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Jennifer Huerta Date

The Association between Food Security and Anemia among Children and Adolescents in the Supplemental Nutrition Assistance Program NHANES (2013-2014)

By

Jennifer Huerta
Master of Public Health

Applied Epidemiology

Amy Girard, PhD
Committee Chair

John Pugliese
Committee Member

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B.S.
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An abstract of
A thesis submitted to the Faculty of the
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Abstract

The Association between Food Security and Anemia among Children and Adolescents in the Supplemental Nutrition Assistance Program NHANES (2013-2014)

By Jennifer Huerta

Background: Public health experts estimate that 20% of American children will have anemia at some point in their childhood. Anemia is defined as having a hemoglobin concentration (Hgb) less than the 5th percentile for age. Iron deficiency is the most common cause of anemia and often is a result of a poor diet. Although there is a recommended amount of daily iron consumption for children, food insecure children are at a greater risk of not meeting the recommended iron intake. Studies show that iron deficiency anemia is a clinically important health indicator for cognitive and health consequences and therefore food assistance programs that address children's food insecurity should be studied.

Methods: Data from the 2013-2014 National Health and Nutrition Examination Survey (NHANES) was used to assess the relationship between child food security and anemia. Multivariable logistic regression analysis was used to obtain odds ratios (ORs) with 95% confidence intervals (CI) and model imputation was used to impute missing values and generate parameter estimates.

Results: The odds of having anemia were 30% (CI [95] 0.94, 1.02) higher for females when compared to males. The odds of having anemia were twice as high for those who are black when compared to those who are white (CI [95] 1.72, 2.72). The odds of anemia among those who have low food security is 21% (CI [95] 0.88, 1.67) higher when compared to the odds of anemia among those who are completely food secure, holding all other variables constant. Although not significant, the odds of having anemia are less likely for those with marginal food security 0.26 (CI [95] 0.50, 1.10) when compared to those who are completely food secure. Also, not significant are the odds of anemia among those who have not received SNAP benefits in the past 12 months. The odds of having anemia are 26% (CI [95] 0.92, 1.35) higher when compared to the odds of anemia among those who received SNAP benefits in the past 12 months, holding all other variables constant.

Discussion: In conclusion, our study suggests that there is a slight insignificant association between CFS and the odds of developing anemia among children and adolescents age (0-18) in the U.S. Carefully designed prospective studies with longitudinal follow-up are needed to verify that CFS is linked to anemia in order to demonstrate potential benefits of SNAP participation on CFS.

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1 Manuscript

The Association Between Food Security and Anemia among Children and adolescents in the Supplemental Nutrition Assistance Program: The National Health and Nutrition Examination Survey (2013-2014)

Jennifer Huerta, MPH Candidate;
Amy Webb Girard, PhD (awebb3@emory.edu);
John Pugliese, PhD (john.pugliese@cdph.ca.gov)

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2 Introduction

The United States Department of Agriculture (USDA) estimates that one in every eight Americans was food insecure in 2017. This equates to 40 million Americans including more than 12 million children.[1] USDA classifies low food security (FS) as having reduced quality, variety or desirability of diet. Others define food insecurity (FI) more broadly as an experience ranging from eating less desirable foods, skipping meals to not eating for an entire day.[2] FI in children has been linked to an increased risk of anemia due to iron deficiency (ID) in their diet.[3] Children with ID are at risk for reduced psychomotor, cognitive, mental and behavioral development and are most likely to experience persistent effects of ID that alter functioning in adulthood.[4] [5] The Supplemental Nutrition Assistance Program (SNAP) previously known as the food stamp program was implemented in the early 1960's to combat food insecurity and in-turn reduce the prevalence of micronutrient deficiencies in food insecure populations. Prior research has shown an association between SNAP participation and a reduction in FI, however there has been little research to assess how SNAP participation may influence the association between FI and anemia.[6,7] Using data from a nationally representative survey of US households conducted in 2013-2014, this study aims to determine if the association between FS varies as a function of SNAP participation by conducting a multivariable logistic regression (MLR) and generating adjusted odds ratios (aOR). The present study seeks to find an association between CFS and SNAP participation in order to better inform policy decisions centered around food security in the U.S. We hypothesize that CFS is associated with the odds of having anemia for those who are FI and the association is modified by SNAP participation.

3 Review of Literature

3.1 Anemia in Children

Hemoglobin is an iron-rich protein that attaches to oxygen in the lungs and carries it to tissues throughout the body.[8] Anemia occurs when there are not enough red blood cells or the red blood cells are not functioning properly. A hemoglobin count below the 5th percentile of a normal population curve for hemoglobin value for a specified age is defined as anemia and is further divided into gender specific categories after age 12. Anemia is further classified into three different types of categories: microcytic, normocytic or macrocytic.[9] Microcytic anemia is defined as insufficient hemoglobin production, normocytic anemia is defined as decreased blood volume and macrocytic anemia is defined as insufficient cell production and or maturation.[10] The most common cause of microcytic anemia in children is iron deficiency anemia (IDA). IDA is the most common type of anemia and occurs when there is not enough iron in the body.

Iron deficiency anemia (IDA) is a public health concern specifically because prospective studies have shown motor and cognitive impairment and mood disorders in children who are iron deficient.[11,12] Data from The World Bank shows a steady increase in the percentage of children under age 5 that have anemia in the United States (U.S.). The prevalence of anemia among children has increased from 6.1% in 2009 to 8.5% in 2016.[13] Furthermore, an analyses of NHANES data from 2003 to 2012 found that there are high risk groups for anemia among individuals identifying as Hispanic or non-Hispanic black.[14] The study also found that anemia prevalence in preschool-age black male children was 6.1% (95% CI: 4.1–8.2%), higher than that of both white (2.6%, 95% CI: 0.9–4.2%) and Hispanic (3.7%, 95% CI: 2.3–5.0%) male children in the same age group.

3.2 Anemia and Food Insecurity

The U.S. Household Food Security scale (U.S. HFSS)[15] was designed to identify food insecurity as it relates to lack of access to nutritious food. FS is defined as either having high FS or having marginal FS. FI is defined as either having low FS or very low FS. Low food security is classified as having reports of reduced quality, variety or desirability of diet with little or no indication of reduced food intake. Very low food security is defined as having multiple indications of disrupted eating patterns and reduced food intake.[1]

According to the USDA, 88.2 percent of U.S. households were food secure in 2017, up by .6% when compared to food security in 2017.[16] The 2017 USDA report also showed that prevalence of FI varied considerably among household types. FI was higher than the national average (11.8%) for the following groups: All households with children (15.7%), households with children under age 6 (16.4%), households with children headed by a single woman (30.3%), households with children headed by a single man (19.7%), women living alone (13.9%), men living alone (13.%), black, non-Hispanic households (21.8%), Hispanic households (18.0%), and low-income households with incomes below 185 percent of the poverty threshold (30.8%).[16] Trends in prevalence rates of food insecurity remained the same from 2012-2014 at 14% prevalence. From years 2015-2017, there was a steady decline in food insecurity at 11.8% by 2017. In the previous decade, FI had increased from 10.5% in 2000 to nearly 12 %in 2004. Then FI decreased to 11% in 2005-2007 and then increased to 14.6% in

2008. FI rated then remained unchanged at that level in 2009 and 2010.

FS has been shown to be associated with one or multiple micronutrient deficiencies among children.[17] Research has revealed a connection between FS and low scores on measures of both health and academic performance.[18] Several other cross-sectional studies show associations between FI and self-reported chronic diseases which include heart disease, diabetes, hypertension and overall health.[19,20] Poverty, FI, and poor nutrition have serious consequences for the health and well-being of children and adults, which includes a greater risk for developing chronic diseases. As a result, it is recommended that programs, policies and other interventions be designed to eliminate health disparities in children who are living in food insecure households. Increased utilization of federal nutrition programs such as SNAP and Child Nutrition Programs have been shown to be effective in improving the health and well-being of vulnerable Americans. Research has shown that such programs can reduce food insecurity, alleviate poverty, support economic stability, improve dietary intake and health, protect against obesity and improve cognitive development.[21]

3.3 Supplemental Nutrition Assistance Program and Food Security

SNAP was established in 1933 in the midst of the Great Depression and was referred to as the federal Surplus Relief Corporation. The program was then formalized and labeled as the Food Stamps plan which provided food assistance to low-income individuals. Since then, The Federal Nutrition Service (FNS), a branch of the USDA has stated that participation in SNAP has improved FS among low-income children. SNAP eligibility is determined using a formula that takes family income, employment status, family size, household resources and assets to determine eligibility. Households receive SNAP benefits on electronic benefit transfer (EBT) cards, which can be used only to purchase food at one of the 263,100 authorized retail locations around the country. Currently, participants of the SNAP program can purchase virtually any food. A report from USDA in 2016, shows that twenty-three cents of every SNAP dollar is used to buy candy, desserts, salty snacks, sugar and sweetened beverages.[22] Participation in the SNAP program varies by State. In most southern States such as Georgia and Alabama, 1 in every 6 individuals participates in the SNAP program (2018). In California, the range is larger, in which only 1 in 10 individuals participates in the SNAP program. Although SNAP participation varies by State, the national average in 2018 was 33 million, or 1 in every 8 individuals in 2017. Demographic data from the USDA, states that 40.2% of SNAP recipients are white, 25.7% are black, 10.3% are Hispanic, 2.1% are Asian and 1.2% are Native American.

4 Methods

4.1 Study Design

Data came from the 2013-2014 NHANES cycle (n=14,322). NHANES uses a complex multistage design to sample civilian, noninstitutionalized populations living in the United States and D.C. Sample selection for the 2013-2014 cycle included four stages in which counties were selected, then blocks within the counties, households within these segments and finally the households were surveyed. The 2013-2014 cycle included people living in 30 different locations who participated in interviews, examinations and laboratory measurements. The response rate for this NHANES cycle was 68.5%. Demographic data were also collected during the interview process. A total of 4,253 children and adolescents age 0-18 years old had data available for both food security and anemia status and were included in these analyses.

4.2 Setting, Study Size and Target Population

In the 2013 -2014 NHANES cycle, 14,332 individuals were selected from 30 different survey locations. Of those who were selected, 10,175 completed the interview and 9,813 completed the laboratory examination, as seen in Figure 1. Individuals over age 18 years (n=5,992) were excluded in the analysis which left 4,253 children and adolescents between the ages of 0 and 18. One percent of data were missing for the variable SNAP12, 3% of data were missing for the variable childFS and 40% of data was missing for hemoglobin values, as shown in Table 1. For each of these variables, missing data values were imputed using multiple imputation. Five imputed datasets were created using Markov's Chain Monte Carlo (MCMC) method. A total of five imputations were generated, to obtain different plausible imputed data sets which will then be appropriately combined to obtain parameter estimates after assessing model fit. The final study size in the data set was 4,253 children and adolescents.

The target population for this cross-sectional NHANES study was the noninstitutionalized civilian resident population in the United States. The sampling procedure oversampled non-Hispanic asians, Hispanics, non-Hispanic blacks, older adults and low-income whites/others. To facilitate oversampling, there were recorded and written translations of instruction in: Mandarin Chinese, Korean, Vietnamese, Amharic, French, Haitian Creole, Hindi and Spanish. Additionally, staff participated in cultural competency training to help participants recognize cultural differences. There was no participant dietary, physiological or nutritional characteristics that were considered when selecting the target population.

4.3 Variables

The primary exposure variable used in the analysis is childhood food security (CFS). The CFS variable was derived from eighteen questions that were asked of households who had children under the age of 18. The CFS variable was obtained by collecting responses to 18 items coded as: FSD032a-f, FSD041, FSD052, FSD061, FSD071, FSD081, FSD092, FSD102, FSD111, FSD122, FSD132, FSD141, and FSD146.[23] The recall period for all 18 CFS questions is 12 months. FSD032a-f contained questions focused on: running out of food, food not lasting, not being able to afford to eat a balanced meal, relying on low-cost food, and not feeding the child a balanced meal due to affordability, respectively. Questions FSD041, 052, 061, 071, 081, 092 and 102 focused on adults: skipping or reducing size of meals, frequency of skipping or reducing a meal, eating less due to lack of affordability, being hungry due to of lack of affordability, losing weight due to lack of affordability, not eating all day due to lack of affordability and frequency of not eating all day due to lack of affordability, respectively. The last five questions FSD111, 122, 132, 141, 146 collected information on the child or children in the household. These questions focused on: reducing the child's food size due to lack of affordability, child skipping meals due to lack of affordability, frequency of the child skipping meals due to lack of affordability, the child being hungry due to lack of affordability and child not eating in an entire day because of lack of affordability. CFS categorical variables were generated from the affirmative responses to questions FSD032d-f, 111, 122, 132, 141 and 146.

CFS was defined on a scale from 1 to 4 in the NHANES dataset, 1 represents full or marginal food security with no affirmative response, 2 represents marginal security with an affirmative response, 3 represents low food security, while 4 represents very low food security. Affirmative responses to CFS questions are defined as: answered "often true" or "sometimes true" for items FSD032a-f, "yes" for items FSD041, FSD061, FSD071, FSD081, FSD092, FSD111, FSD122, FSD141, or FSD146 and "almost every month" for items FSD052, FSD102, or FSD132. CFS was left as a categorical variable with values ranging from 0 to 2 in the analysis, representing marginally food secure to not food secure, respectively. CFS categories for those who have low food security and very low food security were merged to be in category 2, due to the small sample size of those who are very food insecure (n=55, 1.24%)

The outcome variable is anemia as defined by hemoglobin values. In order to obtain hemoglobin values, a blood collection venipuncture procedure was performed on participants enrolled in the study. The procedure consisted of first administering a questionnaire to screen for conditions that may exclude a participant from having blood drawn, then determining fasting status and lastly, performing a blood draw. A certified phlebotomist with experience in venipuncture withdrew a blood sample through intravenous injection. A certified medical technologist was then responsible for performing a complete blood count (CBC) and processing the blood sample.

A child or adolescent is defined as having anemia if their hemoglobin concentration (<g/dL) is less than 11.0 for those who are less than or equal to 2 years of age, 11.1 for those between the ages of 2-5, 11.5 for those between the ages of 5-8, and 11.9 for those who are between

ages 8-12. Additional coding was required for those who were older than 12 years of age due to differences in hemoglobin values that define anemia at age of menarche. Males are defined as anemic if their hemoglobin concentration is less than 12.5 for ages 12-15 or if their hemoglobin concentration is less than 13.3 for ages 15-18. Females who are non-pregnant are defined as being anemic if their hemoglobin concentration is 11.8 for ages 12-15 or if their hemoglobin concentration is less than 12.0 for ages 15-18. All other individuals who did not meet the criteria for diagnosis were defined as not having anemia.

Potential effect modifiers explored in the analysis are SNAP participation. SNAP participation was defined as 1 if the participant reported receiving SNAP benefits within the past 12 months prior to the interview and 0 if not. Other variables included in the model are age, gender, and race. Age was left as a continuous variable and individuals older than 18 years of age were excluded from the analyses. As seen in Table 2, race was divided into five categories: Hispanic/Latino, Non-Hispanic White, Non-Hispanic Black, Non-Hispanic Asian and multi-racial.

4.4 Data Sources

Criteria for diagnosis of anemia varied in the literature. A report provided by the WHO diagnosed anemia for those between the age of six months to 6 years old as being a hemoglobin level less than 11.[24] For those who are between the ages of 6 to 12, anemia is diagnosed as having hemoglobin levels less than 12, according to the WHO. In contrast, CDC's criteria for diagnosis of anemia is more detailed. The CDC provides threshold hemoglobin concentration values for children in three age groups: 0-2, 2-5 and 8-12 years old. The criteria for diagnosis was further divided into three age categories 12-15, 15-18 and 18+ which is dependent on gender. For our analyses we used CDC criteria to define the presence or absence of anemia.[25]

4.5 Bias

Social desirability bias is a concern due to the nature of the administration of the food security questionnaire, which was administered as a face-to-face interview. Analytically, we cannot account for social desirability bias. Recall bias is also a concern because SNAP participation questions solicited recall information from an individual's lifetime, the past 12 months and the past 30 days. There were six questions specifically designed to obtain more information on whether a family received SNAP benefits: ever received SNAP, received SNAP in the past 12 months, currently receiving SNAP, last time received SNAP, amount, and number of people in household receiving SNAP benefits. Out of these six variables, the variable designed to collect data on current SNAP participation was not subject to recall bias. Only SNAP participation within the past 12 months was included in the present analysis.

4.6 Statistical Methods

Data were extracted and merged from the 2013-2014 NHANES cohort. Statistical analyses were conducted using SAS version 9.4. Sampling weights accounted for unequal probability of selection and the complex sample design. Statistical significance was defined as having a p-value of <0.05.

SNAP12 was recoded as missing if the participant forgot (n=3 (.08%) or refused (n=2 (0.05%) to answer the question on SNAP participation within the past 12 months. Race was recategorized to correspond to numerical values of 1 – 5 instead of the original 1, 3, 4, 6, and 7. CFS was also recategorized to fall within numerical values of 0-2 instead of the original 1-4. CFS categories for those who have low food security and very low food security were merged to be in category 2, due to the small sample size of those who are very food insecure (n=55, 1.24%). In addition, SNAP12 and gender values of 2 were recoded to 0.

As shown in table 1, out of the sample size of 4,253, SNAP12 was missing in 50 (1%) cases, Hemoglobin values were missing in 119 (3%) cases, and CFS responses were missing for 1253 (40%) cases among the entire sample size 10,175. In order to minimize biased estimates that would lead to invalid conclusions, multiple imputation was considered. Before imputation of missing values, it was necessary to identify if data was missing completely at random (MCAR) and missing at random (MAR) if not MCAR. Little's Test was used determine whether the data was MCAR. The null hypothesis of Little's Test is that data are MCAR. The analysis confirmed that data was not MCAR ($p < 0.01$). MAR was then assessed by recoding missing variables to 0 and variables with values to 1, for SNAP12, hemoglobin and CFS. Inferential statistics were then run for comparison between recoded binary variables and other predictors in the model. Results from looking at correlations between binary variables and other analytic variables confirmed that there is an association between predictor variables and missingness'.

Missingness was statistically significant when comparing missing hemoglobin, SNAP12 and childfs values with all other variables. Because missingness is conditional on other variables, MAR is assumed, and we move forward with imputation. Imputation was used on the entire dataset 10,175 in order to generate anemia values based on the hemoglobin values generated.

Weighted frequencies using proc surveyfreq were run to look for potential outliers and examine the distribution and skewedness of the data. Characteristics of the participants were assessed with descriptive statistics using proc surveyfreq. Mean values were used for continuous variables and percentages were used for categorical variables.

Multiple imputation started by analyzing the missing data pattern. Based on this, it was determined that the data had an non-monotone missing pattern. Next, five imputed datasets were created using Markov's Chain Monte Carlo (MCMC) method. Multiple imputation was then processed using a forced-monotone regression method and checked for outliers within the imputed values.

Post-imputation, variables for anemia were generated using the imputed hemoglobin values, and age using CDC criteria. Binary variables that were imputed to be continuous were then rounded up or down to the nearest valid integer. Hemoglobin was then dropped from the analysis and negative or out of range values for CFS and SNAP12 were rounded to the nearest value. Our final imputed datasets included the following variables: anemia, age, gender, ethnicity/Race, CFS, and SNAP12 (see Table 2).

Using the aggregated parameter estimates, Multivariate logistic regression (MLR) was performed to quantify the association between CFS and anemia, demonstrated in Table 4. Table 5 shows variance information for every predictor variable by the aggregation of the five imputations.

Model fit statistics were then run to determine the best model to use in the analysis and the results were combined for each imputed dataset. Only results from the combined imputation dataset results are reported. A "Full Model" was generated including all possible interactions between variables. Then, a "Reduced Model" was generated to exclude all interactions. After running a log likelihood test between the Full and Reduced Models, it was determined that the reduced model had the best model fit given a p-value >0.05 which indicated no evidence of interaction. The reduced model was then considered the gold standard. The final step was then to assess confounding between all possible variations of the predictor variables as shown in Table 3. There was no other model that presented a gain in precision when compared to the gold standard reduced model, so this model was chosen as the best and final model. Collinearity was not computed given that the standard error estimates were low. Given the complex survey design and limitations within proc survey logistic Hosmer & Lemeshow was not examined.

Reduced, Gold Standard Model

$$logit(P(Anemia = 1|CHILDFS, AGE, GENDER, RACECAT, SNAP12) = \beta + \beta_1 CHILDFS + \beta_2 AGE + \beta_3 GENDER + \beta_4 RACECAT + \beta_5 SNAP12$$

Full Model

$$logit(P(Anemia = 1|CHILDFS, AGE, GENDER, RACECAT, SNAP12) = \beta + \beta_1 CHILDFS + \beta_2 AGE + \beta_3 GENDER + \beta_4 RACECAT + \beta_5 SNAP12 + \beta_6 CHILDFS * AGE + \beta_7 CHILDFS * GENDER + \beta_8 CHILDFS * RACECAT + \beta_9 CHILDFS * SNAP12 + \beta_{10} SNAP12 * RACECAT$$

4.7 IRB Review

Prior to data retrieval and analysis, per HHS regulations (45 CFR 46) Emory University Human Subjects Review committee reviewed the IRB application for this study and subsequently exempted it from additional review as this study was deemed as de-identified, secondary data analysis.

5 Results

5.1 Key Findings & Summary of Results

Overall, 4,253 participants met the eligibility to be included in the analysis. Among the sample population 93.47% were not anemic and 6.53% had anemia. The distribution of sample characteristics of the study population is shown in Table 2 by anemia status.

Univariate comparisons were assessed and demonstrated significant differences with respect to age, Ethnicity/Race for those who are black, SNAP participation for those who reported "yes" and CFS for those who are fully secure and those who had low food security. The mean values for the aforementioned variables were higher for individuals with anemia than the study participants that had not been categorized as having anemia. Significant differences all variables were observed between study participants that were categorized as anemic than those who were not categorized as being anemic.

In the weighted MLR model that used anemia as the outcome variable, predictor variables for age, gender and ethnicity excluding multiracial were found to be statistically significant predictor variables in the model [Table 4]. The parameter estimates in table 4 indicate statistically significant parameters for variables: age, gender, and ethnicity excluding multiracial. Interpretation for parameter estimates and aOR's are shown in table 6.

An adjusted model was created which included age, gender, Ethnicity/Race and CFS. Variables were assessed for evidence of interaction with all variables. None of the interactions were significant (p-value <0.05). Therefore, interaction variables were dropped from the model (data not shown, but SAS code in appendices). A confounding assessment was performed to evaluate all possible subsets of the control variables and compare to the gold standard model. The gold standard model is the reduced model without interaction terms. Precision values of the ORs were obtained for each model and percent differences were calculated to assure OR values fell within a 10% gold standard. In the end, the gold standard model was chosen as the final model which included all demographic and food security predictor variables, shown in Table 3.

The hypothesis that CFS is associated with the odds of having anemia for those who are FI and the association is modified by SNAP participation was not supported by the model. SNAP participation within the past 12 months and CFS were dropped in the model when assessing interaction. Our reduced model did not contain interactions and therefore we were unable to analyze whether SNAP participation modified the association of CFS and anemia. Nevertheless the probability of having anemia was 21% higher for those who are low food secure compared to those who are fully food secure, holding all other variables constant, (aOR = 1.21, CI[95] 0.88, 1.67). Results also reveal that those who are marginally secure, although not statistically significant (CI[95] 0.50, 1.10) had a .26 times less likely chance to have anemia when compared to those who are fully food secure. Other key findings include differences in anemia diagnosis by Race/Ethnicity. Those who are black have 2 times the odds of having anemia when compared to those who are white, this was significant (CI95: 1.72 2.72). In contrast, the odds of having anemia for those who are Hispanic/Latino, is 0.25 times less likely when compared to those who are white, this aOR was significant (CI95: 0.58 0.98). Although not significant, the odds of having anemia among those who have not received SNAP benefits in the past 12 months is 26% higher when compared to the odds of anemia among those who received SNAP benefits in the past 12 months, holding all other variables constant(CI95: 0.92, 1.35).

6 Discussion

6.1 Background and Summary of Results

MLR was conducted with outcome variable anemia as predicted by various demographic and [Table 4]. Association between CFS and anemia was not significant for any category of CFS after adjustments for demographic variables (age, gender, and race/ethnicity) and food security factors (SNAP participation). The odds of anemia among those who have low food security is 26% higher when compared to the odds of anemia among those who are completely food secure, holding all other variables constant.

Our results from this national cohort of U.S. children and adolescents (ages 0–18 years) using data from NHANES (2013-2014) suggest that CFS is not statistically associated with anemia. Furthermore, all predictor variables did not interact with the association between CFS and the risk of anemia in our study [26,17] The hypothesis that CFS is associated with the odds of having anemia for those who are FI and the association is modified by SNAP participation was not supported by the model.

Our research was consistent with other studies. For example, Eicher-Miller et al. studied children ages 3-19 from NHANES (1999-2004) and reported the odds of iron deficiency anemia among children aged 12–15 were 2.95 times higher (95% CI: 1.18, 7.37; P = 0.02) for children in households with food insecurity among children compared with children in households with food security among children.[26] Moradi et al. research on 95,993 infant and toddlers showed that there was an overall positive relationship between food insecurity and anemia risk (OR=1.27, CI[95] 1.13, 1.40).[27] We replicated the analysis Eicher-Miller et al. using NHANES 2013-2014 and found that for every unit increase in age anemia is 0.02 times less likely to occur, holding all other variables constant (CI[95]: 0.94, 1.02). The results in our analysis were similar to Moradi et al., in that food insecurity increased the odds of anemia by 26% when compared to the odds of anemia among those who are completely food secure, holding all other variables constant (CI95: 0.88, 2.33).

Our study suggests that there is a weak non-significant association between CFS and anemia, controlling for all other variables. The odds of having anemia were 30% higher for females when compared to males. The odds of having anemia were twice as high for those who are black when compared to those who are white. The odds of anemia among those who have low food security is 21% higher when compared to the odds of anemia among those who are completely food secure, holding all other variables constant. Although not significant, the odds of having anemia are less likely for those with marginal food security 0.26 when compared to those who are completely food secure. Also, not significant are the odds of anemia among those who have not received SNAP benefits in the past 12 months. The odds of having anemia are 26% higher when compared to the odds of anemia among those who received SNAP benefits in the past 12 months, holding all other variables constant.

6.2 Limitations

The study has several strengths and limitations. A strength of the NHANES dataset is the use of standardized protocols, rigorous quality control in data collection and reporting, inclusion of a large nationally representative study sample and careful data analysis. Hemoglobin measurements were collected through a blood collection venipuncture procedure. A limitation is that hemoglobin concentrations were measured only once in NHANES therefore, it does not accurately represent changes as it relates to CFS or SNAP participation. CFS and SNAP participation values could have changed within hours, weeks after blood work had been collected. Ebben et al. demonstrated that during a 6-mo period, hemoglobin levels in almost all studyof patients seem to fluctuate. Ebben et al. concluded that the instability of patient hemoglobin levels may have significant implications in outcome studies that attempt to assess hemoglobin levels as they relate to morbidity. Another limitation is that our analyses were based on cross-sectional data; therefore, we cannot establish temporal causality. This study did not identify whether low CFS caused anemia. As with any observational study, confounding due to unobserved confounder variables is possible. Example of such confounders are: level of education, area of residence (rural/urban), socioeconomic status (SES), and body mass index, WIC participation. Area of residence was not provided in the public use dataset, as this type of data is confidential. Other confounders such as SES, parent level of education and WIC participation were not used in the analyses as the variables were only associated with parents and thus were removed from the analysis when the exclusion criteria was applied (leaving only ages 0-18). WIC was also removed from the analysis, as it was directly associatied with SNAP participation. If the response was "yes" for SNAP participation, it was also "yes" for the WIC participation question. Furthermore, the household interviews may not accurately identify SNAP participation or CFS. Due to social desirability bias people who respond in a socially desirable way may systematically respond in favor of a variety of questions. Future research might expand on the present analyses by including predictor variables in the model that may account for differences in those who were assigned as being anemic. Predictor variables that should be considered for future analyses are BMI, SES, area of residence and level of education among parents.

This analysis focused only on SNAP participation within the past 12 months given that all other food security questions were relevant to the past 12 months. In the future, however current SNAP participation should be incorporated in the model to see if it has any effect on CFS. Another reason as to why current SNAP participation was not included in the model was because current SNAP participation was dependent on other SNAP variables (ever received, received in the past 12 months) therefore significantly reducing our sample size.

6.3 Generalizability and Conclusion

In conclusion, our study suggests that there is a slight insignificant association between CFS and the odds of developing anemia among children and adolescents age (0-18) in the U.S. Carefully designed prospective studies with longitudinal follow-up are needed to verify that CFS is linked to anemia in order to demonstrate potential benefits of SNAP participation on CFS.

Implications for the future include focusing program efforts to address anemia in children and adolescents for those who are black and those who are female. Our analysis indicates that those who are black have 2 times the odds of developing anemia when compared those who are white. Although SNAP participation did not modify the association between CFS and anemia, those who did not receive SNAP benefits had 26% greater odds of developing anemia. Table 7, shows the characteristics of the study population, 94% of those that did not receive SNAP benefits in the past 12 months had anemia when compared to those who did receive SNAP benefits (91.50%). Table 7 shows the ethnicity/race breakdown for those who receive SNAP benefits. Table 7 demonstrates that SNAP participation is highest among those who are white (35.40)% when compared to those who are black who only account for 24% for all ethnicity/race groups. Further implications show that those who are more food secure have decreased odds of having anemia, thus food assistance programs like SNAP should be geared towards those who have low food security.

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8 Tables and Figures

Figure 1. Study Population and Inclusion Exclusion Critera, NHANES, 2013-2014

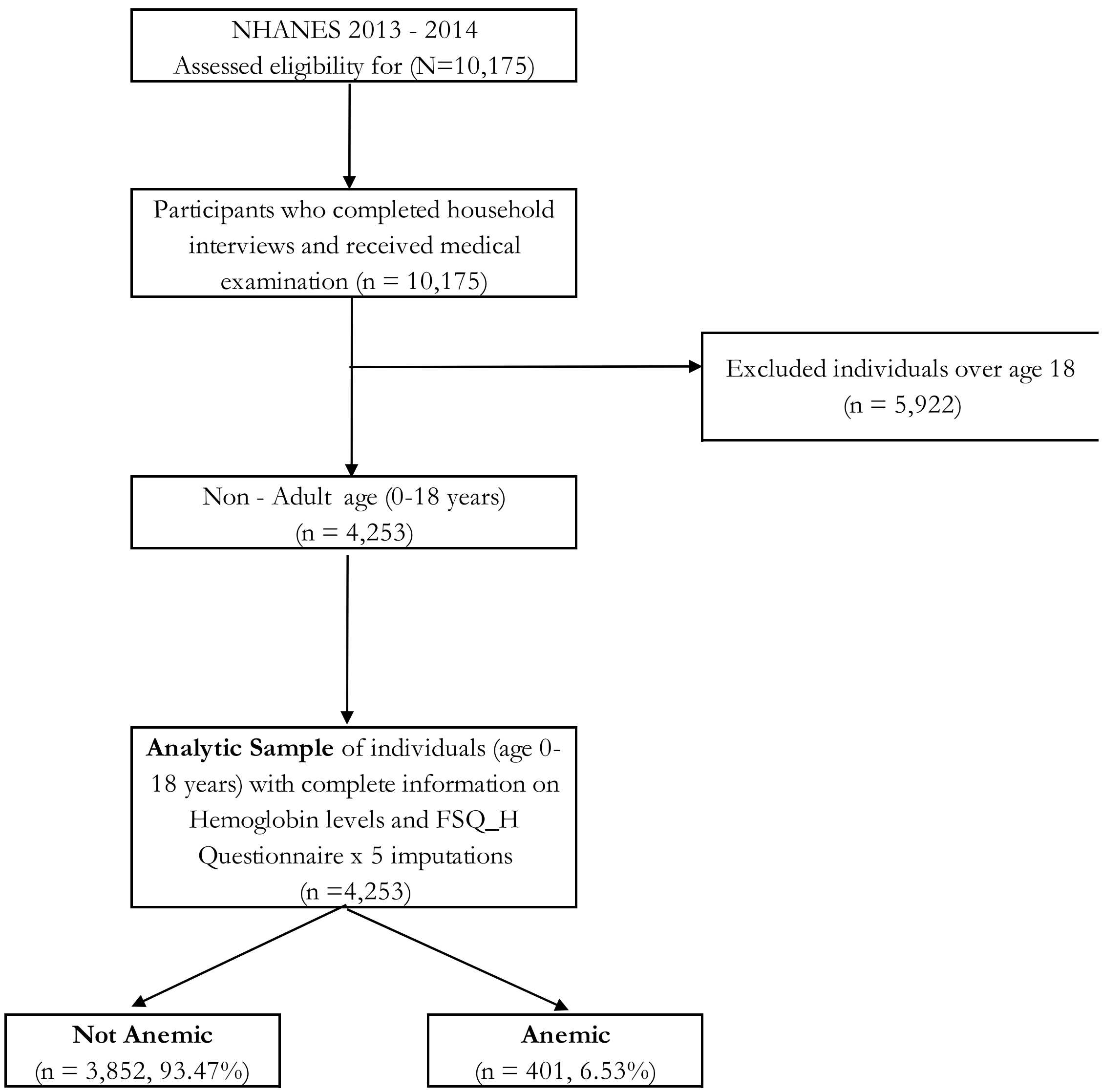

Table 1. Amount of missing data in 3 variables used in the final model to analyze the association between food security and anemia among children and adolescents age (0-18 years), NHANES 2013-2014

Varable	n (%) missing	
SNAP12	50	1%
ChildFS	119	3%
Hemoglobin	1233	40%

a Abbreviations: CI, Confidence Interval; n, sample size; NHANES, National Health and Nutrition Examination

Table 2. Descriptive statistics of children & adolescents ages (0-18 years) by imputation comparison, NHANES 2013-2014

Characteristics	Total (n=4,253)	Anemic (n=401)	Not Anemic (n=3,852)
Age, n (%)			
0 to 2	945 (14.82)	128 (26.26)	817 (14.02)
2 to 5	658 (15.59)	43 (13.40)	615 (15.74)
5 to 8	712 (16.05)	51 (11.51)	661 (16.37)
8 to 12	852 (21.22)	82 (19.52)	770 (21.34)
12 to 15	544 (16.13)	38 (11.29)	506 (16.58)
15 to 18	542 (16.19)	59 (18.02)	483 (16.06)
Gender, n (%)			
Male	2182 (51.22)	155 (39.00)	1825 (47.93)
Female	2071 (48.78)	246 (61.00)	2027 (52.07)

Ethnicity/Race, n (%)			
Hispanic/Latino	163 (23.88)	96 (22.01)	1267 (24.00)
White	1156 (52.17)	58 (29.00)	1098 (53.79)
Black	1054 (13.94)	168 (32.78)	886 (12.62)
Asian	395 (4.91)	47 (8.74)	348 (4.64)
Other including multiracial	285 (5.10)	32 (7.48)	253 (4.94)
Child Food Security, n (%)			
Fully Secure	3496 (85.45)	333 (84.41)	3163 (85.52)
Marginally Secure	333 (6.47)	23 (5.10)	310 (6.56)
Low Food Security	424 (8.08)	45 (10.49)	379 (7.92)
SNAP Participation past 12 months, n (%)			
No	2676 (71.44)	222 (62.83)	2454 (72.04)
Yes	1577 (28.56)	179 (37.17)	1398 (27.96)

1 All percentages are weighted

2 Abbreviations: CI, Confidence Interval; n, sample size; NHANES, National Health and Nutrition Examination Survey;

Table 3. Confounding Assessment to determine final model for imputation 5, NHANES 2013-2014

Variables	OR	CI Lower	CI Upper	Precision		Percent Difference	Within 10%
Gold Standard							
ChildFS 1 vs 0	0.703	**0.352**	**1.404**	**3.99**			
ChildFS 2 vs 0	1.166	**0.734**	**1.851**	**2.52**			
<u>Dropped Variable(s)</u>							
Age							`
ChildFS 1 vs 0	0.668	0.339	1.319	**3.89**	-0.0255288	-2.55	Yes
ChildFS 2 vs 0	1.09	0.696	1.707	**2.45**	-0.0336879	-3.37	Yes
Gender							
ChildFS 1 vs 0	0.697	0.349	1.393	**3.99**	-0.0042857	-0.43	Yes
ChildFS 2 vs 0	1.151	0.725	1.825	**2.52**	-0.0064739	-0.65	Yes
Racecat							
ChildFS 1 vs 0	0.773	0.405	1.476	**3.64**	0.04742547	4.74	Yes

ChildFS 2 vs 0	1.257	0.737	2.146	**2.91**	0.03755675	3.76	Yes
SNAP12							
ChildFS 1 vs 0	0.714	0.358	1.426	**3.98**	0.00776288	0.78	Yes
ChildFS 2 vs 0	1.2	0.749	1.924	**2.57**	0.01437025	1.44	Yes
Age and Gender							Yes
ChildFS 1 vs 0	0.663	0.335	1.314	**3.92**	-0.0292826	-2.93	Yes
ChildFS 2 vs 0	1.08	0.684	1.705	**2.49**	-0.0382903	-3.83	Yes
Age and Racecat							
ChildFS 1 vs 0	0.739	0.39	1.402	**3.59**	0.02496533	2.50	Yes
ChildFS 2 vs 0	1.191	0.705	2.014	**2.86**	0.0106067	1.06	Yes
Age and SNAP12							Yes
ChildFS 1 vs 0	0.686	0.348	1.351	**3.88**	-0.012239	-1.22	Yes
ChildFS 2 vs 0	1.137	0.721	1.793	**2.49**	-0.0125923	-1.26	Yes
Gender and Racecat							
ChildFS 1 vs 0	0.761	0.403	1.438	**3.57**	0.03961749	3.96	Yes
ChildFS 2 vs 0	1.229	0.717	2.106	**2.94**	0.0263048	2.63	Yes
Gender and SNAP12							
ChildFS 1 vs 0	0.709	0.355	1.417	**3.99**	0.00424929	0.42	Yes
ChildFS 2 vs 0	1.184	0.739	1.896	**2.57**	-0.4961702	-49.62	Yes
Drop all variables							
ChildFS 1 vs 0	0.787	0.426	1.454	**3.41**	0.05637584	5.64	No
ChildFS 2 vs 0	1.343	0.791	2.281	**2.88**	0.07054603	7.05	Yes

Table 4. Weighted Logistic Regression Analysis Identifying Associations between Predictor Variables and Anemia Diagnosis using final model with aggregated imputations, NHANES 2013-2014

Predictor Variable	Estimate	Std Error	95% Confidence Limits		p-Value	aOR	95% Confidence Limits for aOR	
Age	-0.0237	0.022	-0.07	0.03	0.3084	0.98	0.94	1.02
Gender	0.26137	0.07914	0.11	0.42	0.0012	1.30	1.11	1.52
Ethnicity/Race								
1 Hispanic/Latino	-0.2845	0.13357	-0.55	-0.02	0.0355	0.75	0.58	0.98
2 White (ref)								
3 Black	0.77211	0.11643	0.54	1.01	<.0001	2.16	1.72	2.72
4 Asian	0.4167	0.19958	0.02	0.81	0.0382	1.52	1.03	2.24
5 Other including multi	0.05683	0.17785	-0.29	0.41	0.7494	1.06	0.75	1.50
Child Food Security								
0 Fully Secure (ref)								
1 Marginally Secure	-0.2945	0.19857	-0.69	0.10	0.1404	0.74	0.50	1.10
2 Low Food Security	0.19112	0.16442	-0.13	0.51	0.2455	1.21	0.88	1.67
SNAP Participation past 12 months	0.10954	0.09602	-0.08	0.30	0.2596	1.12	0.92	1.35

1 All percentages are weighted, percentages do not include missing data

b Effect size for categorical variables are based on Somer's D

2 Abbreviations: CI, Confidence Interval; n, sample size; NHANES, National Health and Nutrition Examination Survey; SD, Standard Deviation; aOR, Adjusted Odds

Table 5. Variance Information using Aggregated Imputation Final Logistic Regression Model, NHANES 2013-2014

Variance

Predictor Variable	Between	Within	Total	DF	Relative Increase in Variance	Fraction Missing Information	Relative Efficiency
Age	0.000263	0.000168	0.0005	9.3879	1.879766	0.708813	0.875839
Gender, male	0.000847	0.005247	0.0063	151.9500	0.193674	0.173064	0.966545
Ethnicity/Race							
Hispanic/Latino	0.002876	0.01439	0.0178	106.9300	0.239793	0.208089	0.960045
White (ref)							
Black	0.00348	0.009379	0.0136	42.1390	0.445292	0.338755	0.936548
Asian	0.004866	0.033994	0.0398	186.1200	0.171782	0.155624	0.969815
Other including multiracial (ref)	0.001591	0.029722	0.0316	1097.8000	0.06424	0.06207	0.987738
Child Food Security							
Fully Secure (ref)							
Marginally Secure	0.00567	0.032625	0.0394	134.3200	0.208554	0.184616	0.964392
Low Food Security	0.001783	0.024893	0.0270	638.3100	0.085967	0.082033	0.983858
SNAP Participation past 12 months	0.002223	0.006553	0.0092	47.7930	0.407065	0.317285	0.94033

Table 6. Interpretaion of Weighted Logistic Regression Analysis Identifying Associations between Predictor Variables and Anemia Diagnosis using final model with aggregated imputations, NHANES 2013-2014

Predictor Variable	Estimate	p-Value	aOR	95% Confidence Limits for aOR		Interpretation of aOR
Age	-0.0237	0.3084	0.98	0.94	1.02	The odds of anemia for every unit increase in age is 0.02 times less likely, holding all other variables constant. This aOR is not statistically significant (CI95: 0.94, 1.02).
Gender	0.26137	0.0012	1.30	1.11	1.52	The odds of anemia among females is 30% higher compared to the odds of anemia among males, holding all other variables constant. This aOR is statistically significant (CI95: 1.11, 1.52).
Ethnicity/Race						
1 Hispanic/Latino	-0.2845	0.0355	0.75	0.58	0.98	The odds of anemia for those who are Hispanic is 0.25 times less likely when compared to the odds of anemia for those who are white, holding all other variables constant. This aOR is statistically significant (CI95: 0.58, 0.98).
2 White (ref)						
3 Black	0.77211	<.0001	2.16	1.72	2.72	The odds of anemia among those who are black is 2 times higher when compared to the odds of anemia among those who are white, holding all other variables constant. This aOR is statistically significant (CI95: 1.72, 2.72).
4 Asian	0.4167	0.0382	1.52	1.03	2.24	The odds of anemia among those who are Asian is 52% times higher when compared to the odds of anemia among those who are white, holding all other variables constant. This aOR is statistically significant (CI95: 1.03, 1.50).
5 Other including multi	0.05683	0.7494	1.06	0.75	1.50	The odds of anemia among those who are multiracial is 6% higher when compared to the odds of anemia among those who are white, holding all other variables constant. This aOR is not statistically significant (CI95: 0.75, 1.50).

Table 6. Interpretaion of Weighted Logistic Regression Analysis Identifying Associations between Predictor Variables and Anemia Diagnosis using final model with aggregated imputations, NHANES 2013-2014

Predictor Variable	Estimate	p-Value	aOR	95% Confidence Limits for aOR		Interpretation of aOR
Child Food Security						
0 Fully Secure (ref)						
1 Marginally Secure	-0.2945	0.1404	0.74	0.50	1.10	The odds of anemia among those who are marginally secure is .26 times less likely when compared to the odds of anemia for those who fully food secure, holding all other variables constant. This aOR is not statistically significant (CI95: 0.50, 1.10).
2 Low Food Security	0.19112	0.2455	1.21	0.88	1.67	The odds of anemia among those who have low food security is 21% higher when compared to the odds of anemia among those who are completely food secure, holding all other variables constant. This aOR is not statistically significant (CI95: 0.88, 1.67).
SNAP Participation past 12 months	0.10954	0.2596	1.12	0.92	1.35	The odds of anemia among those who have not received SNAP benefits in the past 12 months is 26% higher when compared to the odds of anemia among those who received SNAP benefits in the past 12 months, holding all other variables constant. This aOR is not statistically significant (CI95: 0.92, 1.35).

Table 7. Descriptive statistics of children & adolescents ages (0-18 years) by imputation comparison for SNAP participation, NHANES 2013-2014

Characteristics		Total (n=4,253)	Yes SNAP (n=1,577)	No SNAP (n=2676)
Age, n (%)				
	0 to 2	945 (14.82)	394 (18.9)	551 (13.27)
	2 to 5	658 (15.59)	271 (18.10)	387 (14.58)
	5 to 8	712 (16.05)	289 (18.26)	423 (15.17)
	8 to 12	852 (21.22)	311 (20.19)	541 (21.6)
	12 to 15	544 (16.13)	172 (13.18)	372 (17.31)
	15 to 18	542 (16.19)	140 (11.58)	402 (18.03)
Gender, n (%)				
	Male	2071 (48.78)	760 (49.64)	1311 (48.44)
	Female	2182 (51.22)	817 (50.36)	1365 (51.56)
Ethnicity/Race, n (%)				
	Hispanic/Latino	1363 (23.88)	533 (31.63)	830 (20.77)
	White	1156 (52.17)	328 (35.40)	828 (58.88)
	Black	1054 (13.94)	555 (24.22)	499 (9.83)
	Asian	395 (4.91)	48 (2.19)	347 (5.99)
	Other including	285 (5.10)	113 (6.57)	172 (4.52)
Child Food Security, n (%)				
	Fully Secure	3475 (84.57)	1154 (74.20)	2342 (89.94)
	Marginally Secure	354 (7.42)	157 (9.57)	176 (5.23)
	Low Food	424 (8.02)	266 (16.23)	158 (4.83)
Anemia				
	Yes	3278 (72.09)	1398 (91.50)	2454 (94.26)
	No	975 (27.91)	179 (8.50)	222 (5.74)

1 All percentages are weighted

2 Abbreviations: CI, Confidence Interval; n, sample size; NHANES, National Health and Nutrition Examination Survey;