and chronic diseases
- Discussed and reviewed Chinese regulatory compliance for a dairy product of Dairy Farmers of America importing to China and helped with language barriers and translation
- Participated in strategic planning for outreach projects by analyzing strengths, weaknesses, opportunities and threats of dairy industry
- Completed cultural presentation showcasing dairy foods in Chinese food culture to team members

Bayer Healthcare Company Limited, Beijing, China July 2016 – August 2016

Quality Technician Assistant Intern

- Improved testing methods for tablets dissolution by making use of an experimental container as intermedia in the experimental procedure to reduce the difficulty in operation of the test
- Conducted quality inspections for pharmaceutical packaging materials to make sure the packaging materials met the required standard to guarantee safety of medicine in storage and transportation

China National Cereals, Oils and Foodstuffs Corporation (COFCO), Beijing, China January 2016

Digital Health Tech Intern

- Constructed of Food Ingredients & Function Database by screening and analyzing related articles from fitness websites, as well as translating the articles from English to Chinese for easy access to Chinese readers

Tongren Hospital, Beijing, China December 2015 – January 2016

Clinical Pharmacist Shadowing

- Communicated with doctors about usage of medicine through daily meeting and visits to patients
- Located and organized pharmaceutical literature for better review and tracking of the latest progress in the area

- Gained clinical experience working with patients and healthcare professionals

China Agricultural University, Beijing, China August 2015

Research Assistant

- Studied effects of specific gel treatment in formation of acrylamide in deep fried foods by performing pH measurement, sample preparation for HPLC and data collection

Skills

- Proficient in SAS, R Studio and Microsoft Office
- Strong oral and written communication skills in English and Chinese (Mandarin)
- Familiar with lab techniques such as DNA extraction, DNA measurement, qPCR, and sample preparation for HPLC
- Stakeholder management skills through problem solving and collaboration with cross-functional and interdisciplinary teams in projects of various types