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## Recommended Citation

McElrone, M.; Colby, S. E.; Franzen-Castle, L.; Olfert, M. D.; Kattelman, K.; and White, Adrienne A., "Prevalence and Predictors of Household Food Insecurity among Adult/Youth Dyads at the Initiation of the iCook 4-H Two-Year Obesity Prevention Study" (2018). *Health and Nutritional Sciences Faculty Publications*. 235.  
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DOI: 10.21767/2572-5394.100055

# Prevalence and Predictors of Household Food Insecurity among Adult/Youth Dyads at the Initiation of the iCook 4-H Two-Year Obesity Prevention Study

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**Received date:** April 30, 2018; **Accepted date:** May 07, 2018; **Published date:** May 11, 2018

**Citation:** McElrone M, Colby SE, Franzen-Castle L, Olfert MD, Kattelman K, et al. (2018) Prevalence and Predictors of Household Food Insecurity among Adult/Youth Dyads at the Initiation of the iCook 4-H Two-Year Obesity Prevention Study. J Child Obes S1-002.

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## Abstract

**Objective:** Determine food insecurity prevalence and predictors among adult/youth dyads enrolled in a childhood obesity prevention study (iCook 4-H).

**Methods:** The iCook 4-H intervention was designed for youth (9-10 years old) and their adult main meals preparer to cook, eat, and play together. Although not an inclusion criteria, diverse, low income, and/or rural families were the target during recruitment. At baseline, adults completed surveys on food insecurity, socioeconomic and demographic characteristics and youth anthropometrics were collected with body mass index (BMI) calculated. Descriptive statistics were computed and chi-square analysis was conducted to test differences between potential predictors and food insecurity. Binomial logistic regression was used to assess the relationship between food insecurity and its predictors.

**Results:** Thirty-four percent of households (n=71 of 206) were food insecure. Youth were primarily white (69.9%) and normal weight (58.3%). Adults were also primarily white (74.8%), overweight or obese (67.9%), married (68.9%), not participating in government assistance programs (57.8%), and held no college degree (55.3%). Based on the logistic regression model, households with a non-white youth (OR=13.53; 95% CI=3.33, 55.05), an adult without a college degree (OR=5.62; 95% CI=2.01, 15.73), and government assistance program participation (OR=5.63; 95% CI=2.63, 12.07) were significantly associated with household food insecurity. However, there was no significant association with BMI found (youth p=0.167; adult p=0.179).

**Conclusion:** Consistent with previous findings, household food insecurity status was associated with youth race, adult education, and government assistance program participation. In contrast, no relationship between BMI and

food insecurity status was observed in this study, which warrants further investigation.

**Keywords:** Food insecurity; Food security; Obesity; Nutrition

## Introduction

The United States Department of Agriculture (USDA) defines food insecurity as the limited or uncertain availability or ability to acquire, in a socially acceptable way, nutritious and safe foods adequate to sustain basic human health requirements [1]. More recently, the definition was expanded to state that if at any point during the previous year a household experienced uncertainty in the availability or ability to acquire foods sufficient enough to meet basic human needs, they were considered food insecure [2]. Thus from the perspective of being food secure, all household members there must have access and limited risk of losing access to healthy and safe foods [1].

Overall nationwide food insecurity trends have significantly decreased since 2014 [3]; however, rates varied considerably by household composition, race and ethnicity, income level, area of residence, and geographic location in the US [4]. According to the 2016 USDA report, households with children had higher food insecurity rates (16.5%) compared to both households without children (10.5%) and the national average (12.3%) [4]. Even higher rates were noted in households with children headed by a single parent (single woman 31.6%, single man 21.7% vs. married-couple 9.9%), in both black, non-Hispanic (22.5%) and Hispanic households (18.5%) compared to white, non-Hispanic (9.3%), and in households reporting incomes below the 185 percent of poverty line (31.6%) compared to those above (5.6%) [4]. Additionally, rural households (15%) experienced higher rates compared to both urban (14.2%) and suburban households

(9.5%). Geographically, households located in the South (13.5%) had the highest reports of food insecurity rates compared to those in the Midwest (12.2%), West (11.5%), and the Northeast (10.8%) [4].

The USDA recommends assessing and addressing food insecurity at all ages, across all populations, and considers food security status as a measure of overall well-being [5]. Children living in food insecure households have been found to have, on average, lower overall dietary quality [6]; specifically, diets lower in dark green vegetables [7], fruit [8], and iron [8], and higher in french fries [9] and have a greater percentage of calories coming from fat [10] than food secure counterparts. Moreover, food insecure middle and high school youth reported eating fewer breakfasts and family meals, and perceived more barriers to eating a healthy diet than food secure youth in the same study [10]. Additionally, Gundersen et al. [11] found children living in food insecure homes were at an increased risk of poor overall health, including mental and psychosocial health. Food insecure children in the study reported higher rates of gastrointestinal distress and headaches, hospital admissions, iron deficiency, and poorer learning readiness than their counterparts [11]. Other health conditions among children associated with food insecurity include higher rates of asthma [12], anxiety and depression [12], and dental caries [13], in addition to reduced physical activity [14], academic performance and social skill development [15].

Similar to findings among youth, food insecurity among adults has been associated with various negative nutrition and health related outcomes. The diets of food insecure adults have been shown to have more inadequate vitamin A and B-6, vegetable, fruit, and dairy intake compared to food secure adults [8]. Additionally, food insecure adults were at an increased odds of various medical conditions including arthritis [16], diabetes [16], metabolic syndrome [17], stroke [16], hypertension [16], heart disease and high cholesterol [16,18], myocardial infarctions [16], kidney disease [19], and human immunodeficiency virus infection [20] vs. those in food secure households.

Prevalence of adult overweight and obesity have been found in both food secure and insecure households; however, higher rates of obesity among food insecure women have been noted compared to their counterparts [21-23]. Literature related to food insecurity and increased risk of overweight and obesity among children remains inconsistent [24-28]. Although youth body mass index (BMI) did not statistically differ by food insecurity status, Nguyen et al. [27] found youth BMI was statistically different among those who participated in government food assistant programs compared to those who did not. Further research is needed to investigate such contradictions on the relationship between youth weight and food insecurity status.

Because of the negative health impacts across the lifespan, food insecurity has become a public health concern. The American Dietetic Association (now the Academy of Nutrition and Dietetics) stated in a 2010 position paper that eliminating food insecurity among all populations, of all ages is vital to attain a healthy US population [20]. Additionally, food insecurity is addressed in Healthy People 2020 related to objectives about

nutrition and increasing healthy food access [29]. And, for the first time, the relationships between food insecurity and health outcomes were acknowledged in the 2015-2020 Dietary Guidelines for Americans [30] with the Advisory Committee statement about the need for stronger federal nutrition policies and improved equity to healthy food access [31]. As the relationship between household food insecurity and its adverse impact on health continues to evolve, finding comprehensive models to accurately predict food insecurity are crucial.

Although household characteristics may provide potential predictors, no isolated indicator can predict household food insecurity status. As a multifaceted issue, involving all members of household, characteristics of various household members should be explored in food insecurity models. Including both youth and adult characteristics may lead to a more comprehensive predictive model for the household level measurement, rather than isolating family members in separate models.

As part of the iCook 4-H program, youth-adult dyads from diverse, rural, and/or low socioeconomic status populations completed a childhood obesity prevention program with sessions focused on cooking, eating, and playing together as a family. Grounded in the social cognitive theory (SCT) [32] and the 4-H experiential learning model [33], the iCook 4-H program design included a "learn by doing" approach with observational and hands-on learning. Key SCT components were incorporated to impact behavioral outcomes by having adults model and reinforce desired behavior to youth [32] while intertwining 4-H experiential learning, focusing on social support as a way to achieve a healthful lifestyle [33]. The objective was to determine the household food insecurity prevalence and predictors among youth-adult dyads, newly enrolled in the iCook 4-H study at baseline.

## Methods

### Study design

The iCook 4-H intervention was longitudinal multi-state study focused on nutrition education, physical activity, and family meals. Researchers conducted this collaborative project across their five respective states: Maine, Nebraska, South Dakota, Tennessee, and West Virginia. The study was a randomized control treatment design with baseline and follow-up assessments at 4, 12, and 24 months.

### Participants

Participants were familial dyads with youth, 9-10 years, and their primary adult meal preparers. Dyads (with a focus on diverse, rural, and/or low socioeconomic status) were recruited by researchers, community stakeholders, 4-H program staff, and Extension specialists and educators through flyers, emails, and word-of-mouth in schools, after school programs, and other community outlets, such as recreation centers. Participants who indicated interest in person, through email, or over the phone were screened for eligibility before being enrolled in the program.

Selection of eligibility criteria was based on factors that would facilitate participation in the larger iCook 4-H study. Criteria specific to youth included being 9-10 years old at enrollment, and specific to the adult included being  $\geq 19$  years old. Additionally, both youth and adult eligibility criteria included: ability to participate in the iCook 4-H sessions with their adult primary meal preparer/their youth, being free of food allergies and activity-related medical restrictions, having Internet access, and consuming a diet that allowed for the intake of meat and dairy products. For the purposes of this project, treatment and control youth and adult participants were treated as one singular data source, as only baseline measurements were used. This sub-project used baseline data collected from iCook 4-H participants before the treatment group began receiving the intervention.

## Data collection

Baseline assessments were collected from youth and adult participants from both the treatment and control group over a 6 weeks period between the end of July and early September, 2013. Youth and adult participants from both the treatment and control groups completed online surveys and physical assessments at baseline, 4, 12, and 24-month time points. Both youth and adult participants each received a \$10 gift card incentive after each completed assessment. Other methods and outcomes for the overall intervention are described elsewhere [34,35]. All researchers completed human subjects' research training and the Human Subjects Institutional Review Board for each participating state approved all research procedures.

## Data collection instruments

The iCook 4-H program was pilot tested one year prior to the intervention study of which this project was part [36]. Pilot survey questions were developed by nutrition experts working on the project and were related to specific skills the program curriculum addressed as well as various sociodemographic indicators. Only variables used in this analysis are described below. Questions were face validated with youth and adults, revised, and administered during intervention implementation through online survey software (Qualtrics, Provo, UT, USA).

## Sociodemographic questions

Youth demographic information included age, race, and sex. Adult demographic information included age, sex, marital status, education level, state of residence, and number of children in the household. Additionally, adults were asked to indicate their current participation in government assistance programs for low-income (up to 185% of poverty) individuals and families, such as Head Start, Supplemental Nutrition Assistance Program (SNAP), Temporary Assistance for Needy Families (TANF), or the Women, Infants and Children Program (WIC), which was used as a proxy for income.

## Household food insecurity

The Six-Item Short Form of the USDA Household Food Security Survey Module [37] was used to measure household food insecurity. This abbreviated tool, shown to be a valid measure of

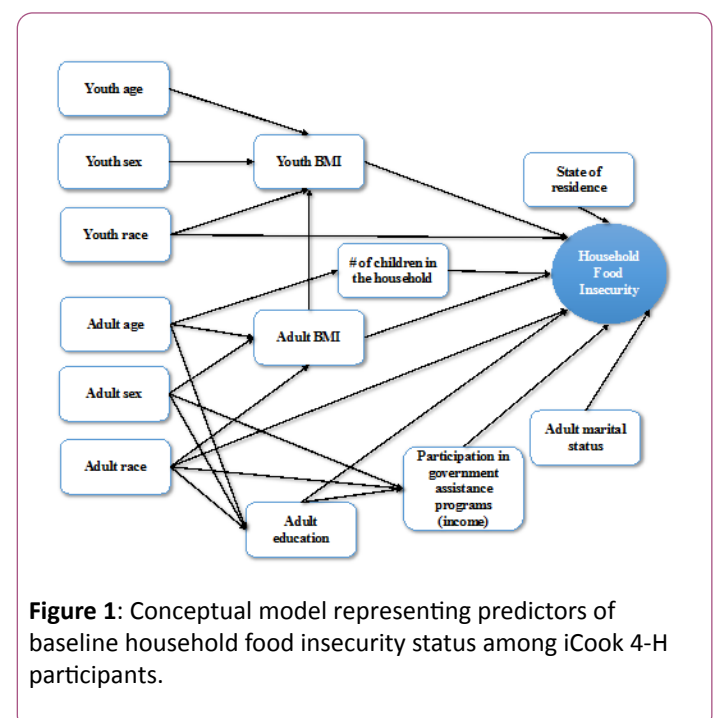
food insecurity [38], was used to reduce respondent burden. Following the coding and assessment procedures outlined in the Six-Item Short Form, households were classified as food insecure if the participant responded affirmatively to two or more of the six household food insecurity questions [37]. Households were classified as food secure if the participant responded affirmatively to one or less of the six questions [37].

## Body mass index

Trained research assistants collected anthropometric measurements of youth, including height and weight. These measurements along with age were used to calculate youth's BMI-for-age percentile ranking in accordance with Centers for Disease Control and Prevention (CDC) growth charts. Percentile ranking allowed for determination of each youth's weight category as underweight (less than the 5<sup>th</sup> percentile), healthy weight (5<sup>th</sup> percentile to less than the 85<sup>th</sup> percentile), overweight (85<sup>th</sup> to less than the 95<sup>th</sup> percentile), or obese (equal to or greater than the 95<sup>th</sup> percentile). Adult self-reported height and weight were used to calculate adult's BMI, which allowed for determination of each adult's weight status using standard CDC categories as underweight ( $<18.5$ ), normal weight (18.5-24.9), overweight (25.0-29.9), or obese ( $\geq 30.0$ ).

## Data analyses

All analyses were performed using Statistical Package for the Social Sciences (SPSS) version 24.0. The outcome variable of interest was household food insecurity status. The online survey and codebook were reviewed to identify potential predictors of food insecurity status. Based on a conceptual model (Figure 1), 13 potential predictor variables of food insecurity status were investigated further: youth and adult race, sex, age and BMI, participation in government assistance programs (income proxy), adult marital status, adult education level, state of residence, and number of children living in the household.



**Figure 1:** Conceptual model representing predictors of baseline household food insecurity status among iCook 4-H participants.



### Data preparation and descriptive analyses

The independent variable, household food insecurity status, was dichotomized into food secure or food insecure. Twenty-two respondents who omitted food insecurity related responses were excluded. Out of the 228 dyads measured at baseline, 206 were included in this study. Because of the over representation of participants identifying as white compared to other race/ethnicities, race/ethnicity was re-coded by combining Asian, Black, Hispanic, Native American, and Other race as one category; leaving white and non-white as two separate categories. The following categorical variables were dichotomous: youth and adult sex (male, female), participation in government assistance programs (yes, no), adult marital status (married, not married), and adult education level (at least an associate degree, some college or less). The following multi-categorical variables were investigated: BMI (underweight, normal, overweight, obese) and state of residence (Maine, Nebraska, South Dakota, Tennessee, West Virginia). The age of youth was a count variable since only 9-10 year olds were included in the study while adult age was continuous. The number of children in the household was a count variable ranging from 0-7.

Percentages were calculated for all categorical variables. The continuous variable (adult age) was centered on the mean (39.13). Shapiro-Wilk test was used to test normality and shape of the distribution was assessed using a histogram of the centered variable. Chi-square tests were used to investigate bivariate relationships between the outcome (food secure, food insecure) and potential predictor variables with statistical inferences based on a critical  $p \leq 0.05$ . One-way ANOVA tests were used to further investigate the relationships between both adult and youth BMI and participation in government assistance programs.

### Binomial logistic model data

Simple binomial models between each potential predictor and the binomial food insecurity status outcome led to the multivariable binomial logistic model. Predictor variables that were significantly associated with the outcome ( $p \leq 0.05$ ) were considered for the final model. To avoid multi-collinearity issues, Pearson's correlation coefficients were used to assess the two-way correlations between potential predictors.

Manual backwards elimination was used to fit the final multivariable binomial logistic model with all variables that had

statistically significant simple associations with household food insecurity status, with a removal standard set at  $p \leq 0.05$ . Confounding was assessed using a 20% change in parameter estimates when run with and without the potential confounder. Predictors with significant associations ( $p \leq 0.05$ ) or that were seen to have a 20% change on the other model variables were included in the final main effects model. Two-way interaction terms of the predictor variables in the final main effects model were assessed and statistically significant interaction terms were retained in the final model. The odds ratios (OR) and the associated 95% CIs were computed for all final model variables. Model goodness-of-fit was assessed using the Hosmer-Lemeshow test (final model  $p=0.838$ ). The impacts of individual observations were assessed using appropriate graphs.

## Results

### Descriptive statistics

Sample characteristics of youth and adult participants are summarized in **Table 1**. Dyads ( $n=206$ ) were diverse in race, sex, weight status, income, marital status, education level, state of residence, number of children, and household food insecurity status. The average youth age was 9.35 ( $SD \pm 0.65$ ) and the average adult age was 39.13 ( $SD \pm 8.06$ ) years. More than two-thirds of youth (69.9%) and adults (74.8%) identified as white vs. non-white. Youth were more diverse in sex (43.7% male vs. 56.3% female) than adults (10.1% male vs. 89.9% female). More than half of youth were categorized as normal (58.3%) weight while over a third of youth were overweight (17.0%) or obese (19.9%). The majority of adults were categorized as obese (42.0%) with an additional 25.9% being overweight. More than half of the adult caregivers held no college degrees (55.3%), while more than two-thirds were married (68.9%). A majority of households did not participate in government assistance programs (57.8%) and had a mean of 2.75 ( $SD \pm 1.23$ ) children living in the house (range 0-7). The dyads were from 5 states (Maine, Nebraska, South Dakota, Tennessee, and West Virginia), with the largest fraction residing in Maine (27.2%). Thirty-four percent of households were deemed food insecure while the remaining 66% reported household food security based on survey responses.

**Table 1:** Baseline demographic, socioeconomic, and weight status characteristics of household youth and adults ( $n=206$  dyads) participating in iCook 4-H.

Characteristic	Categories	N=206 <sup>m</sup>	Weighted %
<b>Youth</b>			
Age (years) <sup>a</sup>	8	17	8.3
	9	102	49.5
	10	84	40.8
	11	3	1.5

	Mean	9.35	-
	Standard Deviation	0.65	-
Sex <sup>b</sup>	Male	90	43.7
	Female	116	56.3
Race <sup>c</sup>	White	144	69.9
	Non-white	62	30.1
Weight category <sup>d</sup>	Underweight	10	4.9
	Normal	120	58.3
	Overweight	35	17
	Obese	41	19.9
<b>Adult (Primary Meal Preparer)</b>			
Age (years) <sup>e</sup>	Mean	39.13	-
	Range	20-67	-
	Standard Deviation	8.06	-
Sex <sup>f</sup>	Male	20	10.1
	Female	178	89.9
Race <sup>c</sup>	White	154	74.8
	Non-white	52	25.2
Weight category <sup>g</sup>	Underweight	2	1
	Normal	60	31.1
	Overweight	50	25.9
	Obese	81	42
Education level <sup>h</sup>	At least an associates	92	44.7
	Some college or less	114	55.3
Adult marital status <sup>i</sup>	Married	142	68.9
	Not Married	64	31.1
<b>Household</b>			
Participation in government assistance programs <sup>j</sup>	Yes	87	42.2
	No	119	57.8
State of residence (dyads) <sup>k</sup>	Maine	56	27.2
	Nebraska	37	18
	South Dakota	34	16.5
	Tennessee	35	17
	West Virginia	44	21.4
Number of children living in the house <sup>l</sup>	Mean	2.75	-
	Range	0-7	-
	Standard Deviation	1.23	-

<sup>a</sup> Youth were asked via survey "Select your age." Response options were 8, 9, 10, 11.

<sup>b</sup> Youth were asked via survey "Are you a boy or a girl?"

<sup>c</sup> Adults were asked via survey to "Select one group that best represents your child's race." Response options were white, black, Asian, Hispanic, Native American, and other. All but "white" were classified as "non-white."

<sup>d</sup>Youth height and weight were collected by trained researchers and used to calculate youth's BMI-for-age percentile ranking in accordance with CDC growth charts. Percentile ranking was used to classify youth as healthy weight (>5<sup>th</sup> and <85<sup>th</sup> percentiles), overweight ( $\geq 85^{\text{th}}$  and <95<sup>th</sup> percentiles), or obese ( $\geq 95^{\text{th}}$  percentile).

<sup>e</sup>Adults were asked *via* survey to "Record your age in years."

<sup>f</sup>Adults were asked *via* survey to "Select their sex." Response options were male or female.

<sup>g</sup>Adult height and weight were self-reported and used to calculate adult's BMI, which allowed for determination of each adult's weight status using standard CDC categories as underweight (<18.5), normal weight (18.5-24.9), overweight (25.0-29.9), or obese ( $\geq 30.0$ ).

<sup>h</sup>Adults were asked *via* survey to "Select the group that best represents your education level." Response options were some college or less, or at least an associates degree.

<sup>i</sup>Adults were asked *via* survey "Are your married or not married?"

<sup>j</sup>Adults were asked *via* survey "Do you or any members of your family participate in any of the following? Aid to Families with Dependent Children (AFDC)/Temporary Assistance for Needy Families (TANF), Expanded Food and Nutrition Education Program (EFNEP), free/reduced price school meals, Medicaid, Welfare to Work (WTW), Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), Supplemental Nutrition Assistance Program (SNAP), Supplemental Security Income (SSI)"

<sup>k</sup>Adults were asked *via* survey to "Select your state of residence." Response options were Maine, Nebraska, South Dakota, Tennessee, or West Virginia.

<sup>l</sup>Adults were asked *via* survey to "Provide the number of children under the age of 18 living in your home."

<sup>m</sup>Sample size varies due to missing responses and rounding of weighted frequencies.

## Bivariate relationships

Results of the chi-square analyses are summarized in **Table 2**. The following variables had significant relationships with the binomial household food insecurity status variable: race (youth  $p<0.001$ ; adult  $p=0.019$ ), youth sex ( $p=0.050$ ), adult marital status ( $p=0.002$ ), adult education ( $p<0.001$ ), and participation in government assistance programs ( $p<0.001$ ). However, age (youth  $p=0.199$ ; adult  $p=0.051$ ), adult sex ( $p=0.623$ ), BMI (youth

$p=0.167$ ; adult  $p=0.179$ ), number of children living in the household ( $p=0.257$ ), and states of residence ( $p=0.140$ ) did not have a significant relationship with food insecurity. Non-white youth and adults, female youth, unmarried and less educated (some college or less) adults, and households participating in government assistance programs (income proxy) were more likely to live in a food insecure household than their counterparts.

**Table 2:** Predictor prevalence and relationship with household food insecurity status at baseline among iCook 4-H participants.

Characteristic	Categories	Food Secure <sup>m</sup> (n=135; 59%) <sup>n</sup> % within	Food Insecure <sup>m</sup> (n=71; 31%) <sup>n</sup> % within	p-value <sup>o</sup>
<b>Youth</b>				
Age (years) <sup>a</sup>	8	88.2	11.8	0.199
	9	61.8	38.2	
	10	65.5	34.5	
	11	66.7	33.3	
Sex <sup>b</sup>	Male	73.3	26.7	0.05
	Female	59.5	40.5	
Race <sup>c</sup>	White	73.6	26.4	<0.001
	Non-white	46.8	53.2	
Weight category <sup>d</sup>	Underweight	60	40	0.167
	Normal	70	30	
	Overweight	68.6	31.4	
	Obese	51.2	48.8	
<b>Adult (Primary Meal Preparer)</b>				
Age (years) <sup>e</sup>				0.051
Sex <sup>f</sup>	Male	60	40	0.623
	Female	66.3	33.7	
Race <sup>c</sup>	White	70.1	29.9	0.019
	Non-white	51.9	48.1	
Weight category <sup>g</sup>	Underweight	50	50	0.179
	Normal	76.7	23.3	



	Overweight	66	34	
	Obese	59.3	40.7	
Education level <sup>h</sup>	At least an associates	83.7	16.3	<0.001
	Some college or less	50.9	49.1	
Adult marital status <sup>i</sup>	Married	72.5	27.5	0.002
	Not Married	50	50	
<b>Household</b>				
Participation in government assistance programs <sup>j</sup>	Yes	39.1	60.9	<0.001
	No	84.9	15.1	
State of Residence (dyads) <sup>k</sup>				
	Maine	67.9	32.1	0.14
	Nebraska	51.4	48.6	
	South Dakota	79.4	20.6	
	Tennessee	60	40	
	West Virginia	68.2	31.8	
Number of children living in the house <sup>l</sup>				0.257
<p><sup>a</sup>Youth were asked <i>via</i> survey "Select your age." Response options were 8, 9, 10, 11.</p> <p><sup>b</sup>Youth were asked <i>via</i> survey "Are you a boy or a girl?"</p> <p><sup>c</sup>Adults were asked <i>via</i> survey to "Select one group that best represents your child's race." Response options were white, black, Asian, Hispanic, Native American, and other. All but "white" were classified as "non-white."</p> <p><sup>d</sup>Youth height and weight were collected by trained researchers and used to calculate youth's BMI-for-age percentile ranking in accordance with CDC growth charts. Percentile ranking was used to classify youth as healthy weight (&gt;5<sup>th</sup> and &lt;85<sup>th</sup> percentiles), overweight (≥ 85<sup>th</sup> and &lt;95<sup>th</sup> percentiles), or obese (≥ 95<sup>th</sup> percentile).</p> <p><sup>e</sup>Adults were asked <i>via</i> survey to "Record your age in years."</p> <p><sup>f</sup>Adults were asked <i>via</i> survey to "Select their sex." Response options were male or female.</p> <p><sup>g</sup>Adult height and weight were self-reported and used to calculate adult's BMI, which allowed for determination of each adult's weight status using standard CDC categories as underweight (&lt;18.5), normal weight (18.5-24.9), overweight (25.0-29.9), or obese (≥ 30.0).</p> <p><sup>h</sup>Adults were asked <i>via</i> survey to "Select the group that best represents your education level." Response options were some college or less, or at least an associates degree.</p> <p><sup>i</sup>Adults were asked <i>via</i> survey "Are you married or not married?"</p> <p><sup>j</sup>Adults were asked <i>via</i> survey "Do you or any members of your family participate in any of the following? Aid to Families with Dependent Children (AFDC)/Temporary Assistance for Needy Families (TANF), Expanded Food and Nutrition Education Program (EFNEP), free/reduced price school meals, Medicaid, Welfare to Work (WTW), Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), Supplemental Nutrition Assistance Program (SNAP), Supplemental Security Income (SSI)"</p> <p><sup>k</sup>Adults were asked <i>via</i> survey to "Select your state of residence." Response options were Maine, Nebraska, South Dakota, Tennessee, or West Virginia.</p> <p><sup>l</sup>Adults were asked <i>via</i> survey to "Provide the number of children under the age of 18 living in your home."</p> <p><sup>m</sup>The Six-Item Short Form, households were classified as food insecure if the participant responded affirmatively to two or more of the six household food insecurity questions [37]. Households were classified as food secure if the participant responded affirmatively to one or less of the six questions [37].</p> <p><sup>n</sup>Sample size varies due to missing responses and rounding of weighted frequencies.</p> <p><sup>o</sup>P values determined <i>via</i> Pearson's Chi-Square tests with food insecurity status as the dependent variable.</p>				

Further, results of the one-way ANOVA analyses investigating the relationship between both adult and youth BMI, and household participation in government assistance programs are summarized in **Table 3**. No significant relationship was found between adult BMI category and participation in government

assistance programs ( $p=0.078$ ,  $F=3.150$ ). However, there was a statistically significant relationship between youth BMI and participation in government assistance programs ( $p=0.012$ ,  $F=6.497$ ).

**Table 3:** Associations of participation in government assistance programs with BMI category at baseline among iCook 4-H participants.

Variable	n <sup>d</sup>	df	F	p <sup>e</sup>
<b>Youth BMI<sup>a</sup></b>				
Participation in government assistance programs <sup>c</sup>	206	1	6.497	0.012

Yes	87			
No	119			
<b>Adult (Primary Meal Preparer) BMI<sup>b</sup></b>				
Participation in government assistance programs <sup>c</sup>	193			
Yes	78	1	3.15	0.078
No	115			
<sup>a</sup> Youth height and weight were collected by trained researchers and used to calculate youth's BMI-for-age percentile ranking in accordance with CDC growth charts. Percentile ranking was used to classify youth as healthy weight (>5 <sup>th</sup> and <85 <sup>th</sup> percentiles), overweight (≥ 85 <sup>th</sup> and <95 <sup>th</sup> percentiles), or obese (≥ 95 <sup>th</sup> percentile). <sup>b</sup> Adult height and weight were self-reported and used to calculate adult's BMI, which allowed for determination of each adult's weight status using standard CDC categories as underweight (<18.5), normal weight (18.5-24.9), overweight (25.0-29.9), or obese (≥ 30.0). <sup>c</sup> Adults were asked via survey "Do you or any members of your family participate in any of the following? Aid to Families with Dependent Children (AFDC)/Temporary Assistance for Needy Families (TANF), Expanded Food and Nutrition Education Program (EFNEP), free/reduced price school meals, Medicaid, Welfare to Work (WTW), Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), Supplemental Nutrition Assistance Program (SNAP), Supplemental Security Income (SSI)" <sup>d</sup> Sample size varies due to missing responses and rounding of weighted frequencies. <sup>e</sup> p values determined via one-way ANOVA with BMI category as the dependent variable.				

### Multivariable binomial logistic model

Results of the final binomial logistic regression model are presented in **Table 4**. The revised conceptual model including the significant predictors and final model results are in **Figure 2**. All predictors, based on this final model, were significantly associated with household food insecurity status. Households with a non-white youth ( $p<0.001$ , OR=13.53, 95% CI: 3.33, 55.05), a less educated adult ( $p=0.001$ , OR=5.62, 95% CI: 2.01, 15.73), and participation in government assistance programs

( $p<0.001$ , OR=5.63, 95% CI: 2.63, 12.07) were more likely to be food insecure than their counterparts. Although, the statistically significant interaction term, youth race\*adult education ( $p=0.001$ , OR=0.058, 95% CI: 0.01, 0.30) indicated a decrease in the odds of living in a food insecure household when the dyad was a non-white youth and less educated adult, the households with this combination of variables were still more likely to be food insecure.

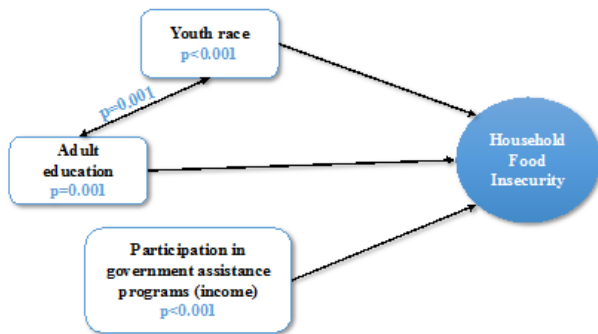
**Table 4:** Final multivariable binomial logistic regression model investigating predictors of baseline household food insecurity status among iCook 4-H participants

Characteristic	Categories	Food Insecure Household <sup>d</sup>	
		OR <sup>e</sup> (95% CI)	p-value <sup>f</sup>
<b>Youth</b>			
Race <sup>a</sup>	Non-white	13.53 (3.33, 55.05)	<0.001
	White	Reference group	
<b>Adult (Primary Meal Preparer)</b>			
Education Level <sup>b</sup>	Some college or less	5.62 (2.01, 15.73)	0.001
	At least an associates	Reference group	
<b>Household</b>			
Participation in government assistance programs <sup>c</sup>	Yes	5.63 (2.63, 12.07)	<0.001
	No	Reference group	
<b>Interaction terms</b>			
Youth Race <sup>a</sup> *Adult Education Level <sup>b</sup>	-	0.058 (0.01, 0.30)	0.001
<sup>a</sup> Adults were asked via survey to "Select one group that best represents your child's race." Response options were white, black, Asian, Hispanic, Native American, and other. All but "white" were classified as "non-white." <sup>b</sup> Adults were asked via survey to "Select the group that best represents your education level." Response options were some college or less, or at least an associates degree. <sup>c</sup> Adults were asked via survey "Do you or any members of your family participate in any of the following? Aid to Families with Dependent Children (AFDC)/Temporary Assistance for Needy Families (TANF), Expanded Food and Nutrition Education Program (EFNEP), free/reduced price school meals, Medicaid, Welfare to Work (WTW), Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), Supplemental Nutrition Assistance Program (SNAP), Supplemental Security Income (SSI)"			

<sup>d</sup>The Six-Item Short Form, households were classified as food insecure if the participant responded affirmatively to two or more of the six household food insecurity questions [37]. Households were classified as food secure if the participant responded affirmatively to one or less of the six questions [37].

<sup>e</sup>OR=Odds ratio

<sup>f</sup>P values determined via binomial logistic regression tests with food insecurity status as the dependent variable.



**Figure 2:** Conceptual model representing only the significant predictors of baseline household food insecurity status based on the binomial logistic model among iCook 4-H participants.

## Discussion

Overall, for this sample, significant differences were found in the odds of living in a food insecure home by youth race, adult education, and participation in government assistance programs. Compared to national rates among black, non-Hispanic and Hispanic households [4], food insecurity rates among non-white youth and adult iCook 4-H participants were more than double. Similarly, rates among white youth and adult respondents were more than twice the national estimates for food insecure white, non-Hispanic households [4]. Although both food insecure non-white and white households were overrepresented in this study, consistent with previous reports, food insecurity was still disproportionately higher in minority households [4].

Bivariate relationships between race, both youth and adult, were significantly associated with food insecurity status, consistent with findings from a nationally representative sample [4]. However, notably adult race alone was significantly associated with food insecurity status, but when added to the binomial logistic model it no longer was a significant predictor. In a nationally representative sample, Coleman-Jensen et al. [4] examined characteristics of food insecure households by the head of household socio-demographics. Head of household data were not collected in the iCook 4-H study, which may have impacted study results [4]. However, using the final binomial logistic regression model, significant differences were found in the odds of living in a food insecure home by youth race. To produce more predictive food insecurity models, further research should be conducted to investigate the impact of both household youth and adult races on food insecurity.

Although previously researchers have shown significant differences between adult sex and food insecurity status [39], significant differences were not found in this study. Researchers have shown higher food insecurity rates among adult females compared to males [39]; however, overrepresentation of female adults in this study may have potentially limited the detection of this relationship. Although youth sex has been noted to play a role in the relationship between youth obesity and food insecurity status [15], studies on the direct connection between household food insecurity status and youth sex are limited. Although youth sex was not included in the final model, in this study female youth were more likely to be food insecure than male youth. With noted sex differences in adulthood [39], particular attention to potential sex differences in youth food insecurity status should be further investigated.

Adult demographics including educational level and marital status, and household characteristics including participation in government assistance programs were also significantly associated with food insecurity status, analogous to previous findings [4,40]. The prevalence of both household food insecurity and participation in government assistance programs among iCook 4-H dyads at baseline was nearly double the national averages [4,41]. These results echoed the program's targeted recruitment efforts for low-income families.

Researchers investigating the relationship between food insecurity and BMI continue to produce inconsistent results [24-28]. No relationship between youth or adult BMI category and food insecurity status was found in the current study. However, similar to the findings from Nguyen et al. [27], youth BMI category was significantly different among those who participated in government assistant programs compared to those who did not. This discrepancy continues to support the need for more research on the relationships between government safety net programs and weight status.

Based on these study results, there might be important differences in the predictors between food secure and food insecure households. Although the interaction term youth race\*adult education decreased the odds of living in a food insecure home, households with both a non-white youth and less educated adult were still more likely to be food insecure when compared to a household with only one of these characteristics. Providing a unique examination into the combined impact of both youth and adult predictors on household food insecurity status in a single logistic model, significant differences by youth race, adult education, and participation in government assistance programs on the odds of living in a food insecure home were noted. Interventions to address household food insecurity may be more effective if concentrated on both youth and adult characteristics.

## Limitations

While still contributing important information to the literature, there are some notable limitations to this study. Although these data were collected from five different states across the US, the cross-sectional nature of the study is limiting. Without repeated measures over time, temporal sequencing was not possible. Therefore, casual inferences cannot be made from these data [42]. Additionally, self-reported data, including food insecurity status, participation in government assistance programs, and adult BMI are limiting and may lead to bias through misreporting [43].

Using binomial logistic regression models provides insight into differences between predictors and dichotomous outcomes. It is useful to compare predictors of food secure vs. food insecure households; however, this method limits interpretation to these macro levels of food insecurity. Because of sample size, this study was limited to this binomial model. In designing future research, there should be consideration for multinomial or ordinal logistic regression to further explore the connection between youth and adult characteristics at the micro levels of food insecurity including high food security, marginal food security, low food security, and very low food security.

## Conclusion

Household food insecurity status was associated with race, youth sex, adult education and marital status, and government assistance program participation. Furthermore, based on the final logistic model, households with non-white youth, less educated adults, who participated in government assistance programs were more likely to be food insecure than their counterparts among iCook 4-H dyads. No relationship between BMI and food insecurity was observed in this study; however, youth BMI was associated with participation in government assistance programs, which warrants further investigation.

## Acknowledgements

Agriculture and Food Research Initiative Grant no. 2012-68001-19605 from the USDA National Institute of Food and Agriculture, Childhood Obesity Prevention: Integrated Research, Education, and Extension to Prevent Childhood Obesity, A2101 and respective State Agriculture Experiment Stations.

## Funding

Funding provided by Agriculture and Food Research Initiative Grant no. 2012-68001-19605 from the USDA National Institute of Food and Agriculture, Childhood Obesity Prevention: Integrated Research, Education, and Extension to Prevent Childhood Obesity, A2101 and respective State Agriculture Experiment Stations.

## Competing and Conflicting Interests

The authors declare that there is no conflict of interest regarding the publication of this article.

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