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COMBATING FOOD INSECURITY IN THE U.S. NAVY

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THESIS

COMBATING FOOD INSECURITY IN THE U.S. NAVY

by

Alan J. Lee

March 2023

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COMBATING FOOD INSECURITY IN THE U.S. NAVY

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To combat food insecurity, the Department of the Navy will increase the Basic Needs Allowance (BNA) total household income requirement up to 150% of the Federal Poverty Guideline (FPG) in accordance with the National Defense Authorization Act of 2023. This thesis uses machine learning techniques on comparable civilian data to create a model that best predicts the risk of food insecurity and the characteristics of Sailors who are food insecure. To measure the effectiveness of the BNA, this study simulates the increase in total household income up to 130% and 150% FPG, with and without the Basic Allowance for Housing included in the total household income calculation, and reruns the prediction model to see the changes in predicted risk of food insecurity. The model suggests that 17.6% of Sailors are food insecure. Additionally, the BNA in each simulation insignificantly decreases the food insecurity rate. Less than 1% of Sailors qualify for the BNA, while 17% are predicted to be food insecure. Therefore, the BNA provides an insufficient amount of allowance to an inadequate number of families to effectively reduce food insecurity in the Navy.

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LIST OF ACRONYMS AND ABBREVIATIONS

BAH	Basic Allowance for Housing
BNA	Basic Needs Allowance
DEERS	Defense Enrollment Eligibility Reporting System
DMDC	Defense Manpower Data Center
DOD	Department of Defense
DON	Department of the Navy
FPG	Federal Poverty Guideline
FSS	Food Security Supplement
LASSO	Least Absolute Shrinkage and Selection Operator
NDAA	National Defense Authorization Act
NSIPS	Navy Standard Integrated Personnel System
OPA	Office of People Analytics
SNAP	Supplemental Nutrition Assistance Program
SPM	Supplemental Poverty Measure
USDA	United States Department of Agriculture
WIC	Women, Infants, Children

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I would not have come to the Naval Postgraduate School without my wife's commitment and encouragement. I certainly would not have finished this degree without her loving support. Nikki, I owe you this success and many more to come. You and Ziggy are the irreplaceable joys of my life.

Appa and Umma, your lifelong sacrifices are the roots of my successes. I hope this thesis represents our values of honesty, work ethic, and service.

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Also, Professor Latika Hartmann, thank you for your patience and diligence in making this thesis better than I could have alone. I will carry your editing knowledge and recommendations with me for the rest of my professional career. Thank you, again, for believing in me and my writing skills!

I dedicate this thesis to Sailors and their families who have waited in line at the food pantry, struggled to pay the bills and groceries, and sacrificed after-school activities to put food on the table. Your country thanks you for your sacrifices.

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I. INTRODUCTION

A. OVERVIEW

COVID-19 put unprecedented strains on military families. The economic stressors elevated living expenses faster than military pay raises. On November 17, 2021, Defense Secretary Austin released a memorandum to jumpstart the Department of Defense's (DOD) response to financial challenges, such as food insecurity and the housing shortage (Secretary of Defense, 2021). Unfortunately, the DOD and the Navy lacked sufficient data and analysis to address the issues immediately. As part of the solution, the DOD adopted the United States Department of Agriculture's (USDA) widely accepted definition of levels of food insecurity in 2021 (Office of the Under Secretary of Defense for Personnel and Readiness, 2022a). The memorandum from the Office of the Under Secretary defines food security for servicemembers as having access to a sufficient amount of food for an active, healthy life for all of their household members. Similarly, low food security means the servicemember's household has reduced quality or diversity in their food source but not a reduction in quantity. The memorandum defines very low food security as a reduction in both the quantity and quality of household food consumption. This definition was also used in the 2018 and 2020 Status of Forces Survey of Active-Duty Members and the 2021 Active-Duty Spouse Survey (Office of the Under Secretary of Defense for Personnel and Readiness, 2022a). While self-reported food insecurity along with other personal stressors is surveyed regularly throughout the DOD, the department lacks a standardized method of measuring the risk of food insecurity and its determinants.

B. PURPOSE OF THE STUDY

Almost a year after the initial memorandum, Secretary Austin released a follow- on memorandum on September 22, 2022, that included the Basic Needs Allowance (BNA) as part of the new initiatives starting in 2023 (Secretary of Defense, 2022). A few months later, President Biden signed the Fiscal Year 2023 National Defense Authorization Act (NDAA) that increased the BNA total household income requirement from 130% of the Federal Poverty Guideline (FPG) to 150% of the FPG (H.R. 7776, 2022). Currently, the

BNA is a monthly supplemental allowance awarded to Sailors with dependents whose gross household income fall below the 130% FPG based on their household size and permanent duty station location, but the requirement is expected to change to 150% below the FPG by 2024, per the Fiscal Year 2023 NDAA (Chief of Naval Operations, 2022). The new NDAA details that the allowance is meant to bring gross household income up to 150% FPG. Gross household income includes all income from every member of the household, including military allowances and government food assistance programs, like Supplemental Nutrition Assistance Program (SNAP) and Women, Infants, and Children (WIC) (Office of the Under Secretary of Defense for Personnel and Readiness, 2022b). Some of the exceptions to the household incomes are incomes of dependents who are not required to file taxes, military travel allowances, and Basic Allowance for Housing (BAH) for the high cost of living areas (Office of the Under Secretary of Defense for Personnel and Readiness, 2022b). According to NAVADMIN 289/22, Sailors must apply for the allowance, report any changes to their household size, notify MyNavy Career Center of an increase in monthly gross household income over $150, and reapply annually (Chief of Naval Operations, 2022). The NAVADMIN also identifies the commands as a liaison between the Sailors and MyNavy Career Center and deliver monthly reports of the number of total Sailors receiving BNA. Ultimately, as outlined in the NAVADMIN, MyNavy Career Center screens applications monthly and notifies commands of selections. The entire process levies administrative burdens on the Sailors, commands, and MyNavy Career Center. Although supplemental income can relieve financial burdens, the Navy has no means of analyzing how much the BNA reduces the risk of food insecurity.

C. RESEARCH QUESTIONS

Without a standardized measure of the risk of food insecurity amongst Sailors, the Department of the Navy (DON) will continue to struggle to resolve the issue efficiently and effectively. While civilian data such as the Current Population Survey can measure food insecurity levels from large, randomized samples, the DOD surveys are voluntary and self-reported. This survey method can either overestimate or underestimate the levels of food insecurity because the Navy's culture may not encourage Sailors to disclose their food insecurity or only those who are struggling may want to respond to the survey. To combat these biases and analyze the risk of food insecurity, this thesis answers the following questions:

1. Which characteristics of Sailors are best predictors of those who are at risk for food insecurity?

2. Based on the predictive model, does the Basic Needs Allowance (BNA) reduce predicted food insecurity rates?

Due to its complex nature, finding direct causal relationships between food insecurity and other characteristics have been historically difficult. However, answering the research questions will help the DON better understand the risk of food insecurity and the Sailors who are impacted by it. A better understanding will have a broader impact on recruiting, readiness, retention, and attrition.

D. METHODOLOGY

To answer both research questions, I create a dataset that includes civilian food insecurity status and relevant characteristics that apply to the Navy's population. I then generate a predictive model based on the self-reported civilian food insecurity status and characteristics using a machine learning technique, Least Absolute Shrinkage and Selection Operator (LASSO). I test the validity of the model by halving the civilian observations into training and testing sets. Additionally, I measure the model's Dorfman and McIntosh goodness-of-fit to better understand the model's predictive power (McIntosh & Dorfman, 1992). I apply the prediction model onto the enlisted data to predict the risk of food insecurity for each enlisted household. To test the effectiveness of the BNA, I run a simulation that elevates Sailors' total household income up to 130% FPG for those who qualify and rerun the predictive model on the simulated data to see the changes in risk of food insecurity. I repeat this simulation for each level of FPG for the BNA eligibility with and without the BAH included in the total household income calculation.

E. SCOPE AND LIMITATIONS

This study analyzes civilian and Navy data from 2013 to 2019. I exclude most recent years due to irregularities from COVID-19. Therefore, the results do not reflect the impact of COVID-19 on Sailors and their families. Although most characteristics in both datasets are similar, such as sex, age, and income range, this study is limited to the variables that are both present or estimated in civilian and Navy data. Because the model predicts a minuscule food insecurity rate in the officer sample, this study focuses on the enlisted population.

F. FINDINGS

1. Research Question 1

The first research question seeks to identify individual characteristics that are most likely to predict food insecurity among Sailors. The prediction estimates that individual characteristics such as being female, a racial minority, and/or a divorced Sailor increase the risk of food insecurity compared to male, white, and/or married Sailor. Household characteristics such as more children also increase the risk. While having two working adults with up to $35,000 in total household income increase the risk, having two working adults with at least $100,000 in total household income decrease the risk. Households in low cost of living states with less than $50,000 in total income have higher risk, while households in high cost of living states and with at least $75,000 in total income have lower risk of food insecurity. In addition to the enlisted sample distribution at the 150% FPG with and without BAH included in the total household income, Figure 1 displays the range of predicted food insecurity rate among the enlisted sample by cost of living, rank, household size, and race. Although single Sailors have a higher predicted risk of food insecurity than those with dependents, they do not qualify for the BNA according to the policy.

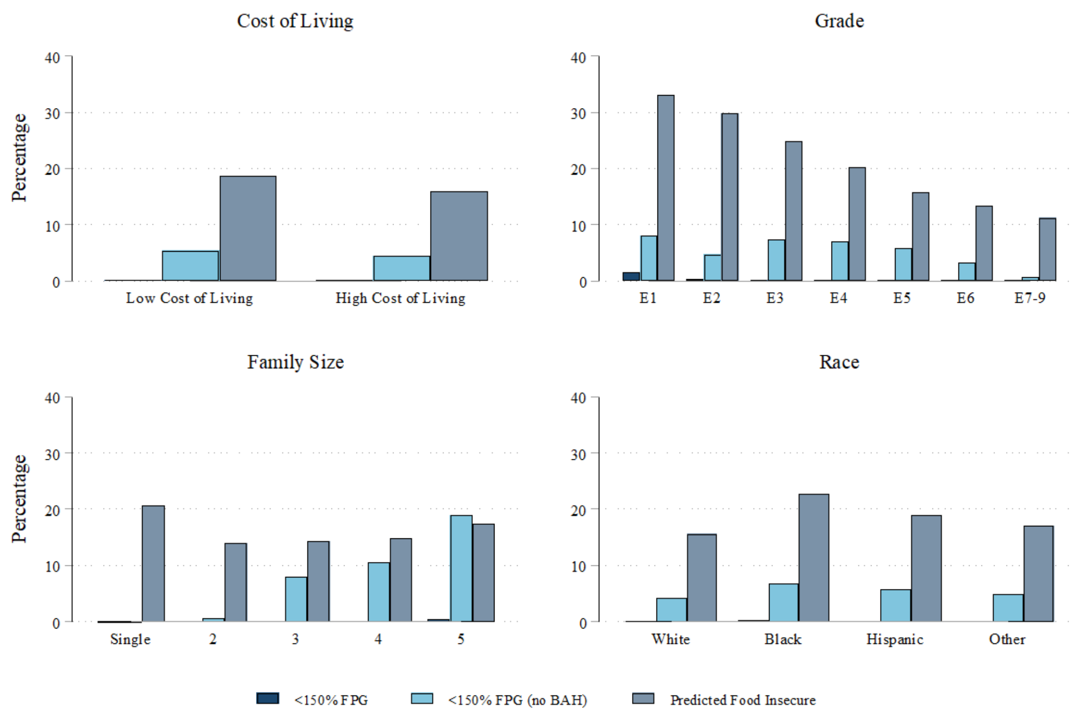

Figure 1. Enlisted Sample at 150% FPG with and without BAH and Predicted Food Insecurity Rate

2. Research Question 2

The second research question evaluates the effectiveness of the BNA in reducing food insecurity. The prediction model estimates that 17.6% of the enlisted sample is at risk of food insecurity. I simulate the effects of the BNA for those who qualify by increasing the total household income up to 130% and 150% FPG and rerun the prediction model through the simulated data. Figure 2 depicts the marginal changes predicted by the simulations. Although the BNA reduces the predicted risk, because less than 1% of Sailors fall below both FPGs, the BNA cannot support the predicted majority who are food insecure and living above the FPGs. The results suggest that neither 130% nor the 150% FPG should be the single threshold to combat food insecurity in the Navy.

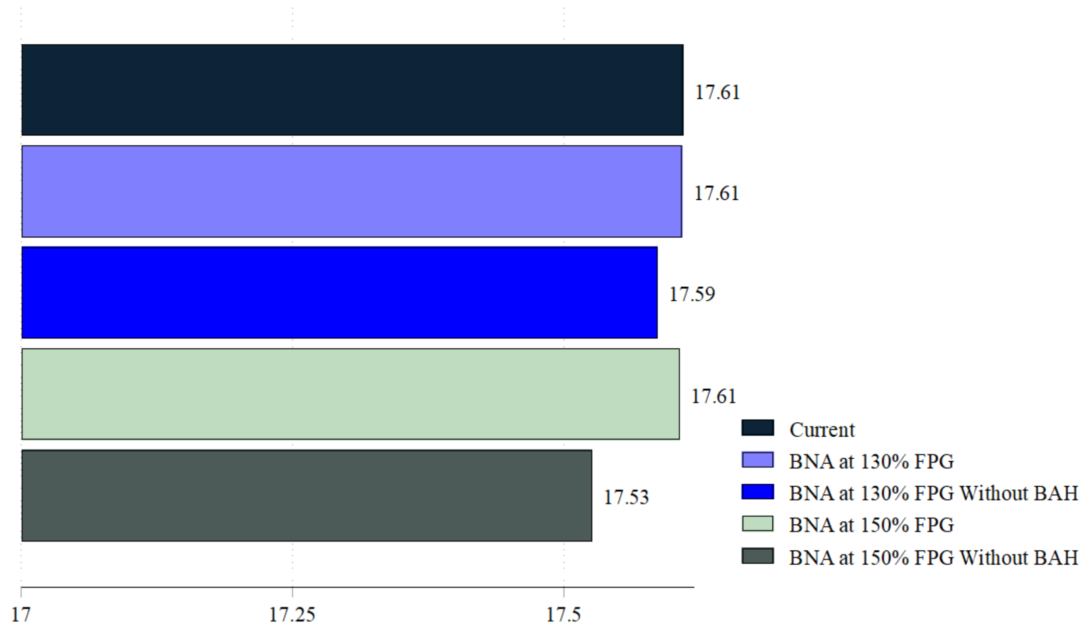

Figure 2. Enlisted Predicted Food Insecurity by BNA Simulation

G. OVERVIEW OF THE CHAPTERS

The rest of this thesis is organized as follows. Chapter II reviews the existing academic literature on food insecurity. Chapter III describes the data used in this study and explains the methodology for analysis. Chapter IV analyzes the results of the study. Finally, Chapter V concludes with recommendations.

II. LITERATURE REVIEW

This chapter is divided into three sections. Section A reviews the prevalence of food insecurity in the military. Section B explores the historical effects of supplemental income on food insecurity. Section C describes studies that look at the correlation between food insecurity and a variety of physical and mental health outcomes.

A. FOOD INSECURITY IN THE MILITARY

The Department of Defense lacks consistent, standardized measures of food insecurity. Most of the findings are through voluntary surveys, so they do not accurately represent the prevalence of food insecurity in the entire Navy. However, research conducted by the DOD's Office of People Analytics has found correlations between food insecurity and servicemembers' characteristics. Although servicemembers receive additional compensations compared to their civilian counterparts, studies have found that they are still vulnerable to food insecurity.

The DOD's Office of People Analytics' (OPA) 2020 Status of Forces Survey of Active-Duty Members received 11,506 responses; this survey included the USDA's six questions about food insecurity status (Office of People Analytics, 2022a). The report found that out of all the respondents, 25% reported low or very low food security status. The results showed that the Navy had the highest food insecurity level with 17% reporting low food security and 13% reporting very low food security. Additionally, among junior enlisted, E1 to E4, up to 35% reported some level of food insecurity. In conclusion, compared to civilians in the same age group from the Current Population Survey, enlisted Sailors reported a higher rate of food insecurity. Financial stress, the number of children in the household, and the employment status of non-military spouse significantly increased the likelihood of food insecurity (Office of People Analytics, 2022a).

These stressors ultimately impact Sailors' readiness, desire to stay in the Navy, and their family support. The same survey found that out of those who reported some level of food insecurity, 35% of them also disclosed that they are unlikely to stay in the Navy beyond their current commitment. Even worse, those who identified as food insecure in the survey were less likely to have family support for their career in active duty, more likely to be stressed about their personal and work life, and less likely to be confident about their personal and unit readiness. Although the results are from voluntarily disclosed surveys, the fraction of reported food insecurity is alarming.

The OPA surveyed 11,764 active-duty spouses in 2021 and found similar results. A quarter of the spouses self-identified as food insecure; about 14.5% had low food security and 10.5% had very low food security (Office of People Analytics, 2022b). For E1 to E4, 45% of spouses reported food insecurity, and 41% of unemployed spouses responded as food insecure. Mirroring the active-duty servicemember survey, this report found that the reporting spouses were less satisfied with their spouses' military affiliation and less supportive of continuing their careers compared to the same survey from 2019. Even though reported food insecurity and spousal unemployment rates are consistent from previous years, it is likely that the pandemic negatively affected spousal employment and access to childcare (Office of People Analytics, 2022b). Permanent Change of Station is another unique issue military families face that causes temporary financial stress. In the same survey, forty-seven percent of spouses who have experienced Permanent Change of Station in the past year reported that they did not find employment in less than 4 months.

Civilian research supports the findings from OPA on how race, rank, number of children in the household, and spousal employment affect servicemembers' food security. Rabbitt et al. (2022) used survey results from Behavioral Health Epidemiological Consultations by Army Public Health Center's Behavioral and Social Health Outcomes Program to describe the trends in soldiers' food insecurity. Rabbitt et al. (2022) measured that out of 2,832 Army households, 15.6% transitioned from highly food secure to marginally food insecure after the pandemic began, but 16.3% disclosed consistent marginal food insecurity. They also discovered that almost half of E1 to E4 became marginally food insecure after the pandemic onset, and almost a third of E5 to E6 shared the same experience (Rabbitt et al., 2022). The authors concluded that their results are in line with other research findings that servicemembers' limited use and access to Supplemental Nutrition Assistance Program and inconsistent spousal employment status affect food security.

The pandemic highlighted the fragile infrastructure support servicemembers have even with their additional compensation. Their level of food security before and after the pandemic is comparable to their civilian counterparts, which questions the strength of military compensation. Military households also face unique financial challenges, such as frequent moves, that induce temporary financial stress. Additional studies are required to better understand who exactly needs the additional support to combat food insecurity and how the support should be implemented.

B. THE EFFECTS OF SUPPLEMENTAL INCOME ON FOOD INSECURITY

Supplemental income has been a popular policy approach in mitigating food insecurity. The research below studied how the Child Tax Credit in American Rescue Plan Act, American Recovery and Reinvestment Act, and SNAP changed the prevalence of food insecurity and poverty. Increasing tax breaks, SNAP benefits, and SNAP participation proved to lift people out of poverty and food insecurity.

Ratcliffe et al. (2011) tried to measure the effect of the Supplemental Nutrition Assistance Program on food insecurity. Using the Survey of Income and Program Participation from 1998, 2003, and 2005 and characteristics of about 36,000 to 46,000 households, including their food insecurity levels, SNAP participation, and household composition over the past four months, Ratcliffe et al. (2011) found that 24.4% of low-income households self-reported as food insecure, and 10.3% self-reported as very food insecure. Additionally, 35.6% of SNAP-recipient households were food insecure and 19.9% of nonrecipients were food insecure. With their bivariate probit model, the authors predicted the likelihood of food insecurity as a function of SNAP participation, controlling for individual and household-level characteristics, state SNAP policies, and year fixed effects. Based on this model, without SNAP participation, the likelihood of food insecurity for SNAP recipients would have been 51.8%, not the reported 35.6% (Ratcliffe et al., 2011). This estimate suggested that SNAP participation reduced the likelihood of food insecurity by 16.2 percentage points or 31.2%. The study also estimated that SNAP recipients who were very food insecure decreased from an estimated 20.2% to a reported 3.9%. Although the food insecurity status and SNAP participation are self-reported and often underreported, other studies report a common pattern with SNAP participation decreasing food insecurity (Ratcliffe et al., 2011).

In February 2009, President Obama signed the American Recovery and Reinvestment Act into law, which expanded SNAP eligibility and increased the monetary benefits (Nord & Prell, 2011). They compared SNAP participation, food spending, and food security levels from the Current Population Survey Food Security Supplement from December 2008 and December 2009. The study controlled for outside factors, such as unemployment rates and food prices for each year, by using a difference-in-difference comparison between nearly-SNAP-eligible households and SNAP-eligible households. Adjusted for other household variables, like income, employment, and household size, the research projected that SNAP participation increased by 3 percentage points from 2008 to 2009. The median SNAP benefit also increased by about 16 % after adjusting for other household factors. Their difference-in-difference analysis estimated an average of 2.2 percentage points increase in food expenditure. Adjusted for household differences, their study found that low food security dropped by 2.2 percentage points and very low food security dropped by 2 percentage points. Although not statistically significant, food insecurity for nearly SNAP-eligible low-income households increased during the same time frame (Nord & Prell, 2011). Considering only about two-thirds of eligible households receive SNAP benefits and a significant number of low-income households cannot receive SNAP due to not meeting the requirements, their results most likely underestimate SNAP's possible effectiveness. However, this event study provides great insight into how increasing the supplemental income rate and expanding the eligibility affect its utility and effectiveness in reducing food insecurity.

Part of the American Rescue Plan Act in 2021 temporarily expanded the eligibility and increased the dollar amount of the child tax credit. A Congressional Research Service study used survey data from the Census Bureau's Current Population Survey Annual Social and Economic Supplement from 2015 to 2017 to simulate the effects of additional federal child tax credit (Crandall-Hollick & Boyle, 2021). Due to this limited timeline, the analysis does not completely capture the dynamic changes in the economy from the pandemic. This study calculated that the expansion allowed 96% of families with children to receive the child credit, compared to the previous 84%. They also measured that the average family's child credit amount almost doubled from $2,597 to $5,086; lower-income families received the largest difference in credit. With this change, average child poverty was estimated to reduce from 13% to 7%. Although the research does not present estimates on the reduction in food insecurity, the estimated drastic decrease in poverty suggests similar results for food insecurity.

Supplemental income, even when temporary, has reduced the risk of food insecurity. The Navy's BNA shares similar benefits and requirements as SNAP, so it could be a successful supplemental income to better protect Sailors at risk. Unfortunately, there is no data or analysis currently to measure its effectiveness in reducing food insecurity.

C. FOOD INSECURITY AND HEALTH EFFECTS

Studies find that food insecurity is negatively correlated with physical and mental health outcomes. Because food insecurity and health issues are affected by characteristics such as income, household size, race, and education level, it is difficult to separate the negative health effects of food insecurity from those other factors. Another identification problem is the reverse causality of food insecurity, namely mental and physical health problems that can lead to food insecurity. Although it is difficult to identify the causal effect of food insecurity on health outcomes, the negative correlations summarized below are alarming and highlight the need for more well-identified studies.

In a 2019 survey of 5,677 soldiers at a US Army base, almost a third of the respondents identified themselves as marginally food insecure (Beymer et al., 2021). Moreover, this group of food-insecure soldiers was ten percentage points more likely to leave the service than those who identified as food-secure. However, their statistical analysis showed that although food insecurity is independently associated with anxiety, depression, and suicidal ideation, it is unrelated to willingness to leave the Army. Rather, anxiety, depression, and suicidal ideation were related to willingness to leave the Army (Beymer et al., 2021). Although food insecurity and mental stressors do not share a causal relationship, one issue can be an indicator of another. If the risk of food insecurity can be predicted, then it could help identify mental health stressors.

Sailors with children face additional challenges with food insecurity. Studies have also found negative associations between food insecurity and childhood obesity. Fleming et al. (2021) studied 4,777 adolescents from the National Health and Nutrition Examination Surveys 2007–2016. The study found that about 26% of those who were food insecure had obesity while only 20% of those who were food secure had obesity. However, when other characteristics such as race, income, and sex were controlled for, food insecurity was no longer strongly associated with obesity. Moreover, the results concluded that being Black or Latino male and below 185% of the FPG was independently associated with childhood obesity. These findings suggest that food insecurity does not cause childhood obesity, but both risks increase with household poverty. Poverty, for example, may limit access to nutritional food, which may affect food security and obesity. Sailors and their family members living in poverty are at higher risk of food insecurity and childhood obesity.

In addition to physical health issues, food insecurity may affect children's mental health. Using data from the National Health Interview Surveys between 2011 to 2014 and survey results from the Strength and Difficulties Questionnaire, Burke et al. (2016) found food insecurity was correlated with mental health disorders in children and adolescents. They found that for children aged 4 to 11, those who had very low food security made up 15.6% of all children with mental disorders with severe impairment but merely 4.5% of those who had no disorder. Similarly, for adolescents aged 12 to 17, those who had very low food security made up 17.2% of all adolescents with mental disorders with severe impairment but 4.5% of those with no disorder. The authors' logistic regressions predicted that children with very low food security had 1.59 times the odds of having a mental disorder with impairment compared to children who are food secure. Burke et al. (2016) also determined that adolescents with very low food security had 2.55 times the odds of having mental disorders with impairment compared to adolescents who are food secure. Their model predicted that children with very low food security were 19% of all children with mental disorders with severe impairment, and adolescents with very low food security were 14% of all adolescents with mental disorders with severe impairment.

Physical and mental health issues related to food insecurity are not limited to civilians. They can also affect military personnel and their families. Health issues can deteriorate Sailors' performance and lead to involuntary medical separations. Sailors with children who are affected by food insecurity are also vulnerable to relative medical conditions. If Sailors are unable to provide for their families, they may choose to leave the Navy for other career options. Finding predictors of the risk of food insecurity and BNA's effectiveness can help prevent Sailors and their families from negative health effects.

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III. DATA AND METHODOLOGY

A. DATA

This study uses civilian and military data. The civilian dataset is a collection of multiple data sources that provide food security status along with relevant demographic information. The military data does not provide food security status but includes similar demographic information about Sailors as the civilian dataset. To accurately predict Sailors' risk of food insecurity based on the civilian data, variables in both datasets must match each other. I append and merge multiple datasets to create one database to accurately choose the strongest predictors of food insecurity from the civilian characteristics that are replicable in the Navy sample.

1. Civilian Dataset

The civilian federal data on food security comes from the Census Bureau's Current Population Survey. It includes 144,750 observations from 2012 to 2019. If a respondent discloses some level of food insecurity in the initial survey, they answer additional questions about food security in the Food Security Supplement (FSS) (Economic Research Service, 2022). The Economic Research Service's website (2022) describes that the FSS has 10 items for households without children and additional 8 items for households with children that ask about their food security status in the past 12 months. On the same website, based on the response, the household is categorized into high food security, marginal food security, low food security, and very low food security. The following are definitions from the website. Marginal food security status reflects minimal or no change in quantity and quality of food sufficiency but increased stress over shortage in food supply. Low food security means that during the past 12 months, at least one household member did not have adequate food due to insufficient money or other resources for food. Very low food security means that during the past 12 months, at least one household member had to reduce their food intake or change their eating pattern because of insufficient funds or other resources for food. I construct a binary measure of food insecurity as one for individuals who are food insecure and zero for individuals identified as food secure. Those who are predicted to be food insecure in the results, therefore, are on the USDA's spectrum of marginal, low, and very low food secure. I include marginal food security as part of food insecure definition because no Sailors and their households should have to worry about feeding their family. Along with food security status, the Current Population Survey includes information about the individual demographics, their household characteristics, income, and geographic details (Census Bureau, 2021).

The Census Bureau also updates the FPG and the Supplemental Poverty Measure (SPM) used in this dataset. The FPG measures the gross pre-tax income for a household and determines the poverty threshold based on the household size (Fox & Burns, 2021). The SPM includes all sources of income, expenditures, and taxes to develop a location-specific poverty threshold; the expenditures originate from the Consumer Expenditure Survey on basic needs, like food, clothing, shelter, and utilities (Fox & Burns, 2021). I merge the FPG and SPM data onto the Current Population Survey data. Based on this merged data, I create binary variables that indicate whether observations fall below the 130% FPG, 130% FPG without BAH, 150% FPG, and 150% FPG without BAH.

To capture the diversity of regional food costs, I use Feeding America's Map the Gap data. Feeding America uses NielsenIQ's county-level multiplier, based on real food sales data, to find the average meal costs at the local levels (Feeding America, n.d.). The merged dataset provides an average meal cost in dollars for each observation based on their county and year at the time of the reporting.

I also construct a cost-of-living variable using data from the 2019 Bureau of Economic Analysis Regional Price Parities. In accordance with the DOD definition, I categorize states at or above 108% of the national price index as having high costs of living (Defense Travel Management Office, n.d.). Approximately 41% of the enlisted and 35% of the officer samples live in high-cost states. Figure 3 illustrates the spread of Regional Price Parities throughout the states. The top six states and Washington, D.C., are considered high-cost living states.

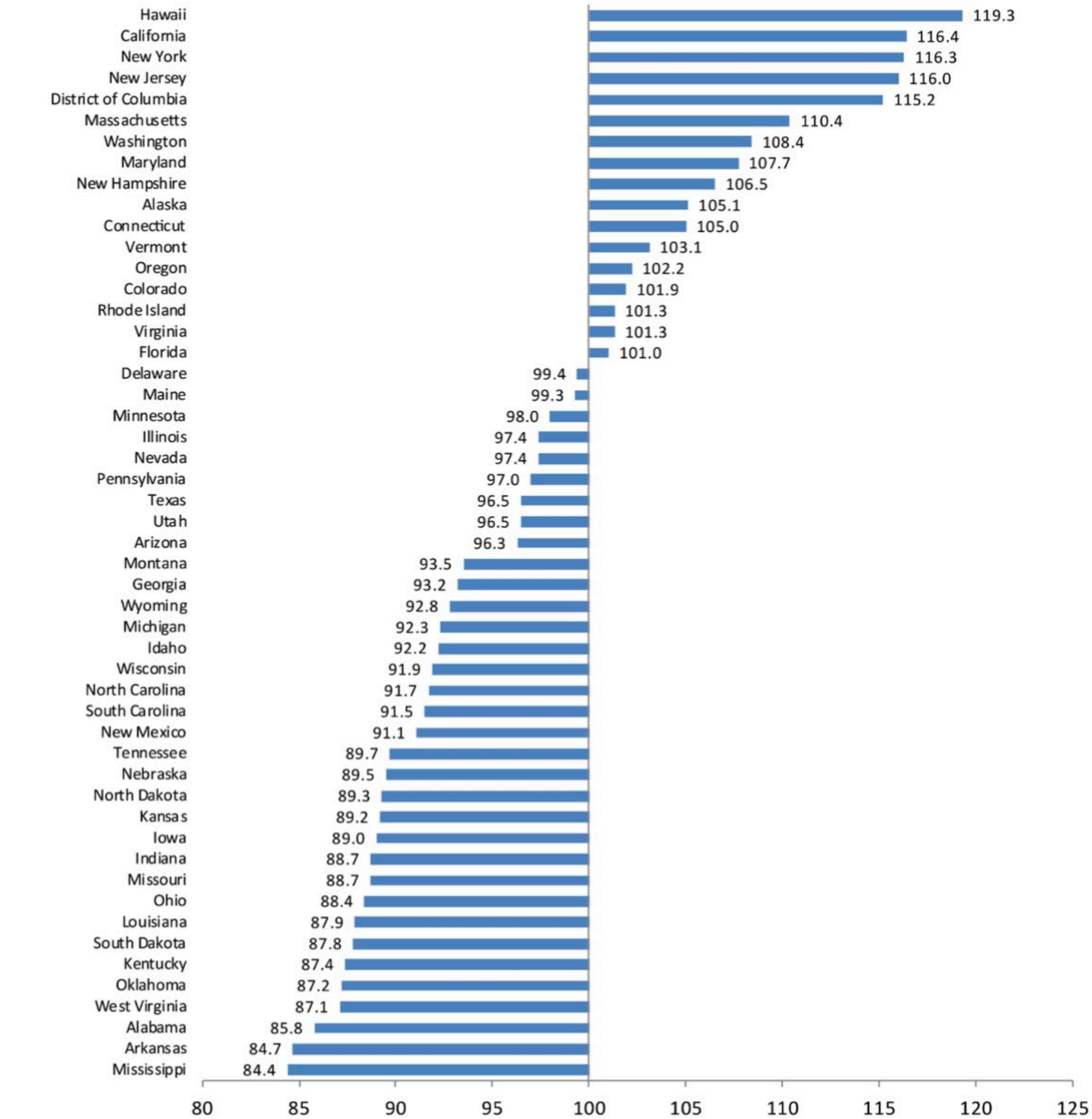

Figure 3. Regional Price Parities for Each State. Source: Bureau of Economic Analysis (2020).

Table 1 presents civilian demographic statistics and their average food insecurity rate. Approximately 18% of the civilian sample is food insecure. About 8% of the sample is at or below the 130% FPG, and about 11% is at or below the 150% FPG. About quarter of the civilian sample live in high-cost states.

Table 1. Summary Statistics

Civilian	Mean	St Dev	Minimum	Maximum
House is Food Insecure	0.18	0.38	0	1
Number of Household Members	2.87	1.49	1	7
Below 130% Federal Poverty Line	0.08	0.27	0	1
Below 150% Federal Poverty Line	0.11	0.32	0	1
Military Family	0.01	0.12	0	1
At least One Adult Is in the Labor Force	0.93	0.26	0	1
Average Meal Cost ($)	3.02	0.40	2	6
High Cost of Living Area	0.25	0.43	0	1
Age	39.74	9.61	17	55
Female	0.47	0.50	0	1
Married	0.59	0.49	0	1
Divorced, Legally Separated, Annulled, Interlocutory Decree	0.15	0.35	0	1
Non-Hispanic White	0.83	0.41	0	1
High School Degree	0.34	0.47	0	1
College Degree	0.43	0.49	0	1
Observations	144,750			

2. Navy Dataset

The Defense Manpower Data Center (DMDC) dataset includes active-duty pay data and Defense Enrollment Eligibility Reporting System (DEERS) record. The active- duty pay data from January 2013 to December 2019 discloses monthly military financial records, such as salary, allowances, taxes, and insurance deductions. I create an annualized six-month net, post-tax income for wage. The DEERS record has demographic information on Sailors and their self-reported dependents. Sailors' household demographics can be modeled by the number of dependents, marital status, age and sex of the children and spouse, and types of dependents. The two datasets allow me to cross-reference the amount of BAH the Sailor receives with the Sailor's dependent status.

I merge the two Navy datasets, so each observation has pay information along with personal demographic information. I then append the merged civilian dataset to the merged Navy dataset to create one database. To better match both datasets, I create variables that are applicable to both civilian and Navy samples. Since I do not have the employment data of civilian spouses, I estimate spouse employment status and income to account for the total household income. Using the spouse employment rate from the 2019 Survey of Active-Duty Spouses, I randomly assign 42% of the spouses as employed (Office of People Analytics, 2022c). Assuming spouses have the same education level as their military spouse, I assign the annualized amount of the Department of Labor's weekly median wage based on education levels to each employed spouse (Bureau of Labor Statistics, 2022). Because the Bureau of Labor Statistics reports this weekly median wage quarterly, I use the third quarter wage to match the end of the military's fiscal year. Assuming military spouses make the same wage, I double the total household wage for dual military families by assigning the same wage to both spouses. I create employment and labor force participation variables for each household to match the civilian data. Dual military families have two employed adults in the labor force. Single and divorced households have one employed adult in the labor force. Married households with civilian spouse have one or two adults based on the random assignment of civilian spouse employment.

Table 2 displays the Navy demographic summary. Less than 1% of Sailors live at or below the 130% and the 150% FPG, which means only a very small number of Sailors will qualify for the BNA. Approximately 40% of the Navy sample live in high-cost states.

Table 2. Navy Summary Statistics

	Mean	St Dev	Minimum	Maximum
Number of Household Members	2.38	1.51	1	7
Below 130% Federal Poverty Line	0.04	0.02	0	1
Below 150% Federal Poverty Line	0.14	0.04	0	1
Military Family	1.00	0.00	1	1
At least One Adult Is in the Labor Force	1.00	0.00	1	1
Average Meal Cost ($)	3.23	0.27	2	6
High Cost of Living Area	0.40	0.49	0	1
Age	29.97	7.60	17	55
Officer	0.19	0.39	0	1
Female	0.19	0.39	0	1
Married	0.58	0.49	0	1
Divorced, Legally Separated, Annulled, Interlocutory Decree	0.02	0.14	0	1
Non-Hispanic White	0.54	0.50	0	1
High School Degree	0.71	0.45	0	1
College Degree	0.21	0.41	0	1
Observations	1,307,834			

B. METHODOLOGY

1. Research Question 1

To find the combination of variables that best predicts the risk of food insecurity, I use the Least Absolute Shrinkage and Selection Operator (LASSO) machine learning technique. LASSO chooses the best predictive coefficients and variables based on the list of variables I include. To accurately represent the Navy population, I limit the civilian sample to comparable characteristics. I drop all civilian observations who are not between the age of 17 and 55. I also drop civilian households who make below $20,000 and do not have a single working adult. Because the risk of food insecurity is between zero and one, I use logistic regressions to estimate a predictive model where the risk of food insecurity is

$$\mathrm{P}(Risk\ of\ Food\ Insecurity = 1 \mid x) = \frac{e^{z}}{(1+e^{z})}\ ,$$

and Z is defined as

$$Z_i = \Delta_{it}A + \Psi_{it}\,B + \Gamma_{it}\,C + \Omega_{it}\,D + \varepsilon_{it}.$$

A represents a set of variables about the make-up of the household, such as the number of children, number of people, and number of children under the age of five. *B* represents a set of variables that measure the financial characteristics of the household. This set includes the number of household members in the labor force, number of employed household members, and average meal cost. *C* includes the effects of interaction variables. I create interaction variables with education and all the other variables, including military family status, number of adults in the labor force, number of employed adults, states with high cost of living, race, female, marital status, total household income, number of household members, number of children, number of children under the age of five, average meal cost, and age. I also interact average meal cost with number of children, total household income with number of household members, female variable with total household income, number of employed adults with total household income, high cost of living states variable with total household income, and race variable with total household income. *D* lists all the individual control variables, such as military family status, race, sex, marital status, age, age- squared, education level, and year. ε_{it} is the error term.

I test the effectiveness of the model by splitting up the civilian data into training and testing sets. I run the logistic regression through the LASSO technique only on the randomly assigned civilian training set. Once the coefficients are estimated, I predict the food insecurity rate on the training and test sets of both Navy and civilian data. To use the McIntosh-Dorfman method, I make the predicted risk of food insecurity a binary variable by rounding up to one or down to zero. If the sum of all correctly predicted ones and zeroes is above 1, the prediction is considered to have strong goodness of fit (McIntosh & Dorfman, 1992). This LASSO model has a McIntosh-Dorfman score of 1.14.

2. Research Question 2

To measure the effectiveness of the BNA, I simulate the increase in total household income of Sailors who qualify and measure the changes in their risk of food insecurity. For Sailors who qualify for the BNA based on their duty location, total household income, and household size I increase their total household income up to 130% of the FPG and rerun the predictive model through the simulated data. Civilian programs, such as SNAP, exclude housing costs from the total household income for eligibility (Department of Agriculture, 2021). Moreover, advocates support the removal of BAH as part of the BNA calculation to expand the eligibility and increase the allowance amount (Feeding America, 2020). Thus, I repeat this simulation with 130% FPG without BAH, 150% FPG, and 150% without BAH. Figures 4 and 5 represent the percentage of enlisted and officer samples under the FPG distributed by rank. Nearly no officers live below either FPG.

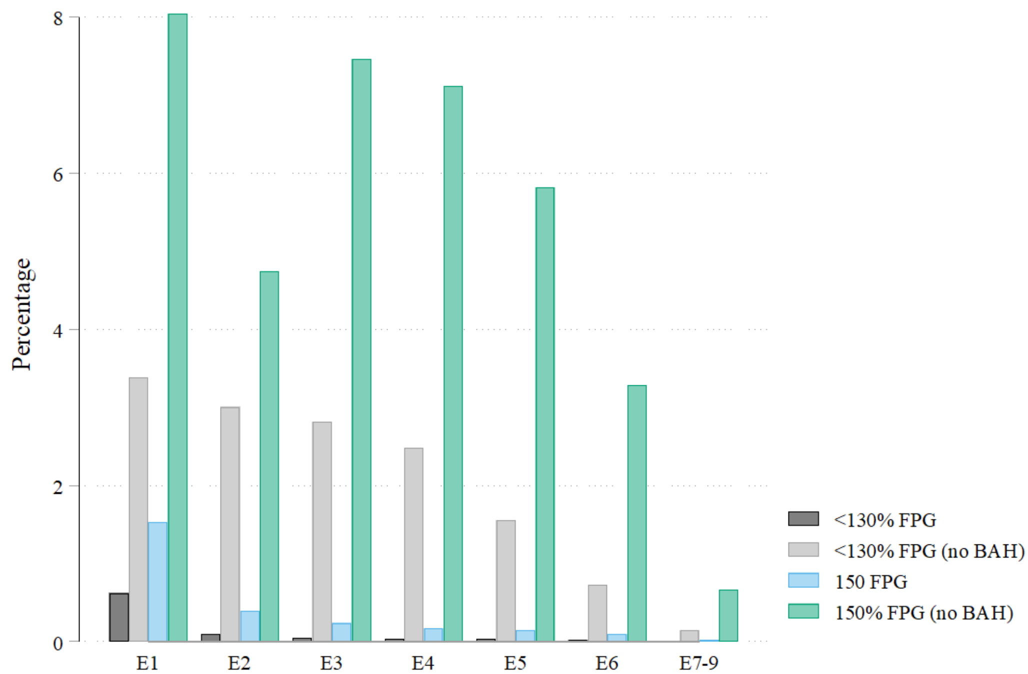

Figure 4. Enlisted Sample at Federal Poverty Guidelines

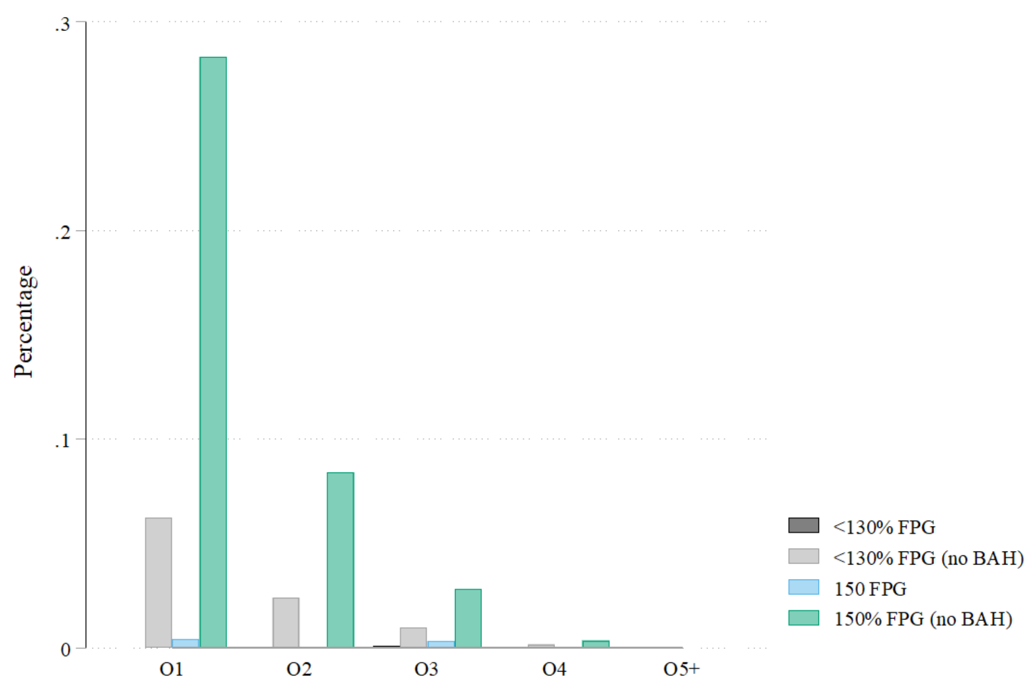

Figure 5. Officer Sample at Federal Poverty Guidelines

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IV. RESULTS AND ANALYSIS

A. RESEARCH QUESTION 1

Research Question 1 aims to define the characteristics of Sailors who are at risk of food insecurity. Using the LASSO technique and logit model, I find the best combination of variables that predict food insecurity in the Navy's enlisted population. This section describes the results of the model in the order of the variables presented in the Methodology section. The full list of results is shown in the Appendix.

For, household characteristics, the model finds that food insecurity increases with an additional number of children and household members. Households with less than $75,000 total income are at higher risk of food insecurity than those with more. Interaction variables describe the complexity of predicting correlated characteristics. While having two working adults with up to $35,000 in total household income increased the risk, having two working adults with at least $100,000 in total household income decreased the risk. Households in low cost of living states with less than $50,000 in total income have increased risk. In states with high cost of living, households with at least $75,000 in total income had decreased risk of food insecurity. As for individual characteristics, female Sailors are predicted to have a higher risk of food insecurity than male Sailors. Being divorced increases the risk, and the model predicts higher food insecurity for single Sailors. White Sailors are predicted to have less risk compared to any other races.

It is important to note that not as many military families live in poverty as civilian families, but other factors such as deployments, spousal unemployment, and frequent moves could increase their risk temporarily. The predicted risk increases with each additional child or a growing number of household members, but the BAH increase does not account for each additional dependent (Department of Defense, n.d.). Being married may lower the risk because of dual income or less expenditure on childcare if a parent decides not to be in the labor force.

Figure 6 illustrates the enlisted sample distribution by category. I assume that the risk of food insecurity decreases with higher rank due to increased total household income.

Household size and cost of living alone are not great differentiators of risk. However, I expect the risk to increase when combined with other factors such as lower household income, as shown in the interaction variables.

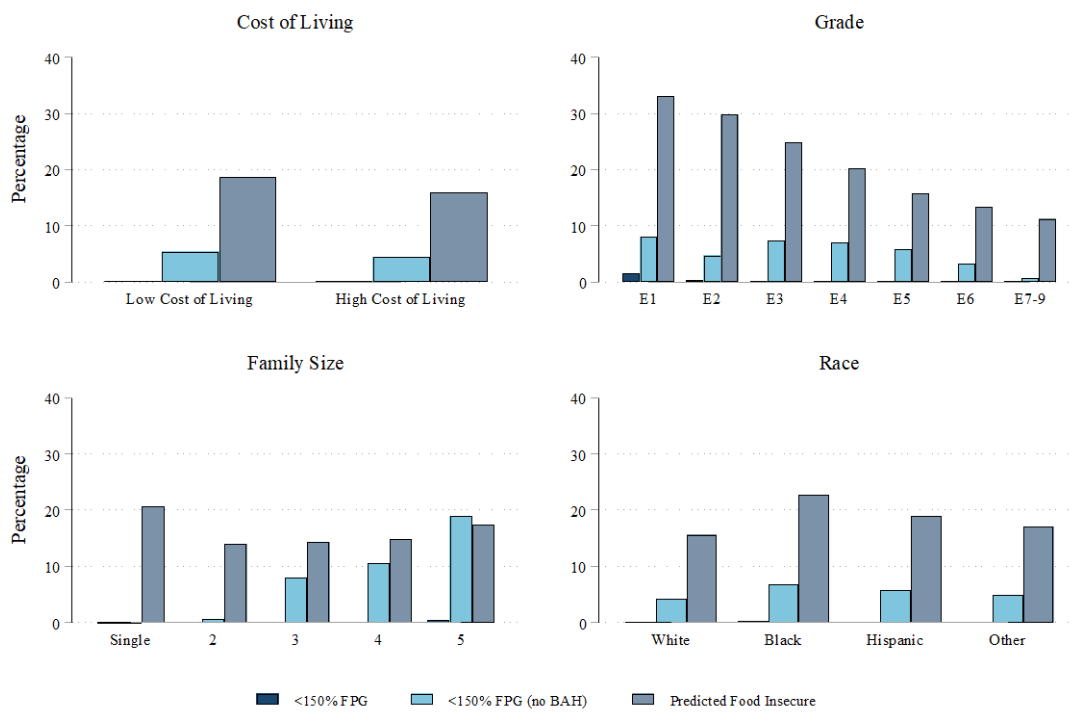

Figure 6. Enlisted Predicted Food Insecurity Compared to FPGs by Category

B. RESEARCH QUESTION 2

Research Question 2 evaluates the effectiveness of the current BNA at 130% and 150% FPG. First, I simulate the effects of the BNA by increasing the total household income of Sailors who qualify for the BNA up to the 130% FPG. I then rerun the prediction model through the simulated data to predict the new rate of food insecurity. I also simulate a BNA policy without the BAH included in the total household income to expand the eligibility of the policy and increase the allowance amount.

Figure 7 depicts the changes in the predicted food insecurity rate by policy simulations. Visually, there is almost no difference in any of the policy simulations in

Figure 7. The top bar represents the 17.61% of the enlisted sample that is predicted to be food insecure. The second bar represents the predicted rate of food insecurity if the qualified Sailors received the BNA to bring their total household income up to the 130% FPG. The third bar visualizes the 17.59% of Sailors who are predicted to be food insecure if their BAH was excluded from their total household income calculation for the BNA eligibility at the 130% FPG. I repeat the two simulations at 150% FPG for the bottom two bars. Even with the most generous allowance, the last simulation only brings 846 households out of food insecurity status from 2013–2019. The simulations do not measure any significant drop in the rate of food insecurity amongst enlisted personnel at all levels of the BNA requirement. The BNA simulations without the BAH included have the bigger drops in the predicted food insecurity rate, but this delta is still less than 1 percentage point.

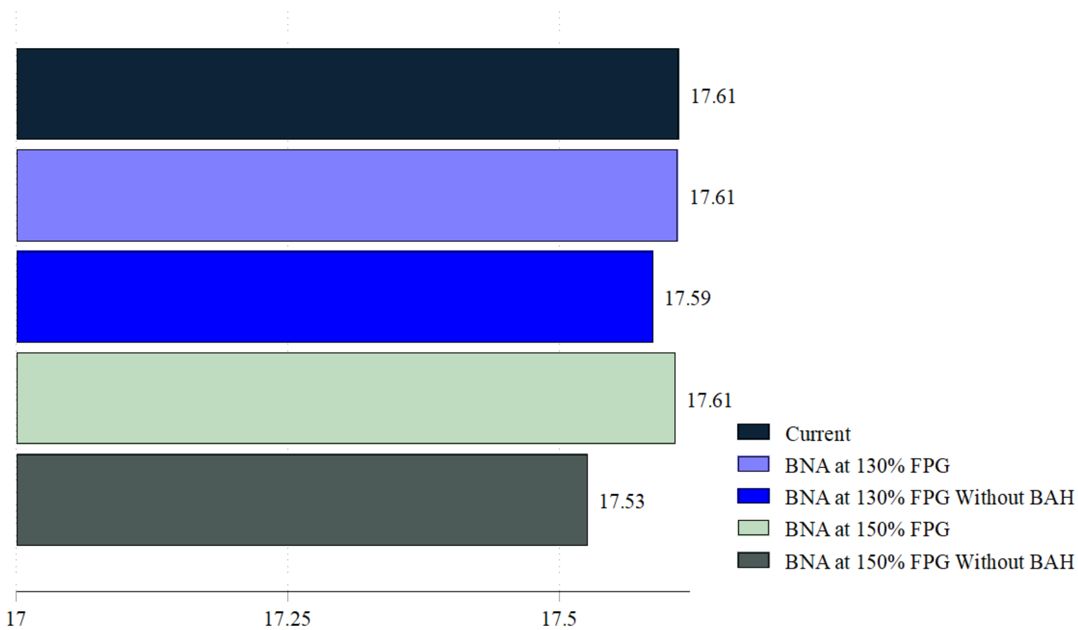

Figure 7. Policy Simulations Result

Figure 8 displays the distribution of predicted food insecurity rate among the enlisted rank by each simulation. E-1 are predicted to have the highest risk of food insecurity, but the risk decreases with rise in rank. Figure 8 presents lack of changes in the food insecurity rate by the BNA simulations at every level of the enlisted rank.

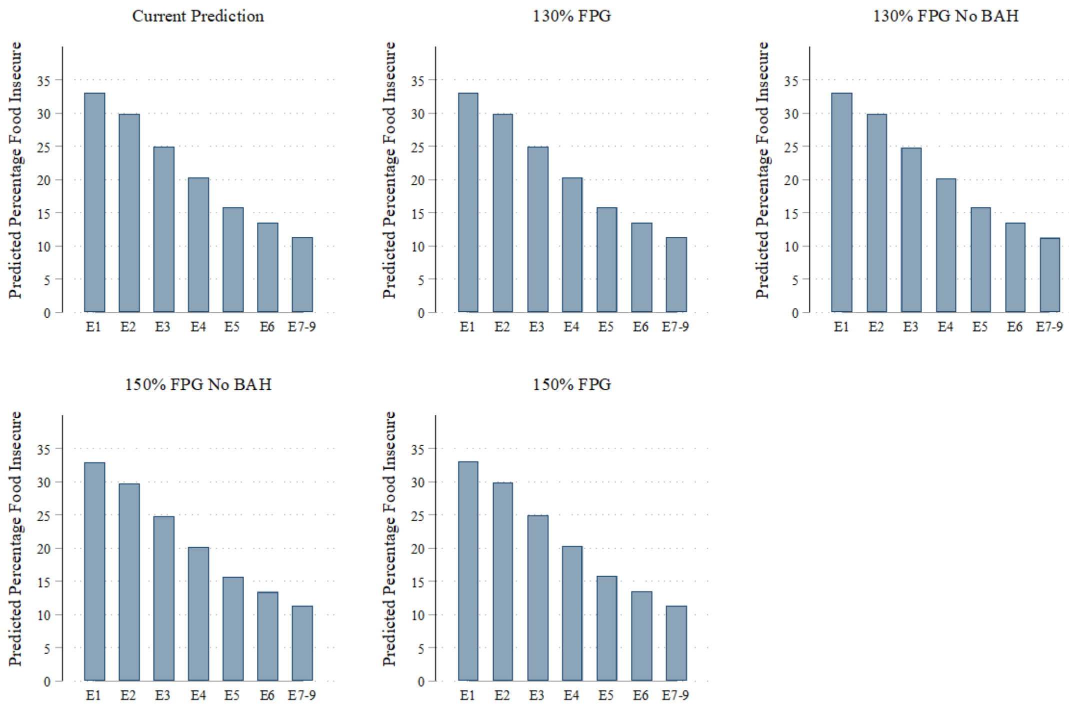

Figure 8. Predicted Food Insecurity Rate by Enlisted Rank per BNA Simulation

Figure 9 shows the distribution of civilian and Navy samples at each FPG. About 7.5% of the civilian sample and .04% of the enlisted sample are at the 130% FPG. While more than 11% of the civilian sample is at the 150% FPG, less than 1% of the enlisted sample lives under the 150% FPG. Approximately 4% of the enlisted sample is at 150% FPG if BAH is not included in the calculation. The requirement of BNA limits the allowance to such a small number of Sailors, so the simulation captures minimal changes across the entire sample.

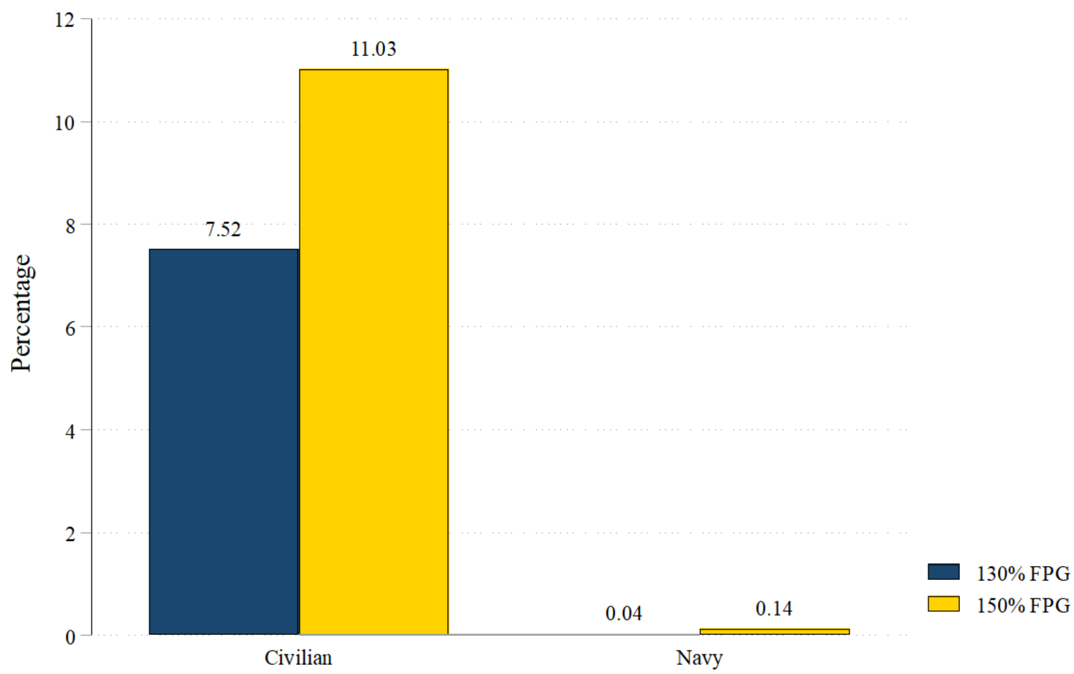

Figure 9. Sample Distribution by FPGs

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V. CONCLUSION AND RECOMMENDATION

A. CONCLUSION

Predicting food insecurity requires a standardized definition and measurement of food insecurity, but the Navy lacks the latter. By applying the BNA requirements, the Navy assumes that the 150% FPG is an accurate predictor of food insecurity. This thesis finds that predicting food insecurity entails a much more complex combination of characteristics. Although certain characteristics can better predict the risk, this study cannot determine a single threshold that can predict the strict cutoff between those who are food insecure and food secure. Figure 10 illustrates the civilian food insecurity rate in 2019 by household poverty level relative to the FPG. As shown in Figure 10, household poverty level at 150% FPG and other FPGs do not display a significant reduction in food insecurity because the food insecurity rate does not exhibit linear discontinuation at any level of the FPG.

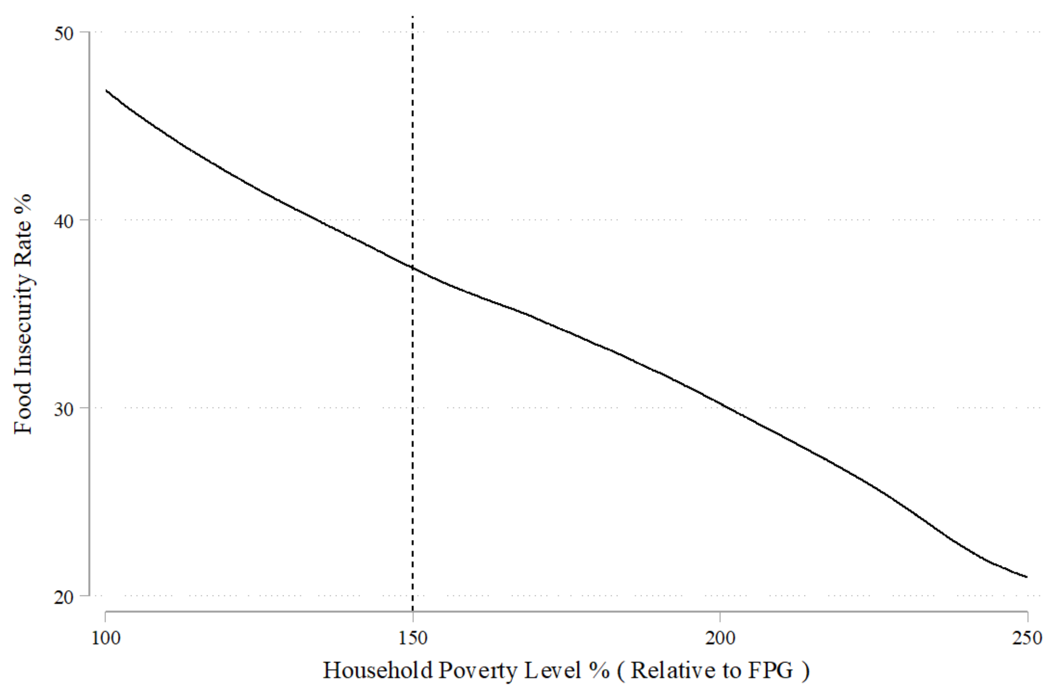

Figure 10. Civilian Food Insecurity Rate by Household Poverty Level

This thesis estimates that based on similar civilian characteristics of food insecurity, less than 1% of the enlisted qualify for the BNA, while 17% are predicted to be food insecure. Therefore, the BNA provides insufficient amount of allowance to inadequate number of families to effectively reduce food insecurity in the Navy.

B. RECOMMENDATION

To address both results, I propose two recommendations. Because predicting food insecurity requires a complex combination of characteristics, I recommend automating the selection process for an allowance. The datasets I use, DMDC and DEERS, both derive from Sailor and command updates, so an automated, strong prediction model can replace the filtering process. If a Sailor updates their dependent information with a new birth certificate on the Navy Standard Integrated Personnel System (NSIPS), and an additional dependent qualifies them for a supplemental allowance based on the automated prediction model, they receive a direct electronic notification on NSIPS or email to take the food insecurity questionnaire for extra allowance. This process can eliminate the administrative burden on the command administration and the fear of cultural stigma on the Sailors. This study's simulations also assume that 100% of those who qualify for BNA receive it. However, historically, supplemental income policies have less than a 100% participation rate. For example, USDA estimates that only 82% of qualified households participated in SNAP in FY 2019, so considering the lower utilization, the expected reduction in food insecurity would be lower than the predicted simulation rates (Department of Agriculture, 2023). By taking the food insecurity questionnaire as part of the selection process, Sailors provide the level of food insecurity that can validate the need for supplemental allowance and the effectiveness of the allowance.

As for the BNA, I recommend the DOD explore other options to mitigate the food insecurity rate. Future data analysis of current BNA utilization can help the DOD better understand the need and resolution. The FPG threshold originates from civilian policies, but Sailors and their families face unique financial challenges compared to civilian families. Military families deserve a solution that better serves them.

APPENDIX.

	LASSO Results
# adults in labor force=2	0.6273
# employed adults=1	0.6311
Black	0.3261
Male	-0.2392
Not married	0.2453
Not divorced	-0.1854
$15,000 - 19,999	1.0947
$20,000 - 24,999	1.1610
$25,000 - 29,999	0.9445
$30,000 - 34,999	0.7868
$35,000 - 39,999	0.7759
$75,000 - 99,999	-0.0359
$100,000 - 149,999	-0.8002
$150,000 and over	-1.7981
Number in household	0.1961
Child in household	0.0746
Avg. meal cost	-0.0100
Age	-0.0067
No HS # # adults in labor force=2	0.2318
HS # # adults in labor force=0	-0.5249
Bachelor's+ # # adults in labor force=0	-0.5757
Bachelor's+ # # adults in labor force=1	-0.1445
No HS # # employed adults=1	0.4727
HS # # employed adults=1	0.0961
Bachelor's+ # High Cost-State	-0.0859
No HS # Black	0.1258
Some college # White	0.0676
Bachelor's+ # White	-0.1258
Bachelor's+ # Black	0.1954
Bachelor's+ # Married	-0.1024

No HS # Divorced	-0.4566
Bachelor's+ # Not divorced	-0.1500
No HS # $40,000 - 49,999	-0.2268
HS # $50,000 - 59,999	0.0399
HS # $75,000 - 99,999	-0.0190
Some college # $20,000 - 24,999	0.0166
Bachelor's+ # $20,000 - 24,999	0.0895
Bachelor's+ # $35,000 - 39,999	0.0227
No HS # Child in household	-0.0456
No HS # Children <5 in household	-0.1213
HS # Children <5 in household	-0.1154
Bachelor's+ # Avg. meal cost	-0.0589
$15,000 - 19,999 # Number in household	-0.0461
$30,000 - 34,999 # Number in household	0.0624
$40,000 - 49,999 # Number in household	0.0954
$50,000 - 59,999 # Number in household	0.0841
Male # $75,000 - 99,999	-0.0780
Male # $100,000 - 149,999	-0.0843
Female # $40,000 - 49,999	0.2699
# employed adults=1 # $15,000 - 19,999	0.4221
# employed adults=2 # $30,000 - 34,999	0.1696
# employed adults=2 # $100,000 - 149,999	-0.2289
$40,000 - 49,999 # Low-Cost State	0.1325
$75,000 - 99,999 # High Cost-State	-0.1473
White # $60,000 - 74,999	-0.0395
White # $75,000 - 99,999	-0.2481
White # $100,000 - 149,999	-0.0493
White # $150,000 and over	-0.1083
Black # $25,000 - 29,999	0.1658
Other # $20,000 - 24,999	0.2427
Hispanic	0.0525
Constant	-2.4984
Observations	36,098

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